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Planning support systems in urban development in the Netherlands

MSc thesis: Marije Schilder

Master of Science graduation thesis by M.C. Schilder
Contact through marijeschilder@hotmail.com

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COLOPHON

PLANNING SUPPORT SYSTEMS
IN URBAN DEVELOPMENT IN THE NETHERLANDS

MARIJE SCHILDER
Student number: 4003071
Email: marijeschilder@hotmail.com
Phone: +316 13 69 15 52
Address: E. du Perronlaan 474, 2624 ND Delft

DELFT UNIVERSITY OF TECHNOLOGY
Faculty: Architecture and the Built Environment
Master track: Management in the Built Environment
Graduation lab: Urban Development Management
Lab Coordinator: Dr. ir. E.W.T.M. Heurkens
Address: Julianalaan 134, 2628 BL Delft
PO box 5043, 2600 GA, Delft
Phone: +31 15 2789111
Website: www.bk.tudelft.nl

GRADUATION COMPANY
Name: AMS, Amsterdam Institute for Advanced Metropolitan Solutions
Address: Mauritskade 62, 1092 AD Amsterdam
Phone: +316 380 80 484
Website: www.ams-institute.org

MENTORS
First Mentor: Dr. ir. T.A. Daamen
Management in the Built Environment:
Urban Development Management
Second Mentor: Dr. ir. R. Binnekamp
Management in the Built Environment:
Real Estate Management

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PREFACE

This master thesis is inspired by the rapid developments in ICT's and urban development that we see today. More and more data is becoming online available while smart city initiatives are emerging globally. Yet it is not clear what role (big) data can play in urban development. While the actual implementation of smart city initiatives are not yet realised in the Netherlands on a large scale, the application of data through planning support systems is already much more common in urban development processes. Before discussing the way in which smart city technologies could be implemented, it is essential for the field of urban development to know how planning support systems can improve urban development processes. During the execution of this research, it was especially the decision-making process of urban development processes that has drawn my attention. The case studies illustrate this complex, dynamic and multi-disciplinary environment.

The graduation research is conducted as part of the Master Management in the Built Environment (formerly Real Estate & Housing) at the faculty of Architecture and the Built Environment at the TU Delft, The Netherlands. This research is related to the Urban Adaptation Strategies research project of the Urban Development Management graduation laboratory. I would like to thank Tom Daamen and Ruud Binnekamp for the supervision and helping me to get on the right track by discussing this thesis over and over. Your different perspectives upon the topic have certainly improved the quality and depth of this research. Also, I would like to thank Ellen van Bueren for her support during the set up of the research proposal.

Furthermore, I would like to thank AMS Institute for offering me a graduation internship. The interesting discussions during the lunch breaks and the inspiring events have broadened my horizon and offered me a motivating work environment.
I would also like to thank the interviewees for cooperating in this research. Your perspectives on using planning support systems in practice were very valuable. I really enjoyed the conversations and connecting the research to the Dutch practice of urban development. I would especially like to thank the Province of Utrecht and TNO for offering me the case studies and putting me in contact with the users of their tools.

Moreover, I am grateful to my family and friends for supporting me and keeping me motivated in order to finalise this thesis. I really enjoyed my student time in Delft and I look forward to the new challenges that lie ahead.

Marije Schilder, January 2016

MANAGEMENT SUMMARY

Abstract

This thesis focuses on the planning support systems (PSS) that are currently being applied in Dutch urban development practice. The use of PSS can support the complex urban development processes by giving insight into the urban processes by structuring and visualising spatial data, and also by supporting the communication and collaboration between stakeholders through interactive workshops. Nevertheless, after years of development, PSS are still scarcely applied in planning practice. One of the bottlenecks to its widespread use is the unfamiliarity of PSS to its potential users.

Therefore, the aim of this research is to increase our understanding of the constraints and benefits of planning support systems; to increase our comprehension of their role in the Dutch urban development processes; and to provide insights into the different factors that influence the perceived usefulness of these applications in the decision-making process in urban development in the Netherlands.

Next to a literature review, four case studies were executed using two different PSS: the MKP-MapTable of the Province of Utrecht and Urban Strategy of TNO. Additionally, the use of Tygron, Planmaat and Play the City is outlined based on semi-structured interviews with the developers to illustrate the broad variety of planning support systems. The results of these case studies have led to recommendations about the use of PSS in the urban redevelopment project Buiksloterham in Amsterdam. The outcomes are explained by using systems theory.

The case studies illustrate that it still takes much preparation time to adapt PSS to the specific spatial issue. Although PSS can be used individually, the application of PSS is especially suitable for complex, integral urban development processes that are characterised by open group decision-making. PSS process explicit knowledge that can determine the feasibility of a plan, while tacit knowledge can be shared during the workshop in order to determine the desirability of a plan. PSS are not able to visualise all the effects of urban development plans, due to the complex relationships between the different elements of urban development. Therefore, PSS advise stakeholders, but stakeholders do not have to abide by the result. PSS need to become more flexible in order to deal with the new insights of stakeholders during the planning process. In Buiksloterham, PSS are especially usefull in sharing information between different stakeholders in order to create a mutual understanding and a broad support on how Buiksloterham should be developed.

Keywords: Planning support systems (PSS); urban development; systems theory; decision-making processes; case studies.

Introduction

This thesis focuses on planning support systems (PSS) that are currently being applied in Dutch urban development practice. According to Vonk et al., (2005, p. 910), "PSS can be considered a subset of geo information-based instruments that incorporate a suite of components (theories, data, information, knowledge, methods, tools, etc.) that collectively support all, or some part of, a unique planning task." Although these tools have improved greatly in recent years, they are still scarcely applied in planning practice. This is remarkable, since it is widely recognised that these tools can greatly improve the decision-making process around urban development projects – projects that, in their outcomes, often fail to meet the original requirements set out for them by planners and other stakeholders. Such failures usually occur due to the complexity created by the high amount of stakeholders, the dynamic context, and the long periods involved, causing impasses that lead to poor decision-making and stagnation (or even cancellation) of the project.
The use of PSS can support these complex processes by giving insight into the urban processes by structuring and visualising spatial data and also by supporting the communication and collaboration between stakeholders through interactive workshops.

The aim of this research is to increase our understanding of the constraints and benefits of planning support systems; to increase our comprehension of their role in the Dutch urban development processes in relation to the evaluation framework and systems theory; and to provide insights into the different factors that influence the perceived usefulness of these applications in the decision-making process in urban development in the Netherlands. The redevelopment project of Buiksloterham will be used to apply my research findings into the specific Dutch context of urban development, resulting in recommendations about the use of PSS in this particular case. The current developments in Dutch practice in using planning support systems will be especially valuable for PSS developers, policy makers, urban planners and real estate developers.

Earlier research regarding PSS is contained in the studies of Lee (1973, 1994), Batty (2003), and Klosterman (1997). These studies are focused on the tool and do not consider the application context thoroughly. Later on, several books were published relating to the application of planning support systems. The works of Stan Geertman and John Stillwell (2003, 2009; Geertman et al., 2013) Brail and Klosterman (2001), and Brail (2008) are well known. Previous research that is relevant for this thesis are especially the dissertations of Peter Pelzer (2015), Tessa Eikelboom (2015), Gustavo Arciniegas (2012), Marco te Brömmelstroet (2010b), and Guido Vonk (2006). These studies are relevant as they study the use of PSS in the Dutch context of planning.

New tools or improvements in planning support systems are developing rapidly, while the perspective on urban development processes is also continuously changing at the same time. This study therefore provides a contribution to the development of knowledge in relation to the current use of planning support systems in practice.
Additionally, the case studies evaluate in detail the planning support systems in its specific context. This supports the facilitators of planning support systems in improving the way their systems are used, and in gaining insights into the strengths and opportunities of their systems. The empirical findings of this study are explained by using systems theory and the SECI model of knowledge creation (Nonaka, 1994; Nonaka & Takeuchi, 1995). Furthermore, the recommendations for the urban redevelopment in Buiksloterham will support the stakeholders in deciding whether to use or not use particular planning support systems in relation to their specific demands and the development stage of the process.

Research methodology
From the perspective of system thinking, I have conducted my research in order to answer the following research questions:
The main research question is, "How could planning support systems improve the decision-making process in urban development in Buiksloterham, Amsterdam Noord?"

The sub questions are:

1. What are the characteristics of the decision-making process in urban development in the Netherlands?
2. What are PSS and how do they work?
3. How are PSS applied in urban development?
4. What is the role of PSS in urban development projects in the Netherlands in relation to Urban Strategy and the MKP-MapTable?
5. In which cases is the application of PSS perceived as useful by its users and developers?
6. How can the development process in Buiksloterham be characterised?
7. How can PSS improve the development process in Buiksloterham?

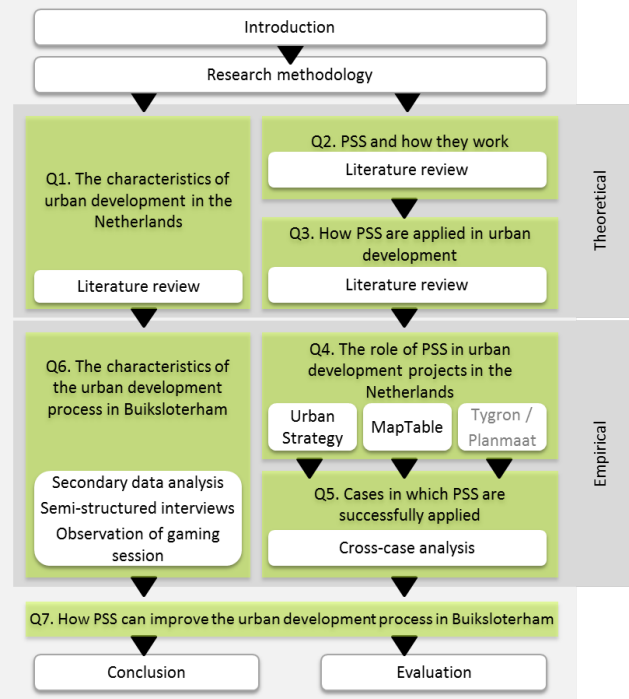

Figure 1 *Research design (own ill.)*

This research is based on a qualitative research approach. It is a comparative case study research design whereby different research methods are aligned to the different research sub-questions, like literature review, semi-structured interviewing, and secondary data analysis. By executing different research methods triangulation is achieved. Triangulation entails using more than one method or source of data, resulting in greater findings as it enables crosschecking findings deriving from different research methods (Bryman, 2012). An overview of the research design is shown in figure 1. The related thesis outline is illustrated in figure 2.

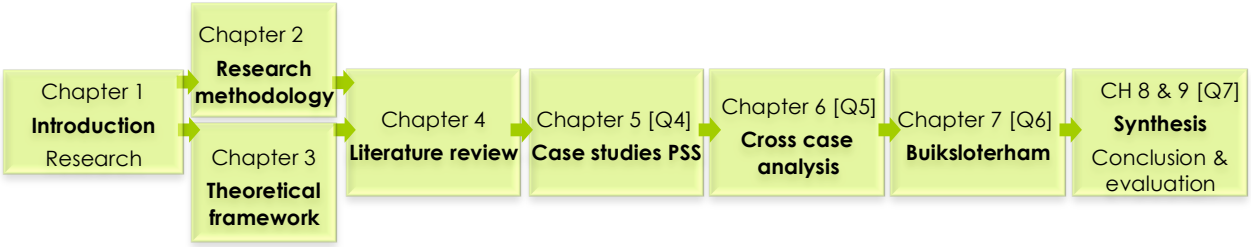

Figure 2 *Thesis outline (own ill.)*

An evaluation framework for executing the case study analysis is made based on the literature review and theoretical framework. The framework relates planning support systems to urban development tasks (based on Eikelboom, 2015) and to the urban development decision-making model, which is based on Willows and Connell's (2003) adaptation framework and Den Heijer's (2003) real estate development cycle.

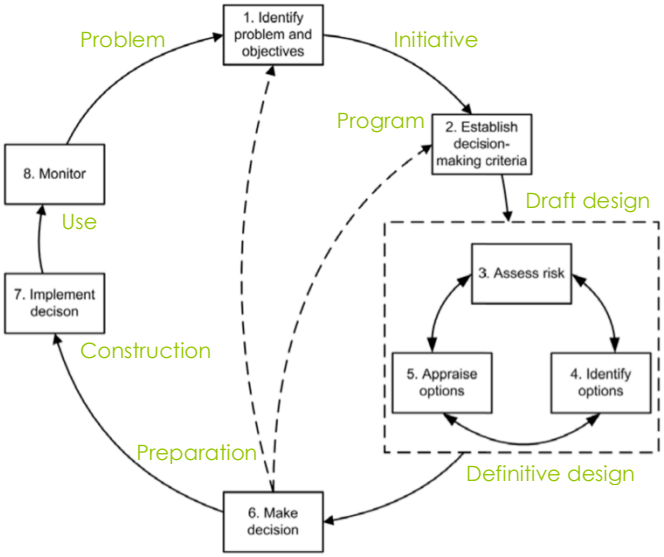

Figure 3 *The evaluation framework, based on Willows and Connell's (2003) adaptation framework and Den Heijer's (2003) real estate development cycle*

Table 1 *Matrix that couples tasks, tools and the stages in the adaptation framework for spatial adaptation (Eikelboom, 2015, p. 39)*

Stage	Task	Tool
Stage 3 Assess risk	Analysis	Evaluation
	Validation	Drawing, Simulation
Stage 4 Identify options	Exploration	Drawing
	Design	Drawing, Simulation
Stage 5 Appraise options	Evaluation	Evaluation
	Negotiation	Drawing

Four case studies were executed using two different PSS: the MKP-MapTable and Urban Strategy. The MKP-MapTable consists of a touch-table of Mapsup with software used by the Province of Utrecht that evaluates the sustainability of plans and policies. Urban Strategy is a calculation model developed by TNO that is able to visualise the environmental impact of a plan or measure. For Urban Strategy "Smart Urban Mobility Plan Tilburg" and "Gezonde Verstedelijking Utrecht" (healthy urbanisation Utrecht) were studied. The MapTable cases described the application of the MKP-MapTable in the Province of Utrecht at the Municipality of Woudenberg and Municipality Stichtse Vecht. Fifteen users were being interviewed for the four cases, which are further supported with eight interviews of PSS experts and developers. Additionally, the use of Tygron, Planmaat and Play the City is outlined based on semi-structured interviews with the developers to illustrate the broad variety of planning support systems. The results of the cases are compared to each other and related to the theoretical framework and the literature review.

The recommendations from the PSS case studies are subsequently applied in the redevelopment project of Buiksloterham in Amsterdam-Noord. The analysis of the project is based upon three semi-structured interviews, secondary data analysis, and the observation of a serious game session with the stakeholders.

In total, 29 semi-structured interviews were performed with users, developers and experts of planning support systems with a variety of backgrounds in order to cover the topic from different perspectives in different urban development contexts. Except for the seven orientating interviews, all the interviews were recorded, transcribed verbatim, and checked for approval by the interviewees. A non-random approach is applied for selecting the interviewees who were present at the PSS workshops in order to cover a diverse range of disciplines. This approach is suitable for this research, as the perception framework of interviewees intensively influences the outcomes, which corespond to the soft systems methodology. The snowball sampling is used to get introduced by the relevant people. This approach is based on purpose sampling whereby samples are based on the relevance of people to the research (Bryman, 2012).

Theoretical framework
In this research, systems theory has been applied in order to define planning support systems in relation to urban development processes. According to Ackoff (1999, pp. 15-16) a system is "a set of two or more elements that satisfies the following three conditions: the behaviour of each element has an effect on the behaviour of the whole; ....the behaviour of the elements and their effects on the whole are interdependent; [and].... the elements of a system are so connected that independent subgroups of them cannot be formed."

Systems theory distinguishes two approaches: the hard system methodology and the soft system methodology. The hard system approach is suitable for structured problems with clear objectives that are fixed and physical variables. The soft systems methodology can be used to solve less defined problems inherent to social systems (Checkland, 1981).
Additionally, Ackoff (1999) divides systems into four types: deterministic systems, animated systems, social systems, and ecological systems.

A spatial problem is an undesired difference between the existing and aspired physical environment. It is the reason to pursue improvements in the area or urban renewal. However, if there are more decision makers, one cannot assume that they agree with each other. As De Leeuw (2002) outlines, problems arise because judgments (normative statements) are spoken about aspects of reality. It is therefore essential that these objectives are outspoken and clear for the stakeholders.

Urban development processes are based on a soft systems approach that is heavily influenced by design thinking and decision-making. Design thinking can be perceived as a way of decision-making, whereby learning and creativity play an important role. New insights, feedback on the plan, will determine the next steps in the design process. These feedback loops cause the iterative and circular character of the design process. The objectives of stakeholders might change during the design process because of new insights. This is indicated by Argyris and Schön (1974) as double-loop learning. Reaching a consensus is based on changing preferences of stakeholders. People try to agree with each other by exchanging views, considering each other's prefrences and through discussions. The SECI model of knowledge creation (Nonaka, 1994) illustrates how knowledge can be shared between different stakeholders in an iterative process including four steps: socialisation, externalisation, combination and internalisation. Planning support systems can be used in order to achieve this learning cycle in interactive workshops.

Research results
Urban development is seen as a complex task often related to ill-defined problems in a dynamic context. It requires an integral approach (Bruil et al., 2004, p. 397), as different spatial scales, development phases, policy domains, spatial scales and disciplines need to be aligned with each other. This alignment takes place within complex decision-making processes in inter-organisational networks (Bruil et al., 2004, pp. 19-20). Hence, it is characterised by complex relationships between societal, economic-financial, technical, political, environmental, legal, and spatial factors. Important aspects of urban development processes are next to the iterative learning process, the human-centred approach and the diverging and converging phases within the process.

Planning support systems are "geo information technology-based instruments that incorporate a suite of components that collectively support some specific parts of a unique professional planning task" (Geertman, 2008, p. 217). The planning tasks can be classified according to Carton and Thissen (2009) and De Bruin et al. (2009). As planning tasks are central in the use of planning support systems, these tasks are incorporated into the evaluation framework as mentioned on page VI.

Planning support systems can be perceived as deterministic systems as they do not have a purpose without people controlling them. They serve the purpose of its users. Urban development processes are examples of social systems, whereby the project team has the goal to physically adapt a specific area to social- economic and spatial needs. Each stakeholder also has individual goals, as different stakeholders from different companies belong to different social subsystems.

Furthermore, it has been clarified that PSS have experienced a shift from technocratic models towards sociocratic models, while urban development has evolved from top-down centralised approaches to bottom-up holistic and integral approaches. These shifts can be related to systems theory as well. Whereas initial planning support systems where developed form a hard systems approach, currently it is widely recognised that a soft system approach is more suitable for these systems

The literature review illustrated that a wide variety of planning support systems exists, which is used in various fields. The models generally focus on a particular aspect of area development by including a limited number of indicators. Consequently, they do not present the complex and dynamic nature of decision-making in area development. Also, they usually do not support the participation of different stakeholders and these models are often not used in practice: They are primarily used to validate theories or simulate urban processes. Therefore, it is difficult to conclude what impact such models have on urban development in practice.

The doctoral dissertations related to this research suggest that different tools can be used for different purposes, and are suitable for different phases in the overall urban development process. They also mention that PSS are still not widely applied in practice. The researchers studied different aspects of PSS in different ways, but they do have some overlap such as examining the extent to which the technology fits the tasks of the stakeholders and the relation between PSS with decision-making theory and knowledge management.

The case studies illustrate the application of Urban Strategy and the MKP-MapTable in practice. Urban Strategy is a planning support tool developed by TNO since 2005 that focuses on visualising environmental effects of different spatial measures. The MKP-MapTable is a digital touchscreen that runs ESRI ArcGIS, a well-known GIS software, with Community Viz Scenario 360. The Province of Utrecht has developed the Environmental Quality Profiles that rates the sustainability of a spatial plan according to 8 to 20 different themes. Based upon the two case studies a SWOT analysis of both tools were created.

Circular Buiksloterham is a bottom-up, organic, transformation project in Amsterdam Noord and part of the wider restructuring of the Northern IJ-Banks in Amsterdam. The industrial area of 100 ha will be transformed into a mixed-use urban area with a timeline running from 2005 to 2030. This means that the project is in its initiation phase whereby decision-making still plays a major role in the process. The contaminated soil and the environmental impact of residual industry together with the high sustainable ambitions increases the complexity of the project, enlarging the need for planning support tools. Additionally, the bottom-up approach of the redevelopment, through which many stakeholders are involved, increases the relevance for a PSS.

PSS can play an important role in sharing information and knowledge between the different stakeholders. This way, they gain a mutual understanding of the complexity of the project, whereby collaboration between stakeholders to develop Buiksloterham in an integral way is supported. Especially planning support systems that improve the communication between different stakeholders and within organisations seem therefore relevant for Buiksloterham. As decision-making powers need to decide soon how to develop Buiksloterham in a circular way, PSS should provide the stakeholders with relevant information to make these decisions. However, a tension exists between the extensiveness of a tool, and the preparation time and costs to organise workshops with this tool. A higher complexity in the tool also influences the transparency of the data and calculation methods.

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TERMINOLOGY

Urban development: "the process of physically adapting a specific area to social-economical and spatial needs, by various stakeholders with different instruments and activities to realise an integral-functional area" (Heurkens, 2014, p. 7).

Stakeholder: "an actor who has a right to act because he has a stake in the issue" (Van Gunsteren & Van Loon, 2000, p. 2). "As such they become decision-makers: parties who collectively decide on how the design ultimately will look like" (Van Gunsteren & Van Loon, 2000, p. 12).

Actors: "parties who only have a right to express their views, but do not have any formal or sanction power" (Van Gunsteren & Van Loon, 2000, p. 11). Therefore, they are not able to make decisions and they cannot directly influence the design, only indirectly.

Planning support systems: "PSS can be considered a subset of geo information- based instruments that incorporate a suite of components (theories, data, information, knowledge, methods, tools, etc.) that collectively support all of, or some part of, a unique planning task" (Vonk et al., 2005, p. 910).

System: "a set of two or more elements that satisfies the following three conditions: the behaviour of each element has an effect on the behaviour of the whole;….the behaviour of the elements and their effects on the whole are interdependent; [and]…. the elements of a system are so connected that independent subgroups of them cannot be formed" (Ackoff, 1999, pp. 15-16).

ABBREVIATIONS

GVU: Healthy urbanisation Utrecht (in Dutch: 'Gezonde Verstedelijking Utrecht')
MKP: Environmental Quality Profiles (in Dutch: 'MilieuKwaliteitsProfielen')
PSS: Planning support systems
SPL: Sustainability profile of the location (In Dutch: DPL 'DuurzaaheidsPrestatie van een Locatie')
SUMP: Sustainable Urban Mobility Plan

1. INTRODUCTION

INTRODUCTION

Cities are currently facing serious challenges relating to rapid urbanisation, sustainable issues, and the current global economy. Since 2008, more than 50% of the world population lives in urban areas, up from 34% in 1960 (United Nations, 2014a). This number will increase to around 66% of the world population in 2050. Incorporating the growth of the global population, this leads to a growth from 3.9 billion urban dwellers currently to 9.3 billion in 2050. By 2030, the world is projected to have 41 mega-cities with more than 10 million inhabitants against the 10 mega-cities in 2014 (United Nations, 2014a). The Netherlands is one of the most urbanised countries of the world. Currently 87.1% of the Dutch population lives in cities, which will increase even further to 95% in 2030 (United Nations, 2014b). Cities need to adapt to accommodate this growth by creating more facilities, greater infrastructure and by redeveloping real estate using the available space efficiently.

The urbanisation will greatly affect the living environment. Currently the three main sustainability issues are the depletion of fossil fuels, climate change and the scarcity of resources (Van den Dobbelsteen, 2015). These sustainability issues have resulted in threats to cities, like natural hazards, flooding, urban heat island effect, air pollution, health issues, and congestion, ultimately also causing social and economic issues (Van Timmeren et al., 2015). A sustainable approach is needed to improve the quality of life by limiting greenhouse gas emissions. Policies are stimulating public and private parties to improve the sustainability of cities. The EU 2020 target for instance strives to reduce greenhouse gas emissions by 20% in comparison to 1990 levels; raising the share of EU energy consumption produced from renewable resources to 20%; and an improvement of 20% in the EU's energy efficiency in 2020. Furthermore, the scarcity of resources increases the need for a circular economy, whereby resources will be reused and recycled.

Additionally, the rise of information and communication technologies (ICTs) has led to globalisation. People and companies are less tied to their physical location as they can connect to anybody, anywhere and anytime. This caused an increased competitiveness between cities. Networks have become the driving forces of urban development and the scale and complexity of these networks are growing at an accelerated pace (Van Timmeren et al., 2015).

With the rise of ICTs, together with shifts in governance frameworks and business models, smart cities are emerging globally. According to Anthony Townsend (2015) 2008 is the year of the birth of the smart city movement as this was the year that: more people lived in cities than the countryside for the first time; the Internet has become primarily untethered having more mobile broadband subscribers than fixed (internet on phone or tabled instead of on the PC); and that more things became connected to the internet than the amount of people in the world. Furthermore, 2008 was the year in which the global financial crisis started. As companies stopped buying IT, IBM CEO Sam Palmisano came up with a solution is his speech entitled 'A smarter planet: the next leadership agenda' (Söderström et al., 2014). He argued that the only way cities will be able to cope with their challenges is to be 'smarter' by becoming more sustainable and economically efficient. Not long after that, IBM trademarked the 'Smarter Cities' campaign to promote ICT as a 'solution in a box' to urban problems. IBM together with the large IT firms and a few start-up companies were vying for market shares while municipalities are still trying to figure out the exact benefits of getting 'smart' (Van Timmeren et al., 2014). As cities try to attract the creative class and investment capital, phrases like 'smart growth', 'intelligent cities', 'digital cities', 'e-cities' and 'smarter cities' have become increasingly popular within the IT, policy and urban planning fields as potential solutions to urban problems. Many different terms are used to indicate smart cities, but a consensus about the meaning and requirements of a smart city is lagging. The definitions of the smart city often refer to the use of data and ICT. Giffinger and Gudrun (2010) define smart cities as being *"smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory governance."*

Smart Cities initiatives were presented to be the solution for hyper urbanisation, sustainability issues and the global economy. Data generated by ICTs can give insight in urban processes and spatial issues. Governance frameworks that have contributed to smart cities are ranging from open data infrastructures and policies for increased data transparency to public-private partnerships and distributed governance. Furthermore, business models like crowdsourcing, open source moment, and the expansion of cloud computing services and software-as-a-service (SAAS) enabled the development of smart city concepts (Van Timmeren et al., 2015).

Through the high investment and the long-term scope of smart city projects, new partnerships and business models are needed. As also the European Innovation Partnership on Smart Cities and communities (EIP-SCC, 2012, p. 4) states *"Many of the component technologies that can deliver intelligent and resource-efficient mobility and energy production and use have already been developed."* However, the technologies are developed by different companies, which need to collaborate to integrate the segregated systems into one urban information model. This is a complex process influenced by many factors and different parties.

Masdar City in Abu Dhabi and Songdo in South Korea are early examples of smart cities. In these cities, data of different processes are gathered and interpreted. An online dashboard gives one access to the real-time data anytime and anywhere. Potentially, it does not only analyse the data, but it also uses the data to stir different processes in the urban environment automatically, like traffic lights and electrical car charging stations. Although these cities are technology focused and top-down organised, they form a great case for subsequent smart city developments in Western Cities. Currently, research programmes and digital roadmaps for implementing a smart network are set up for many cities around the globe, but the actual implementation of smart grids often fail to appear.
The above-mentioned problems relating to sustainability, urbanisation and the global economy are not easy to solve and it has become clear that these challenges are not only manageable through technology. *"The primary problem we face is not the availability of technology, but the lack of socio-technological planning and design methodology to identify and deploy the most sustainable solution in a given geographic and cultural context"* (Guest et al., 2009).

The ICTs and related data form an important aspect of smart cities and can provide insight into urban processes and spatial issues, by which the spatial environment can be better adapted to social-economic and spatial needs. Potentially, this will save huge amount of failing costs and increase the economic and social value of projects in real estate and urban development. The smart city concept has its origin in (spatial) decision support systems and multi-criteria decision analysis. While actual retro-fit integrated smart cities are not yet realised in Europe, the application of data through planning support systems is already much more common in the practice of urban development. This enables a stronger relation between research and practice. Before discussing the way in which smart city technologies could be implemented, it is essential for urban development to know how planning support systems can improve urban development projects and processes. Additionally, the research domain of planning support systems is relatively mature, creating possibilities to verify empirical findings with theory. This has led to my graduation topic of planning support systems in urban development in the Netherlands.

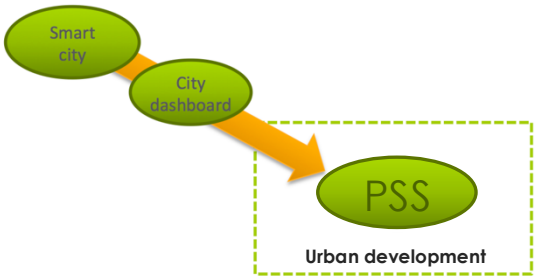


Figure 1 *Inspiration for researching PSS in urban development (own ill.)*

Although planning support systems have improved greatly in recent years, they are still scarcely applied in planning practice. This is remarkable, since it is widely recognised that these tools can greatly improve the decision-making process in urban development projects – projects that, in their outcomes, often fail to meet the original requirements set out for them by planners and other stakeholders. Such failures usually occur due to the complexity created by the high amount of stakeholders, the dynamic context, and the long periods involved, causing impasses that lead to poor decision-making and stagnation (or even cancellation) of the project.

"PSS can be considered a subset of geo information-based instruments that incorporate a suite of components (theories, data, information, knowledge, methods, tools, etc.) that collectively support all, or some part of, a unique planning task" (Vonk et al., 2005, p. 910).

According to Carton and Thissen (2009) and Bruin et al. (2009), the tasks of a planning support system can be grouped into a total of six task categories: analysis, validation, exploration, design, evaluation and negotiation. The use of PSS can support the complex urban development processes by giving insight into the urban processes by structuring and visualising spatial data and by supporting the communication and collaboration between stakeholders through interactive workshops.

However, various bottlenecks are blocking the use of PSS. Although many different authors mention these barriers, empirical case study research studying the application of PSS in the Dutch practice of urban development is often missing. It appears that one of the barriers to the widespread use of planning support systems is the unfamiliarity of these tools to its potential users (Vonk, 2006). Planners, developers and other stakeholders who are involved in the planning process are often not aware of the possibilities of using planning support systems in their development projects: for which aim it can be used, at what moment in the urban development process they can be used, and for what kind of projects they are suitable.

Therefore, the main research question is: **"How could planning support systems improve the decision-making process in urban development in Buiksloterham, Amsterdam Noord?"**

This thesis consists of nine chapters. The thesis starts with an introduction in chapter 1, the research methodology in chapter 2 and the theoretical framework in chapter 3. The literature review will answer the first three research questions in chapter 4. Chapter 5 will outline the executed case studies and chapter 6 will execute the comparative case study analysis. Chapter 7 will analyse the usability of planning support systems for Buiksloterham and chapter 8 and 9 will conclude and evaluate this graduation research.

Earlier research regarding PSS is contained in the studies of Lee (1973, 1994), Batty (2003), and Klosterman (1997). These studies are focused on the tool and do not consider the application context thoroughly. Later on, several books were published relating to the application of planning support systems. The works of Stan Geertman and John Stillwell (2003, 2009; Geertman et al., 2013) and Brail and Klosterman (2001), and Brail (2008) are well known. Previous research that is relevant for this thesis are the dissertations of Peter Pelzer (2015), Tessa Eikelboom (2015), Gustavo Arciniegas (2012), Marco te Brömmelstroet (2010b), and Guido Vonk (2006). These studies are relevant as they study the use of PSS in the Dutch context of planning.
Furthermore, this graduation research made use of systems theory and knowledge creation in order to define planning support systems in relation to urban development processes.

PROBLEM DESCRIPTION

It appears that the first spatial decision support systems developed from the 1970s onwards were expert-based technocratic models based on the hard systems approach (De Wit et al., 2009). These models were too complicated and too big to be user-friendly. During the 1980s and 1990s, these models were improved by developments in geo-information systems and visualisation tools. But it appears that these models were still not embraced by its potential users (Lee, 1994). Next to the critical evaluations of Lee (1973; 1994), other researchers also concluded that, "most of the tools are far too generic, too complex, too inflexible, incompatible with most planning tasks, oriented towards technology rather than problems and too focused on strict rationality" (Geertman & Stillwell, 2003, p. 5).

Shifts in ideas from the central, top-down approach of spatial planning towards a more bottom-up, holistic approach, called for new ways of supporting urban development processes. The former spatial decision support systems were not capable of supporting the social aspects of the decision-making process and the complexity of urban planning. The response was therefore collaborative planning support tools. These tools are actor-based, and sociocratic in order to support participatory planning (De Wit et al., 2009).

Despite the promising development of planning support systems from technology focused models towards participatory human-centred support, the application of planning support systems in practice was still lagging behind (Brail and Klosterman 2001; Geertman and Stillwell 2003; Uran and Janssen 2003; Couclelis 2005; Vonk 2006). Couclelis (2005, p. 1359) argues that this can be explained by the difference that planning is about policy, while the models are based on science.
Also Uran and Janssen (2003) identify the mismatch between the decision problem of end-users and the answers produced by the system as the main factor for this lack of success: technology-driven systems produce the correct answer to the wrong question at the wrong moment.
Additionally, most schemes take into account only a small proportion of urban processes, which does not reflect the reality.

A few years later, Geertman and Stillwell (2009) still confirm that "there exists a fundamental dichotomy between those systems that are demanded for use in practice by potential users and those systems supplied by systems developers according to their perception of what is required". It appears that after decades of development PSS were still not transparent enough, neither flexible nor user-friendly and therefore incompatible with the unpredictable and flexible nature of most planning tasks and information needs.

The reactions of these reviews are numerous. Different authors mention that the major challenge in this area is to better link the decision-support tools to the ways in which stakeholders prefer to use these tools. Petch and Reeve (1999) mention that a PSS should be demand-driven in orientation to be utilised in daily planning practices, and Schetke et al. (2012) argue that participatory methods during the development process should be utilised to better reflect stakeholders' needs for information in the design of PSS.
Some reactions focus on improving PSS software by adding new functions to it; for example, PSS that are more integrated (i.e. 'What If' developed by Klosterman (1999)), more interactive (i.e. 'Urban Strategy' developed by TNO (2015a, 2015b)) or more user-friendly (i.e. 'UrbanSim' developed by Waddell (2002, 2011)). Others follow a more hardware oriented path, such as 'MapTables', 'Sketchtables' and other visual gadgets. Then, there is the process-oriented line that focuses on bridging the human gap between the potential end-users and the PSS developers with more participative, iterative PSS development structures (Te Brömmelstroet & Schrijnen, 2010), like the serious gaming tool of Tygron and Play the City.
These recent developments in PSS are especially interesting to research to review if they have bridged the implementation gap between theory and their use in the practice of urban development.

RESEARCH AIM

The aim of this research is to increase our understanding of the constraints and benefits of planning support systems, to increase the comprehension of their role in the Dutch urban development processes regarding four case studies and to provide insights into the different factors that influence the perceived usefulness of these applications in the decision-making process in urban development in the Netherlands. The redevelopment project of Buiksloterham will be used to apply my findings of the research into the specific Dutch context of urban development, resulting in recommendations about the use of PSS in this particular case.
The current developments in Dutch practice in using planning support systems will be especially valuable for PSS developers, policy makers, and urban planners and urban area developers.

RESEARCH QUESTIONS

The following research questions will guide the research and provide a clear sense of the research topic. The main research question is:

How could planning support systems improve the decision-making process in the urban redevelopment process of Buiksloterham, Amsterdam Noord?

Sub-questions are:

1. What are the characteristics of the decision-making process in urban development in the Netherlands?
2. What are PSS and how do they work?
    a. What kind of functions are included in PSS?
    b. What are benefits of PSS?
    c. What are constraints of PSS?
3. How are PSS applied in urban development?
4. What is the role of PSS in urban development projects in the Netherlands in relation to Urban Strategy and the MKP-MapTable?
5. In which cases is the application of PSS perceived as useful by its users and developers?
6. How can the development process in Buiksloterham be characterised?
7. How can PSS improve the development process in Buiksloterham?

RESEARCH FOCUS

This research will be defined on the basis of four case studies regarding the application of Urban Strategy and the MapTable, supplemented by semi-structured interviews with developers of Tygron, Planmaat and Play the City. The cases will be evaluated on the basis of the evaluation framework as presented at the end of chapter 4. The findings will be related to systems theory as presented in the theoretical framework. The literature review especially covers recent research in urban development and PSS. This research will be related to the current practice of urban development by applying the findings to Buiksloterham, a redevelopment project in Amsterdam Noord.

RESEARCH RELEVANCE

This thesis contributes to the scientific field of the use of planning support systems as:

- Empirical research often focuses on the tool instead of the process in which the tool is applied. Therefore, there has not yet been much empirical research about the performance of planning support systems made;
- Empirical findings are explained and evaluated through the lens of systems theory;
- The study is executed from a Dutch urban development point of view;
- The results of the comparative case analysis are immediately applied in an urban development project in Buiksloterham, Amsterdam-Noord.

This study has a practical relevance, as the context of the application of planning support systems is very dynamic. New tools or improvements in planning support systems are developing rapidly, while the perspective on urban development processes is also continuously changing. This study therefore provides a contribution to the development of knowledge in relation to the current use of planning support systems in practice. Additionally, the case studies evaluate in detail the specific planning support systems in their specific context. This supports the facilitators of planning support systems in improving the way their systems are used, and in gaining insights into the strengths and opportunities of their systems. Furthermore, the recommendations for the urban redevelopment in Buiksloterham will support the stakeholders in deciding whether to use or not use particular planning support systems in relation to their specific demands and the development stage of the proces.

2. RESEARCH METHODOLOGY

INTRODUCTION

The research methodology is based on the research questions and guides the execution of this research methods and the analysis of the subsequent data. There are different research approaches. Quantitative research emphasises the quantification in the collection and analysis of data, while qualitative research emphasises words rather than quantification in the collection and analysis of data (Bryman, 2012). This research is mainly based on a qualitative approach. It is a comparative case study research design whereby different research methods will be used. The different research methods, like literature review, semi-structured interviews, observation and secondary data analysis, are aligned to the different research sub-questions. An overview of the research design is shown in figure 2.

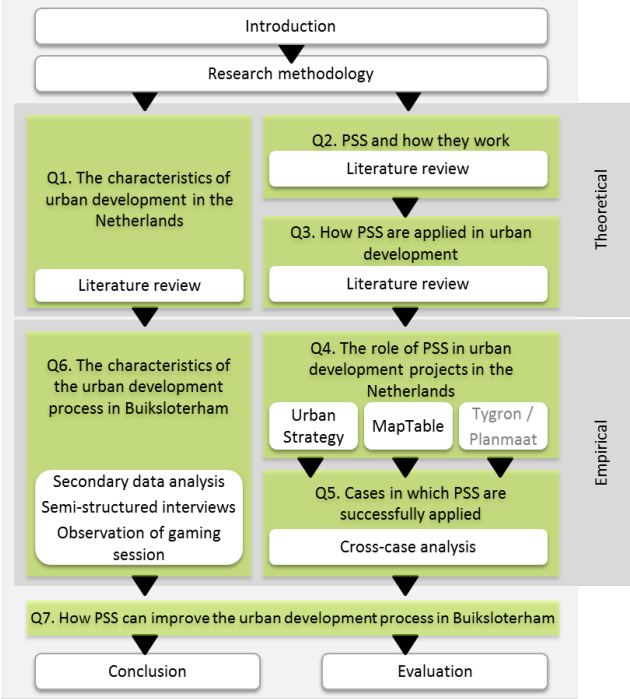


Figure 2 *Research design (own ill.)*

This graduation research is conducted as part of the Master Management in the Built Environment (formerly Real Estate & Housing) at the faculty Architecture and the Built Environment at the TU Delft, The Netherlands. This research is related to the Urban Adaptation Strategies research project of the Urban Development Management graduation laboratory, under guidance of dr. ir. Tom Daamen.
My second mentor is dr. ir. Ruud Binnekamp.
He has researched preference-based design in relation to multi-criteria decision making methods and decision-making processes in real estate management.

The topic of this research covers research areas of planning support systems (PSS), urban development, systems theory, knowledge creation, and decision-making processes.

The use of PSS will influence urban development by giving insight into the urban processes and thereby supporting the decision-making process relating to urban development. This research will study PSS as a tool to analyse urban areas, to evaluate development plans, to validate urban area strategies, and to support the communication and understanding between different stakeholders.

I will accomplish this research at AMS, Amsterdam Institute for Advanced Metropolitan Solutions.

The time schedule for this research is as follows:

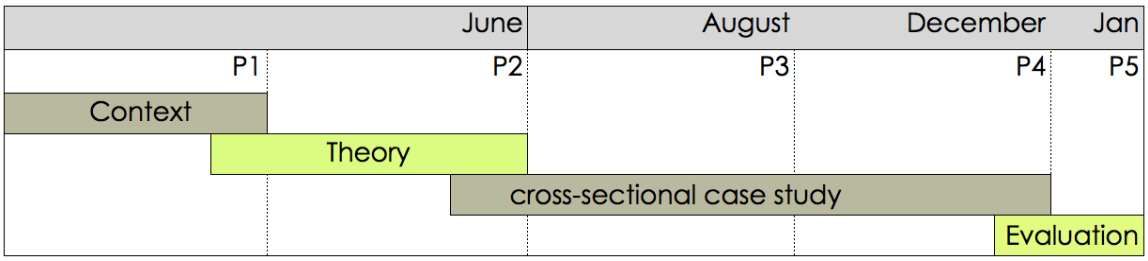


Figure 3 *Time schedule of this research proposal (own ill.)*

NOVEL ASPECTS OF THE RESEARCH APPROACH

This research is distinctive compared to other research as it reviews the use of PSS in the Dutch practice of urban development. It involves empirical research and the study not only focuses on the tool but also pays attention to the process in which the tool is applied. It reviews recent developments in PSS, like the MKP-Maptable, Urban Strategy, and Play the City. Although Urban Strategy and the MKP-Maptable already exist for some years, improvements are made continuously. Therefore, it is interesting to see if they have bridged the implementation gap between theory and their use in the practice of urban development like mentioned in the problem statement. Furthermore, the results of the comparative case study analysis are immediately applied in the urban redevelopment project of Buiksloterham in North Amsterdam.

THESIS OUTLINE

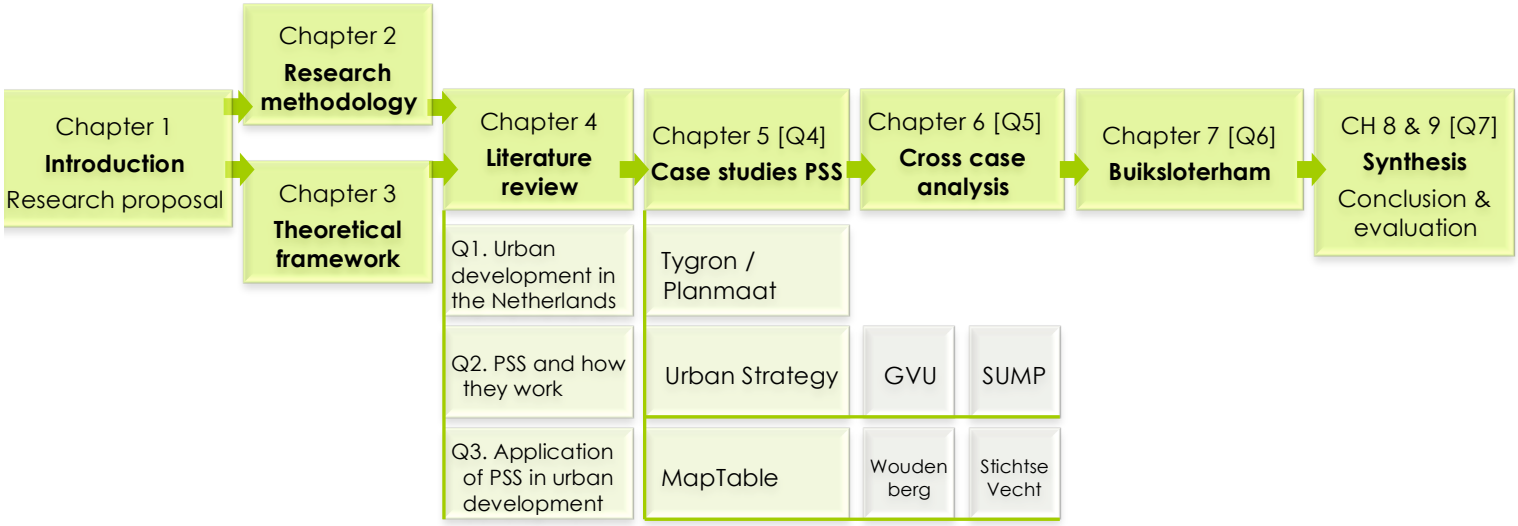


Figure 4 *Thesis outline (own ill.)*

As is shown in figure 4, this thesis consists out of nine chapters. The thesis starts with an introduction in chapter 1, the research methodology is outlined in chapter 2, and the theoretical framework is defined in chapter 3. The literature review will answer the first three research questions in chapter 4. Chapter 5 will outline the executed case studies and chapter 6 will cover the comparative case study analysis. Chapter 7 will analyse the usability of planning support systems for Buiksloterham and chapter 8 and 9 will conclude and evaluate this graduation research.

PUBLICATIONS RELATED TO THIS THESIS

Earlier research regarding PSS is contained in the studies of Lee (1973, 1994), Batty (2003), and Klosterman (1997). These studies are focused on the tool and do not consider the application context thoroughly. Later on, several books were published relating to the application of planning support systems. The works of Stan Geertman and John Stillwell (2003, 2009; Geertman et al., 2013) and Brail and Klosterman (2001), and Brail (2008) are well known. Previous research that is relevant for this thesis are the dissertations of Peter Pelzer (2015), Tessa Eikelboom (2015), Gustavo Arciniegas (2012), Marco te Brömmelstroet (2010b), and Guido Vonk (2006). These studies are further outlined in the literature review.

RESEARCH PHASES AND TECHNIQUES

RESEARCH PREPARATION PHASE

Before I could start with the execution of this research, I have written a research proposal with the problem statement, research questions, research objectives and planned outcome, research focus research relevance, research planning, and an introduction in the research topic. This research proposal is covered in chapter 1. For selecting this topic, I used inspiration lectures, my educational background, scientific articles, orientating interviews and seminars, like seminars organised by Delft Data Science and the Dies Natalis 2014 of the TU Delft.
During orientating interviews, I have spoken to a wide range of professionals and academics about their experiences in their field regarding to the use of data in urban development in The Netherlands.

PHASE 1-3 LITERATURE STUDY

Sub-questions:

1. What are the characteristics of the decision-making process in urban development in the Netherlands?
2. What are PSS and how do they work?
3. How are PSS applied in urban development?

These research questions will be answered through executing a literature review. Research question 3 has led to the evaluation framework for urban development processes in relation to the use of planning support systems, which will be used to evaluate the cases discussed in phase 4 and 5. Additionally, the evaluation framework is also incorporated in applying the findings in Buiksloterham during phase 6.

The evaluation framework for PSS

The evaluation framework is based on the adaptation framework of Willows and Connell (2003). This framework can be linked to the urban development process as described by Den Heijer (2003). Tessa Eikelboom (2015) also used the framework of Willows and Connell (2003) for the evaluation of the use of planning support systems for designing regional adaptation strategies. She relates the work of Carton (2007) and De Bruin et al. (2009) to the adaptation framework for dividing the tasks of planning support systems in six categories: analysis, validation, exploring, design, evaluation, and negotiation. Additionally, she has related the tasks to the three decision phases of the adaptation framework: assessing risk, identifying options, and appraising options.

PHASE 4 PSS CASES

Sub-question:

4. What is the role of PSS in urban development projects in the Netherlands in relation to Urban Strategy and the MKP-Maptable?

I will answer this sub-question through the execution of case studies of two PSS: The MapTable (of Mapsup), a PSS connected to a touch table, and Urban Strategy, a recently developed PSS by TNO. Unfortunately, no users of Tygron consented to contribute to this research. Therefore, this case study is executed based on semi-structured interviews with developers of Tygron and a secondary data analysis. This is further complemented by semi-structured interviews with Planmaat and Play the City.

A non-probability sampling method is applied for selecting the interviewees who were present at the PSS workshops in order to cover a diverse range of disciplines. This approach is suitable for this research as the perception framework of interviewees influences the outcomes intensively, corresponding to the soft systems methodology. Snowball sampling is used to get introduced by the relevant people for my thesis. This approach is based on purpose sampling wherebysamples are based on the relevance of people to the research (Bryman, 2012). The interviewees are selected by the researcher, whereby attention is paid to the background of each interviewee in order to make sure that a wide range of disciplines are covered in the interviewing of users.

A total of 15 users were being interviewed for the four cases, which is further supported with 8 interviews of PSS experts and developers. An overview of the interviewees is shown in appendix A. The interviews lasted 30 to 75 minutes. The interviews with the users lasted in general shorter than the interviews with the developers, as the interviews with the developers were conducted first. During these first interviews general information was gained about the cases, which saved time in the other interviews later on. The transcriptions of the interviews are attached in Appendix D for inspection by the mentors. These transcriptions are checked and approved by the interviewees. The transcriptions are transcribed verbatim and will not be published because of privacy reasons. A range of PSS users with different disciplines participated in this study. For the MapTable case studies civil servants from various domains from the two municipalities were interviewed, like a consultant Infrastructure, consultants Environment, and the municipal project leaders. Furthermore, the urban planner gave interesting insights from his perspective. In relation to the Urban Strategy cases, the project leaders of TNO were interviewed, a project manager of SUMP Tilburg, an urban designer for Healthy Urbanisation Utrecht, and a representative of Rijkswaterstaat.

The interview formats of the PSS developers and PSS users are shown in appendix B and C. These formats are based on the literature review, whereby attention is paid to the context of the cases accordingly to the soft systems approach. Semi-structured interviews were executed to gain information of the individual, personal experiences and opinions from the developers and users.

During the interviews the interviewee is motivated to share their perspectives. The interview outcomes therefore need to be interpreted in the context of the case studies. The different users and developers answered similar questions in order to compare their different perspectives upon the role of planning support systems.
While the interview format offers a guideline for the interview, the topics might be covered in a random order. The interviews tended to especially clarify the perspective of the particular interviewee in relation to his or her background. All interviews started with an introduction of the background of the interviewer and this research. Subsequently the background of the interviewee and his or her role in relation to the case study was elucidated, followed by the different topics of the interview format.

Next to semi-structured interviews of different disciplines, the cases are further supported by secondary data analysis and observation. Most data analysed were obtained from the developers of the tools. I have received a demonstration of every tool to experience the possibilities of the tool by myself.
By executing different research methods triangulation is achieved. Triangulation entails using more than one method or source of data in the study of social phenomena, resulting in greater findings as it enables crosschecking findings deriving from different research methods.

Four projects are in total analysed of Urban Strategy and the MKP-MapTable. For Urban Strategy "Gezonde Verstedelijking Utrecht" (healthy urbanisation Utrecht) and the "Smart Urban Mobility Plan Tilburg" will be researched. The two case studies of the MKP-MapTable are located in Municipality Stichtse Vecht and Municipality Woudenberg at the Province of Utrecht. The Province of Utrecht has developed a guide for sustainable urban development ('Leidraad Duurzame Ontwikkeling') to support municipalities in integral and sustainable urban development. The liveability and sustainability ambitions of the Province of Utrecht are incorporated in the Environmental Quality Profiles (EQP). The EQP are updated in 2013 and extended from 8 to 20 different liveability and sustainability indicators. The EQP are combined with the MapTable, by which stakeholders can gain insights in the environmental quality and sustainability of spatial plans in order to be able to optimise their plans subsequently. A short description of the cases studied can be found below:

Case 1: Urban Strategy: "Smart Urban Mobility Plan Tilburg"
Urban Strategy is used to create the Smart Urban Mobility Plan (SUMP) for the Dutch city Tilburg during the initiation phase for the Municipality of Tilburg, whereby the environmental impacts of different mobility scenarios are calculated.

Case 2: Urban Strategy: Healthy Urbanisation Utrecht ('Gezonde Verstedelijking Utrecht')
Healthy urbanisation ('Gezonde verstedelijking') is a research project executed by Rijkswaterstaat, by order of the ministry of Infrastructure and Environment. The research project studies the health of Dutch cities in general, and the accessibility, safety and liveability of these cities in particular. The project comprises different subprojects, including Healthy Urbanisation Utrecht. For this case study, Rijkswaterstaat, the executive government agency of the Dutch Ministry of Infrastructure and the environment, has used Urban Strategy for the redevelopment of the railway station area and trade fair area ('Jaarbeurs') of Utrecht. Urban Strategy was used during the initiation phase for gaining insights into the impacts of different urban designs upon health related indicators.

Case 3: MapTable: Province of Utrecht: Woudenberg-Oost, Municipality Woudenberg
The MKP-MapTable is used for Woudenberg-Oost, which is a greenfield development of a residential area covering approximately 875 new dwellings. The tool is used during the initiation phase for analysing the possible environmental problems and opportunities and for accordingly determining the spatial and sustainable ambitions of the project. The environmental quality performance of the first urban draft design is determined which is used for creating the Masterplan Hoevelaar.

Case 4: MapTable: Province of Utrecht: Het Kwadrant, Municipality Stichtse Vecht
Het Kwadrant is a former business park that is going to be redeveloped into a residential area.
For this case a design was already made, but it appears to be infeasible due to noise nuisance. By making use of the MKP-MapTable the stakeholders reached a consensus to limit the noise in order to enable the construction of the neighbourhood.

PHASE 5 COMPARATIVE CASE STUDY ANALYSIS

Sub-question:

5. In which cases is the application of PSS perceived as useful by its users and developers?

This question will be answered by executing a comparative case study analysis of the PSS tools and by comparing these findings to the findings from the literature review (sub-question 2). The comparative case study analysis is validated by semi-structured interviews with experts.

PHASE 6 REDEVELOPMENT BUIKSLOTERHAM

Sub-question:

6. How can the development process in Buiksloterham be characterised?

I will answer this question by analysing the development process in Buiksloterham by executing secondary data analysis, supplemented with semi-structured interviews with the stakeholders.

PHASE 7 SYNTHESIS

Sub-question:

7. How can PSS improve the development process in Buiksloterham?

The redevelopment project of Buiksloterham will be used to apply my findings of the research into a specific Dutch context of urban development.
Circular Buiksloterham is a bottom-up, organic, transformation project in Amsterdam Noord and part of the wider restructuring of the Northern IJ-Banks in Amsterdam. The industrial area of 100 ha will be translated into a mixed-use urban area with a timeline running from 2005 to 2030. This means that the project is in its initiation phase whereby decision-making plays a major role in the process. The contaminated soil and the environmental impact of residual industry together with the high sustainable ambitions increases the complexity of the project, enlarging the need for decision support tools. Additionally, the bottom-up approach of the redevelopment, through which many stakeholders are involved, increases the relevance for a PSS.

This research question will be answered by using the conclusions of research question 5 and 6. This is further validated by the observation of the Buiksloterham City Innovation Game session organised by Play the City for stakeholders of the redevelopment project Buiksloterham.

PHASE 8 CONCLUSION AND EVALUATION

Main-question:

How can planning support systems improve the decision-making process in urban development projects in the Netherlands?

The main research question will be answered by answering the sub-questions.

3. THEORETICAL FRAMEWORK

INTRODUCTION

The objects of study are planning support systems in urban development. The way these planning support systems are researched, is from an urban development management perspective. As will be explained in chapter 4, "urban development is the process of physically adapting a specific area to social- economical and spatial needs, by various stakeholders with different instruments and activities to realise an integral- functional area" (Heurkens, 2014, p. 7). In this thesis, urban development is seen as a complex task often related to ill-defined problems in a dynamic context. It requires an integral approach (Bruil et al., 2004, p. 397): ifferent spatial scales, development phases, policy domains, spatial scales and disciplines need to be aligned with each other. This alignment takes place within complex decision-making processes. According to De Leeuw (2002) system thinking provides a good basis for a problem-oriented and interdisciplinary approach, as applied in urban development. Therefore, this chapter will outline the basics of system thinking and distinguish different types of approaches, systems and subsystems.

SYSTEMS THEORY

Systems theory can be divided into two movements. The first and former movement promotes the integration and unity in sciences. This movement emerged around the World War II. Ackoff (1999) outlines that during this war scientists could not solve the complex problems they faced by applying knowledge from just one science domain. This in turn has led to the formation of interdisciplinary efforts: First in the form of operational research during the late 1930s; Later on also management sciences, decision sciences, computer sciences, information sciences, cybernetics, policy sciences, and many other disciplines were approached in an integral way. During the mid-1950s the similarities between these interdisciplines were related to the behaviour of systems. "A system is a set of two or more elements that satisfies the following three conditions: the behaviour of each element has an effect on the behaviour of the whole; .... the behaviour of the elements and their effects on the whole are interdependent; [and].... the elements of a system are so connected that independent subgroups of them cannot be formed" (Ackoff, 1999, pp. 15-16). This first movement of systems thinking is also indicated as first order cybernetics, which can be perceived as hard systems. Hard system thinking assumes that "problems can be formulated as the making of a choice between alternative means of achieving a known end" (Checkland, 1981, p. 15). Checkland (1981) explains that the success of this approach has led to many attempts to use it to solve social problems as well. However, it was not always noticed that social problems could not be defined clearly and unambiguously, resulting in disappointing results. Checkland therefore developed the soft systems methodology (SSM) for other issues than only mechanistic problems.

The soft systems methodology can be used to solve less defined problems inherent to social systems. This second movement has a strong focus on problem solving and consistency. Also,second order cybernetics assumes no unequivocal reality, it recognises actor approaches and thus to ambiguous realities. Ambiguity is a situation wherebythere is no dominant and convincing perception of the situation (De Leeuw, 2002). According to Noordegraaf (1999) actors experience (1) conflicting intentions, as they often have different interests, (2) ambiguous relationships between measures and effects, as actors interpret reality different, and (3) a lack of clarity about the systems of actors, as different actors are involved on different moments in the process and as the level of engagement of actors is changing over time. Sometimes behaviour of actors seems to be irrational. This behaviour can be justified as subjective rational behaviour by inquiring the perceptive that can be associated with this behaviour. This paradigm can also be used in a prescriptive way whereby the plans are rational in relation to its objectives (De Leeuw, 1974). Additionally, second order cybernetics is related to thinking in relationships recognising that many relations are not linear and not causal, but circular, whereby effects become causes and vice versa. This causes the complexity of these systems. Today's problem-oriented systems approach thus pays close attention to: problem orientation, thinking in relationships and processes, thinking in systems and its environment, and to the relation between perception and the observer (De Leeuw, 2002).

Checkland (1981) has clarified the distinction between hard and soft systems in table 1. The explanation of the hard system methodology is based on the work of Jenkins (1969) and the RAND corporation. The hard systems approach studies problems in a systematic way: by using technical knowledge the right answer can be found. The nature of these problems is structured, the variables are physical and the objectives are clear and fixed.

On the contrary soft systems consist of, or cannot be separated from, human actors and activities. Human behaviour is intentional and intertwined with interpretations (De Leeuw, 2002). The problem nature is therefore unstructured; the objectives are unclear and not fixed. This approach therefore starts by analysing the problem, before trying to solve it. As Checkland (1981, p. 18) outlines: "for ill-structured problems involving a number of people the very idea of 'a problem' which can be 'solved' has to be replaced by the idea of dialectical debate, by the idea of problem-solving as a continuous, never-ending process, but one which can be aided, and orchestrated, by the application of systems ideas, particularly that of a human activity system." This approach allow for completely unexpected answers to emerge at later stages, as objectives of stakeholders are not fixed and can change because of new insights. Urban development processes, with the great amount of actors involved, has to cope with the same uncertainty and unpredictability inherent to social systems. As planning support systems try to structure the decision-making process around the unstructured spatial issues, these systems should be perceived from a soft systems approach as well.

Table 1 *'Soft' and 'hard' systems methodology (Checkland, 1981, p. 190)*

Soft systems methodology	Jenkins (1969)	RAND Corporation
a Start: an urge to bring about improvement in a social system in which there is felt to be an ill-defined problem situation.	Start: an urge to solve a relatively well-defined problem which the analyst may, to a large extent, take as 'given', once a client requiring help is identified.	
b Express by examining elements of 'structure' and tern, its objectives, etc., and 'process' and their mutual its place in a hierarchy of relationship. Tentative definition of systems relevant to improving the problem situation.	Analysis by naming the system, its objectives, etc., and its place in a hierarchy of systems.	Analysis by examining the decision-makers' objectives as expressed in the stated need for the required system with a specified performance.
c Formulate root definitions of relevant systems and build conceptual models of simulation those systems.	Design the system by quantitative model building and simulation.	Identify alternative systems for meeting the defined need and compare them by modelling using the performance criteria.
d Improve the conceptual models using the formal system model and other systems thinking.	Optimise the design, using the defined (economic) performance criterion.	Select the alternative which best meets the need and is feasible
e Compare the conceptual models with 'what is' in the real situation, and use the comparison to define desirable, feasible changes in the real world.	No equivalent stage: both approaches know from the start what change is needed.	
f Implement the agreed changes.	Implement the designed system.	

The crux of the soft systems approach is that it is opposed to reductionist views, whereby sciences are reduced into a fundamental science (De Leeuw, 2002). As will be outlined in the chapter 4, urban development is an interdisciplinary science composed of different scientific domains. The whole is greater than the sum of its parts. A reductionist view tries to understand a phenomenon by analysing the different elements of that phenomenon. But the properties of systems are not reducible to the parts from which it is composed (De Leeuw, 2002). According to Ackoff (1999) as systems cannot be divided into independent parts, systems as a whole cannot be understood by analysis or reductionist approaches: "The essential properties of a system taken as a whole derive from the interactions of its parts, not their actions taken separately" (p. 16). Therefore "Synthesis, or putting things together, is the key to systems thinking" (Ackoff, 1999, p. 16). Ackoff considers synthesis complementary to analysis. "Analysis focuses on structure; it reveals how things work. Synthesis focuses on function; it reveals why things operate as they do. Therefore, analysis yields knowledge; synthesis yields understanding. The former enables us to describe; the latter to explain" (Ackoff, 1999, p. 18).

> "If each part of a system, considered separately, is made to operate as efficiently as possible, the system as a whole will not operate as effectively as possible." (Ackoff, 1999, p. 18)

A system is a set of by the observer chosen elements, which are related to each other in such a way, that no (groups of) elements are isolated from each other. A relation between two elements exists, when the elements are not able to vary independently from each other. The collection of all relationships between the objects is referred to as the internal structure. The system boundary is the by the observer made distinction between those objects that belong to the system and other objects that are related to it. There are usually also relationships with objects outside the system. These objects form the environment, or the surroundings of the system. The external structure is determined by the total amount of relationships between the system and its environment. A system that is related to its environment is called an open system.
A closed system is an isolated system that does not have relations with objects outside the system. The terms of closed and open systems are relative as these concepts are determined by the considered

relationships of the observer of the system. It is dependent on the system boundary, which is set by the observer. As urban development is a complex system that is related to many different aspects, it is not possible for this graduation thesis to mention all factors that influence the urban development process. Urban development is therefore perceived as an open system.

Also, the concept of a black box is relative. Black boxes are the lowest level of aggregation in an observation. They are the smallest subsystems whereby one does not take its details, the internal structure, into consideration. Attention is only paid to the relations of the system with its environment, whereby a distinction is made between input, throughput, and output (De Leeuw, 2002). Black boxes have benefits and drawbacks in the design process. A benefit is the freedom to design the internal structure, the details, as long as the output is the same. In other words, different designs are possible, by which the stakeholders are less restricted. A drawback is that people can have different perceptions of the internal structure of the black box. In order to come to a consensus the internal structure need to be determined, by which it is not a black box any more. De Leeuw (2002) also mentions two common objections to the concept of a black box: black box approaches are mechanistic and black boxes do not consider the key points of human behaviour. However, as De Leeuw (2002, p. 107) explains, these objections are based on misconceptions. Black boxes can be perceived as mechanistic as mathematics deal with black boxes whereby the output is only determined by the input (the internal structure is not able to make choices). However, in social sciences a stakeholder can also be perceived as a black box that is able to express free will and therefore does not correspond to mechanistic theories. The second objection is not valid, as systems cannot be explained by reductionistic approaches, but by synthesis as is mentioned previously.

Ackoff (1999) distinguishes four types of systems: deterministic, animated, social and ecological systems. The ecological system is the meta-system as it consists of the other three systems. An overview of these systems is shown in table 2. Ackoff explains that, "Although deterministic systems, including mechanisms, have no purposes of their own, they normally serve the purpose(s) of one or more entities external to them, their creators, controllers, or users. Provision of that service is their function. Although the parts of a mechanistic system do not have purposes of their own, they do have functions serving the function of the whole. Therefore, all the subsystems of a deterministic system are also deterministic systems" (Ackoff, 1999, p. 28). Deterministic systems do not have purposes of their own, as they cannot display choice. Computers appear to make choices, but they do not so as the behaviour of computers is entirely programmed by an external source. Animated systems are animals and humans. They are able to make choices and are therefore purposeful. Animated systems can form part of a social system, like people can be part of corporations, universities, societies, and like animals can be part of herds. Deterministic systems can be a subsystem of social systems as well, for example, when a person controls a computer. Also social systems can be the subsystems of larger social systems, like societies form part of a nation. "Ecological systems contain interacting mechanistic, organismic, and social systems, but unlike social systems have no purpose of their own. However, they serve the purposes of the organisms and social systems that are their parts, and provide necessary inputs to the survival of the non-animate biological systems (plants) that it contains. Such service and support is their function. Although the function of an ecological system is to serve its parts, many people assume the existence of a deity whose purposes the universal ecological system is believed to serve." (Ackoff, 1999, p. 33)

Table 2 *Different types of systems (based on Ackoff, 1999, p. 18)*

Systems and models	Parts	Whole	Example
Deterministic systems	Not purposeful	Not purposeful	Computers, mechanisms
Animated systems	Not purposeful	purposeful	Animals, humans
Social systems	purposeful	purposeful	Corporations, universities, societies
Ecological systems	purposeful	Not purposeful	The universe

Additionally, to Ackoff, Checkland (1981)distinguishes five types of systems: transcendental systems, natural systems, designed physical systems, designed abstract systems and human activity systems: Natural systems have their origin in the origin of the universe and the processes of evolution; designed physical systems are designed as a result of some human purpose; designed abstract systems are the ordered conscious product of the human mind (like mathematics or poems); human activity systems are the innumerable sets of human activities more or less consciously ordered in wholes as a result of some underlying purpose or mission; Transcendental systems are beyond knowledge and beyond natural, designed physical, designed abstract, and human activity systems (Checkland, 1981, pp. 110-111). These systems do have some overlap with the distinction of Ackoff. However, where Ackoff bases his distinction on its purpose, Checkland bases his distinction on the origin of the systems.
For this thesis, the distinction of Ackoff is used as he distinguishes humans in animated systems from social systems, while Checkland considers humans as part of human activity systems, and social systems as

part of the natural system. In order to explain urban development processes it is useful to make a distinction between the person and the social system to which he or she belongs. However, as Checkland (1981, p. 122) argues: "The case of what in everyday language are called 'social systems' shows that real-world entities may well not fit easily into one class; in particular it may not be easy to obtain descriptions upon which all observers agree."

As illustrated in figure 5 and 6, a distinction can also be made between systems and subsystems. De Leeuw (2002) distinguishes three types of subsystems: an aspect system, phase system and component system. A combination of different types of subsystems is also possible. The focus differs per type of subsystem.

- A component system considers only a part of the total system, although it does consider all relationships within that part;
- An aspect system pays attention to the total collection of elements, but is limited to only a part of the existing relationships;
- And a phase system considers the system on a portion of the time points on which the original system is defined (De Leeuw, 2002, p. 103).

According to De Leeuw (2002, p. 105) a smart division of a system exist in subsystems whereby the internal structure of these subsystems is stronger, than the relationships between the subsystems. Such a division is indicated as a decomposition.

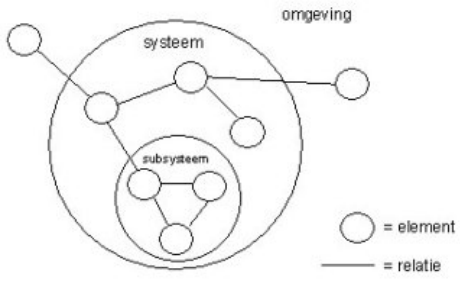


Figure 5 *Environment, system, subsystem, elements and relationships (Eenblogjeom, 2013)*

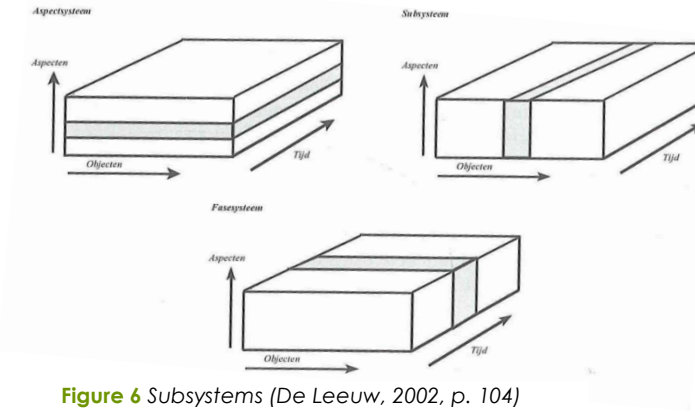


Figure 6 *Subsystems (De Leeuw, 2002, p. 104)*

DESIGN THINKING AND DECISION-MAKING

Designing a plan can be seen as a form of decision-making in order to shape an area. Roozenburg and Eekels (1991) thereby distinguish four types of reasoning: deduction, induction, abduction, and design reasoning. The last three approaches of reasoning are indicated as reductive reasoning. By reasoning we derive a conclusion with one or more given statements (the premises). Urban development reasoning can be seen as a form of design reasoning from objectives for a geographic area to a specific plan for that area. It is a reasoning approach whereby very little is given and much is demanded (Roozenburg & Eekels, 1991).

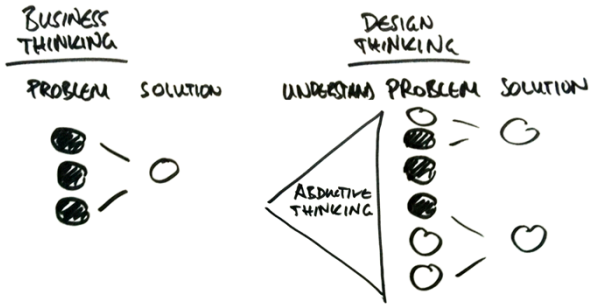


Figure 7 *Business thinking versus design thinking (DTHSG, 2015)*

Whereas business thinking is based on linear thinking according to the hard system methodology whereby a problem leads to one solution, design thinking is an open process that enables many suitable solutions for one spatial issue: there is no algorithm that will lead you to one solution. This is illustrated in figure 7. The problems can be interpreted through various explanations in accordance with the soft system methodology. Therefore design is an open-ended and ill-structured process (Dym et al., 2014) whereby creativity is needed to come to a solution.

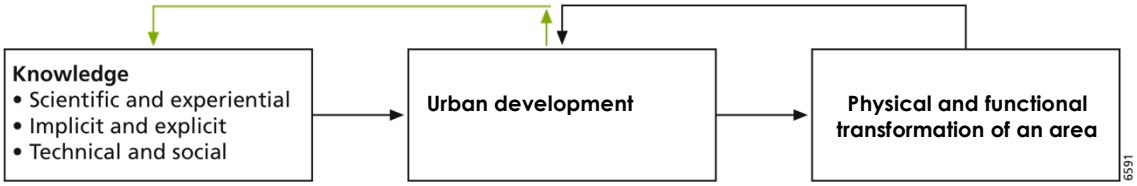


Figure 8 *urban development, connecting knowledge to actions (adapted from Vonk, 2006, p. 13)*

Vonk (2006, p. 13) illustrates the process of planning as an on-going process, connecting various kinds of knowledge to actions in the public domain. These actions influence the planning process. This illustration can be modified by stating that actions in the public domain and the urban development process also generate new knowledge by the involved actors. Furthermore, urban development not only covers actions in the public domain, but also in the private domain as outlined in chapter 3. This is shown in figure 8.

Knowledge of actors in urban development consists of scientific and experiential knowledge, implicit and explicit knowledge, technical knowledge and social knowledge, owned by a range of societal actors (Dammers et al., 1999). According to De Leeuw (2002) there is knowledge in order to understand and knowledge in order to intervene. Knowledge to understand exists of explanations of urban processes. Knowledge to intervene is a mean to improve and change urban areas. Knowledge related to urban development is problem-oriented as knowledge for a specific spatial problem is accumulated. Knowledge is relevant when it covers the practical spatial issue, when it is understandable respectively processable, and when it is available in time (De Leeuw, 2002, p. 79).

"An ounce of information is worth a pound of data.
An ounce of knowledge is worth a pound of information.
An ounce of understanding is worth a pound of knowledge."
(Ackoff, 1999, p. 170)

Data is raw unprocessed material in the form of facts and figures. Data is therefore a resource. PSS are based on data that is processed in order to provide information to support the decision-making process. Information is data that is presented in a meaningful way, whereby different data is related to each other in its context. The application of information will result in knowledge, which enables the stakeholders to understand the situation.

As mentioned before, the soft systems approach stimulates learning between stakeholders as it enriches the planning process, as it will create new insights amongst the stakeholders. New insights, feedback on the plan, will determine the next steps in the design process. This is also the reason why the objectives of stakeholders are not fixed during the planning and decision-making. Learning therefore causes the iterative character of the design process as is shown in the design development cycle in figure 9.

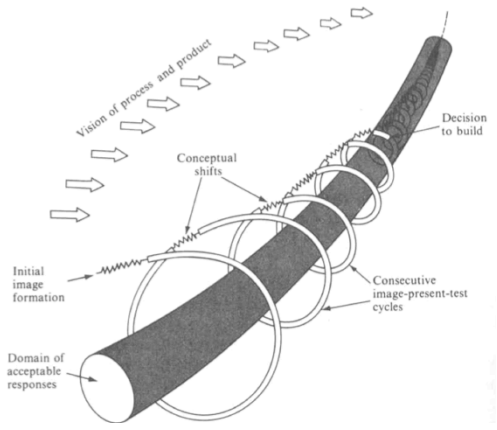


Figure 9 *Design development cycle (Zeisel, 2006, p. 30)*

The design process consists out of divergent and convergent processes. During the divergent phase choices are created, whereas during the convergent phase choices are made. The divergent phase enables team members to think diverse from their specific background. It promotes an open discussion between different disciplines.
The transition between the divergent and convergent phase is a difficult process. This is why Sam Kaner (2007) has called this the groan zone, see also figure 10. As Sam Kaner explains (2007, p. 18)
"Once a group crosses the line from airing familiar opinions to exploring diverse perspectives, group members have to struggle in order to integrate new and different ways of thinking with their own."

Figure 10 *Dynamics of group decision-making (Kaner et al., 2007)*

Defined milestones structure the process over a project timeline. By sorting ideas into categories, and evaluating alternatives stakeholders can reach a consensus. This divergent-convergent cycle will be repeated several times in one decision-making process and results in a decision, which will be the input for the next divergent-convergent cycle.

Decision theory deals with defining strategies for making rational decisions. Sven Ove Hansson (2005) gives an overview of different decision-making models. He highlights that *"decision theory is concerned with goal-directed behaviour in the presence of options"* (Hansson, 2005, p. 6).

Ackoff (1978, p. 12) outlines that "choice exists only (1) when there are at least two possible courses of action available to the decision maker, (2) where there are at least two possible outcomes of unequal value to him, and (3) where the different courses of action have different effectiveness. In other words, choice exists when the action of the decision maker makes a difference in the value of the outcome." Therefore *"not every choice situation is a problem situation, but every problem involves a choice. A problem arises when the decision maker has some doubt about the relative effectiveness of the alternative courses of action.* The solution process is directed at dispelling doubt."

As problems are related to the perception of the person of the situation, problems are subjective. A problem for someone might not be considered as a problem for someone else. This is also why there are sometimes different protest groups against urban development plans, focusing on different aspects of the plan. Most decisions take time and can therefore be divided into phases.

In the first stage, one "discusses the principles that will serve as the basis for decision in a general issue; one examines the various aspects of this issue and the consequences of different ways to make the decision." At this stage, the opinions are personal, and no attempts are made to form a majority. After this follows a second discussion in which "the question is clarified, opinions approach and combine with each other to a small number of more general opinions." In this way the decision is reduced to a choice between a manageable set of alternatives. The third stage consists of the actual choice between these alternatives.
(Condorcet, [1793] 1847, pp. 342-343; in Hansson, 2005, p.9)

Decision-making models

The philosopher Condorcet gives an early example of dividing the decision-making process in three phases for setting up the French constitution of 1793 as is outlined in the textbox. This phasing can be compared to the well-known decision making model of Simon (1960) comprising an intelligence phase, design phase and choice phase as is shown in figure 11. The intelligence phase consists of finding, identifying, and formulating the problem or situation that calls for a decision. Than the design phase consist of determining the objectives for the decision we are to make and the development of alternatives / solutions for the problem mentioned in the intelligence phase.
Subsequently in the choice phase the alternatives are evaluated and a choice will be made between them. Extensions of the model consider the implementation phase of the decision and the review phase, wherein the decision will be evaluated.

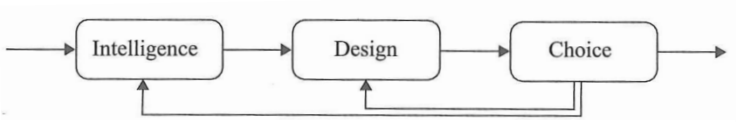


Figure 11 *Decision-making model of Simon (1960)*

The decision model of Simon is based on Dewey's list of five stages to make it suitable for the context of decisions in organisations. John Dewey's list models five stages of problem-solving ([1910] 1978, pp. 234-241):

(1) a felt difficulty;
(2) the definition of the character of that difficulty;
(3) suggestion of possible solutions;
(4) evaluation of the suggestion, and
(5) further observation and experiment leading to acceptance or rejection of the suggestion.

Brim et al. (1962, p. 9) is known for another subdivision of the decision process:

(1) identification of the problem;
(2) obtaining necessary information;
(3) production of possible solutions;
(4) evaluation of such solutions;
(5) selection of a strategy for performance.

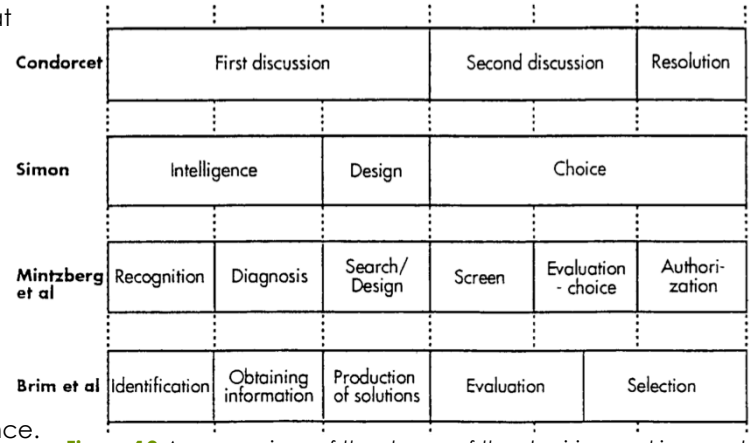


Figure 12 *A comparison of the stages of the decision-making models of Condorcet, Simon, Mintzberg et al and Brim et al. (Hansson, 2005, p. 92)*

These decision models with its linear approach, whereby phases always come in the same order, are indicated as sequential models (Hansson, 2005, p. 10). Non-sequential models were developed after criticism of several authors.

After conducting empirical research, Witte says for instance the following:

> *"We believe that human beings cannot gather information without in some way simultaneously developing alternatives. They cannot avoid evaluating these alternatives immediately, and in doing this they are forced to a decision. This is a package of operations and the succession of these packages over time constitutes the total decision- making process."* (Witte et al., 1972, p. 180)

An example of a non-sequential decision making model is proposed by Mintzberg, Raisinghani, and Théorêt (1976). In this model the three phases of Simon are translated into identification, development and selection in a cyclic and iterative way.
Hansson (2005, p. 92) has made a comparison of these decision-making models as is shown in figure 12.

Tessa Eikelboom (2015) made use of the adaptation framework of Willows and Cornell (2003) in order to evaluate the use of planning support systems for designing regional adaptation strategies. This model, as presented on page 37 can be conceived as a non-sequential decision-making model. This framework is suitable for environmental planning, but also for urban development in general. Related to urban development identifying options can be interpreted as designing alternatives.
This model will be further used in this thesis as it suits the circular and iterative urban development process. It contains feedback and iteration to refine the problem, objectives, decision-making criteria and the design of alternatives or development strategies. This is further outlined in the evaluation framework at the end of chapter 4.

Reaching a consensus

The spatial problem is an undesired difference between the existing and aspired physical environment. It is the reason to pursue improvement or renewal. However, if there are more decision makers, one cannot assume that they agree with each other. Problems arise because judgments (normative statements) are spoken about aspects of reality. It is therefore essential that the role of these objectives is clear. The key is to reveal to whom are the objectives related and what do they imply in order to make these objectives explicit (De Leeuw, 2002).
Also Ackoff (1979, p. 12) mentions that "a decision maker tries to select a course of action that produces an outcome he desires, one that is efficient relative to what he values". In that way the effectiveness of a plan can be related to the group objectives, but also to the personal objectives of the actors. This also corresponds with second order cybernetics.

In theory and practice there are many ideas to deal with this issue, like voting, coalition building, methods to reach consensus by discussing or by using multi-criteria decision-making techniques, power relations (both formal and informal) whereby some people impose their ideas on others, parliamentary democracy, negotiations and so on.

Voting procedures assume that preferences of people do not change during the decision-making process, while consensus mechanisms are focused on changing preferences. People try to agree with each other by exchanging views, considering each other's preferences and through discussions. It is therefore important that one takes time to come to a decision, is willing to listen to each other, and has respect to each other's needs. The concept of democracy is in this way not defined by a formal procedure, but by the attitude of group members and an effective group process.
Key points are that one respects their opponents during the conversations and that people do not use means of power. The great advantage of reaching a consensus is that the decision is supported by everyone, resulting in a greater commitment to implement the decision. A drawback of this decision-making method is that it might take a long time to make a decision, especially when there are profound differences in opinions. Additionally, dedication of participants and expertise of the process manager is needed to accomplish the decision making process successfully. Yet it is not always possible to conduct open and democratic discussions, as people are abusing their powers, withhold information, or deceive others (De Leeuw, 2002).

Multi-criteria decision-making (MCDM)
Multi-criteria decision-making (MCDM) techniques can be used to support the decision making process for reaching a consensus. Multi-criteria decision-making considers different alternatives based on different criteria. As Gonzalez et al. (2013, p. 111) explains:
"Multi-criteria assessments constitute both a framework for structuring decision problems which encompass multiple decision criteria and alternatives, and a set of methods to generate/elicit and aggregate preferences regarding previously established objectives and performance of evaluated alternatives. Multi-criteria assessment techniques are widely used in impact assessment… They help planners and decision-makers learn about the decision problem and explore the alternatives available as well as the decision outcome by helping elicit value judgments about trade-offs between conflicting objectives and, ultimately, facilitating the selection of best alternatives."

Important aspects multi-criteria assessments are the criteria (indicators) or integrity constraints and the weighting method. Criteria are "a means or standard of judging" (The Chambers Dictionary).
More specifically it is "a particular perspective according to which decision alternatives may be compared, usually representing a particular interest, concern or point of view" (Belton & Stewart, 2002, p. 352). They determine how the different design alternatives are tested against the objectives of the project. There are different kinds of MCDM techniques, determining the way indicators are ordered and weighted. Well-known techniques are the analytical hierarchical process (AHP), the ordered weighted average (OWA) and the weighted linear combination (WLC), also known as simple additive weighting (SAW). PROMETHEE and ELECTRE are examples of outranking methods. MCDM is therefore an umbrella term for a range of methods considering multiple criteria to explore different decisions. MCDM integrates objective measurement with value judgement and makes subjectivity explicit (Belton & Stewart, 2002). As Belton and Stewart (2002) outline, this does not mean that multi-criteria decision analysis (MCDA) will give the 'right' answer, relieve decision makers of the responsibility of making difficult judgements, or that MCDA will take the pain out of decision-making.
"Subjectivity is inherent in all decision-making, in particular in the choice of criteria on which to base the decision, and the relative "weight" given to those criteria" (Belton & Stewart, 2002, p. 3).

There are different ways of solving spatial issues through MCDM: by optimisation and by satisfaction. According to Ackoff (1979) a problem is solved through optimisation when the decision makers select those values of the controlled variables that maximise the value of the outcome. In contrast to solving problems through satisficing, whereby values of the controlled variables are selected by decision makers that do not maximise the value of the outcome but produce an outcome that is good enough. A third possibility is to dissolve the problem, by changing the values so that the available alternatives are no longer relevant.
Problem solving through satisficing is related to a sequential process, while problem solving through optimisation is related to an integral non-sequential process. A sequential decision making process is also related to a sequential spatial design process as mentioned before.

An integral design process is an approach to problem solving through a non-sequential process and it demonstrates when the total of all objectives is not achievable. Multi-criteria analysis is a method to support integral design processes. A feasible region is the set of points (solutions) that simultaneously satisfy all the constraints as illustrated in figure 13. This space is also indicated as the 'design space' (Dym et al., 2014) or the 'solution space' (Van Gunsteren & Van Loon, 2000). The constraints are "strict limits that a design must meet in order to be acceptable" (Dym et al., 2014, p. 7). Constraints are determined by the objectives of the stakeholders. "Objectives, or design goals, are the desired attributes of the design, what the design will "be" and what qualities it will have" (Dym et al., 2014, p. 7). In contrast to constraints, objectives may (partially) not be achieved. There are infinitely many feasible points (solutions), unless the feasible region is empty. This is referred as an infeasible case. In order to provide a solution for this case, the constraints need to be adapted. A benefit of an integral approach is that it reveals when the design assignment is not feasible and therefore it prevents wasting time drawing infeasible plans. Additionally, it creates insight into the possible solution framework; it stimulates thinking in objectives and constraints instead of solutions; and it support setting up a feasible programme of requirements. A drawback is that not all objectives are quantifiable or cannot be easily measured. This type of objectives and constraints could not be incorporated in a multi-criteria analysis approach, like used in linear programming methods.

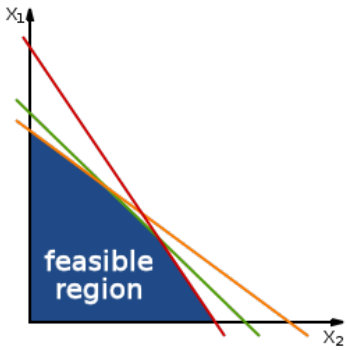


Figure 13 *Feasible solution space (Wikipedia, 2016)*

CONCLUSION

Systems theory distinguishes two approaches: the hard system methodology and the soft system methodology. The hard system approach is suitable for structured problems with clear objectives that are fixed and physical variables. The soft systems methodology can be used to solve less defined problems inherent to social systems (Checkland, 1981).

Urban development is based on a soft systems approach, whereby design thinking and decision-making play an important role. Design thinking can be perceived as a way of decision-making, whereby experiential learning and creativity plays an important role. New insights, feedback on the plan, will determine the next steps in the design process. These feedback loops cause the iterative and circular character of the design process. Furthermore, the objectives of stakeholders might change during the design process because of new insights. This is indicated by Argyris and Schön (1974) as double-loop learning. Important aspects of design thinking are, next to the iterative learning process, the human-centred approach and the diverging and converging phases within the process.

4. LITERATURE REVIEW

INTRODUCTION

In the literature review, we investigate what is already known about urban development processes and planning support systems(PSS). This literature review gives an answer on the following research questions:

1. What are the characteristics of the decision-making process in urban development in the Netherlands?
2. What are PSS and how do they work?
    a. What kind of functions are included in PSS?
    b. What are benefits of PSS?
    c. What are constraints of PSS?
3. How are PSS applied in urban development?

Each section will answer a research sub-question. The chapter will conclude with an evaluation framework for comparing different planning support systems in relation to different types of urban development processes.

THE DECISION MAKING PROCESS IN URBAN DEVELOPMENT

1. What are the characteristics of the decision-making process in urban development in the Netherlands?

A HISTORICAL BACKGROUND IN URBAN DEVELOPMENT IN THE NETHERLANDS

Urban planning has its origin during the 12th century when water management urged the need for rules for the use and management of space in The Netherlands. Later on, the establishment law of 1874 ('Vestingswet') organised the rules for living within and outside a fortified town in order to improve the defensibility of the city (Van Gameren, 2011).

Since the industrial revolution, urban planning became widely applied to improve the bad living conditions of overcrowded urban slums by setting up building rules, zoning plans and housing schemes (Hall, 2002). In the Netherlands, this led to the Housing Act of 1901 (Van Gameren, 2011).

After the Second World War, planning became a significant political activity. Planning acts and strategic plans were developed, while new sub planning fields, like traffic planning, emerged. The Spatial Planning Act of 1961 ('Wet ruimtelijke ordening') turned spatial planning into a governmental task. The way in which the scarcity of land was used, was democratically determined (Van Gameren, 2011). Planning was then conducted as a rational activity, carried out by specialised planners (Brail & Klosterman, 2001). According to Brail and Klosterman (2001) and Geertman (2006) the oversimplified way in which planners were trying to realise the desired future, not taking the wider social, economic, environmental aspects into account, caused many plans to fail to meet their objectives, eliciting criticism regarding the way planning was done. Especially the large-scale demolition plans for traffic infrastructures in many Dutch cities during the 60s and 70s have caused an opposition against the top-down approach (Van Gameren, 2011).

Since the 70s and 80s, a new approach emerged with a focus on the process of planning (Meyer et al., 2014). Since the reports of the Club of Rome showed the limits of growth, environmental aspects gradually became integrated in the development process. Next to engineers and planners, also sociologists, economists and ecologists were involved in the planning process. In the meanwhile, society changed rapidly because of, inter alia, the baby boomers. It became apparent that society could not be shaped by government actions alone (Meyer et al., 2014).

Another shift that is noticeable since the 70s is the decrease of industries, especially in industries related to shipbuilding and textile, followed by the automotive industry and aircraft industry. Particularly the service sector became an increasingly important sector in our economy.

During the 1990s, emphasis was placed on plan implementation. Vonk (2006, p. 16) mentioned that, "over the course of years, an autocratic style had gradually slipped into planning… This causes planning to be very ineffective and inefficient." Increased public participation was seen as an answer for incorporating local information and knowledge crucial for the planning process. The mutual adjustment, negotiation and accommodation between involved parties were known as governance, leading to public-private partnerships (Franzen et al., 2011).

During this decade, the domain of urban development emerged, characterised by the integral way of working of the different stakeholders and disciplines. Whereas urban development was previously characterised by the paradigm of planning by permission of governments, from the 90s onwards private parties became increasingly equivalent to municipalities caused by a neoliberal political movement. As municipalities were interested in private capital to finance spatial development, market and government became more interdependent. They needed each other to realise the ambitions for an area and therefore the new paradigm of development planning arose (Heurkens, 2014).

At the beginning of the 21st century, attention is also paid to the growing share of the creative economy and knowledge economy (Meyer et al., 2014). In contrast to the modernistic planning approach, whereby different functions were separated, the post-industrial planning approach acknowledges the necessity of mixed use. This has several reasons according to Meyer et al. (2014): the creative class and knowledge economy benefit from multi-functional areas; mixed use offers opportunities for intensive use as the same space can be used in different ways; and mixed use creates more sustainable plans.

Recent developments in the Netherlands are related to urbanisation, stabilising population growth, the rise of information and communication technologies and a shift in working due to the financial crisis. After years of population growth, the Netherlands has become a highly dense country. However, the population growth is declining and is expected to stabilise around 2030 (UN, 2014a). While rural areas are coping with shrinkage of population, the scarcity of land in and around cities will increase further through the on-going urbanisation. Cities need to adapt to accommodate this growth by creating more facilities, greater infrastructure and to redevelop real estate using the available space efficiently. Therefore urban projects are mainly brown-field or transformation projects within the urban fringe instead of green field developments. These kinds of transformations are more complex in nature in comparison to the expansion of urban areas on agricultural land.

Furthermore, the rise of information and communication technologies (ICTs) has influenced the urban development sector. People and companies are less tied to their physical location as they can connect to anybody, anywhere and anytime because of these technologies and coincided globalisation. This caused an increased competitiveness between cities and a different approach to using space (Van Timmeren et al., 2015).

Additionally, the area development and the building industry have experienced a great shift in working because of the economic crisis of 2008. Limited budgets and increased awareness of risk correlated with urban development projects induce profound cost-benefit analyses. The consequences of the financial crisis, together with a societal trend towards limited government influence and the empowerment of private parties and civil society, also caused a shift in governmental frameworks to an organic area development approach. Governmental parties facilitate the urban development, while private parties and civil society increasingly take initiatives (Heurkens, 2012). Development projects are typically smaller, and are realised in more phases, than before the financial crisis.

CHARACTERISTICS OF CURRENT URBAN DEVELOPMENT PRACTICES

This history urban development illustrates that it is practiced in a dynamic context, which influences the way we perceive urban development approaches. As Vonk mentions (2006, p. 16), *"planning is involved in a continuous search for an identity suitable for handling the complexity and dynamics of society."*

Spatial, economic-financial, juridical and institutional aspects need to be combined into one approach for transforming an area. As urban development is a complex process with many different aspects, there is not one definition to delineate this area of expertise. According to Bruil et al., (2004, p. 396), urban development is the physical and functional transformation of an area.

Heurkens (2014, p. 7) combines different definitions of area development by stating that *"area development is the process of physically adapting a specific area to social-economical and spatial needs, by various stakeholders with different instruments and activities to realise an integral-functional area."*

In this thesis, the definition of Heurkens is adopted as it covers the major aspects of area development: the process takes place within a geographical area, it is an attempt to adapt the location to socio-economic and spatial needs, different stakeholders are involved and it covers an integral and multifunctional issue.

The diagram of Jan van 't Verlaat (2008) summarises the urban development process as is shown in figure 14. The conceptualisation of a problem, as defined by Ackoff (1979, pp. 11-12), can be linked to this diagram. Ackoff divides a problem into five types of components:
(1) The one(s) faced with the problem coincide with the actors of the urban development process;
(2) Those aspects of the problem situation that the decision maker can control, the controllable variables, correspond to the content of the urban development process;
(3) The uncontrolled variables are those aspects of the problem situation that the decision maker cannot control, but which, together with the controlled variables, can affect the outcome of his choice. These uncontrolled variables can be interpreted as the context of the development process;
(4) Constraints imposed from within or without the development process on the possible values of the controlled and uncontrolled variables, correspond to the means for realisation; And
(5) The possible outcomes produced jointly by the decision makers' choice and the uncontrolled variables are the outcome of the urban development process. As I perceive it, this outcome is also produced by the means and content of the development process.

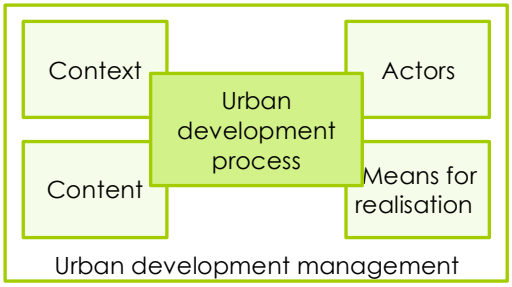


Figure 14 *Schematic overview urban development (adapted from Van 't Verlaat, 2008)*

Whereas urban planning is primarily executed by urban planners, also called urban designers, urban development is not executed by a specific discipline. It "involves a multitude of public and private activities and disciplines needed for planning and development of an area (Franzen et al., 2011, p. 10)." Therefore, urban development cannot be positioned from a scientific point of view as a fundamental science. The field of urban development connects and is composed of different scientific domains such as sociology, economics, geography, management sciences, public administration, real estate development and management, planning and law, and architecture and urbanism (Heurkens, 2014). It can be seen as an interdisciplinary science which is related to the aforementioned domains, but which has its own characteristic perspective and distinctive identity.

Spatial planning differs from urban development as spatial planning is rooted in social sciences, thereby often adopting a governmental point of view. It studies the geographic, policy and urban planning related aspects of spatial development and less the economic and managerial aspects like in the urban development domain. However, just as urban development is evolving, spatial planning is evolving as well, by which they are recently paying more attention to governance and management issues. Nevertheless, economic aspects, real estate management and market dynamics often oppose the sociological basis of planning and therefore they are of less interest in spatial planning compared to urban development.

Next to spatial planning, urban development also differs to real estate development.
Real estate development is often sector specific: studying dwellings, offices, retail, hospitality properties or accommodation of public functions. In case more functions are developed into one property or different types of properties are developed, the development is designated as mixed-use development.
Furthermore, real estate development has often a private perspective; the development scale creates a greater focus on the role of the end-users and client, and on the financial result of the development.

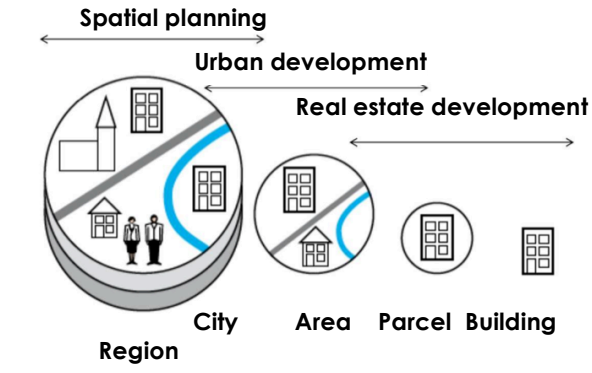


Figure 15 *Level of scale of urban development (Heurkens, 2014, p. 4)*

Although urban development differs from spatial planning and real estate development, these domains are closely related to each other as illustrated in figure 15. The level of scale of urban development determines the multi-functionality of the assignment. According to Daamen (2005, p. 11) urban development has a distinctive position between the national, regional, urban and the local level, as this level connects the buildings on the parcels to the public space and different infrastructures of the city in order to realise a well-functioning area.

Next to the scale, also the timeframe of the urban development influences the way we perceive urban development approaches. Problems in our direct living environment can be often specifically indicated and solved in a time span of a few months up to a few years. Development plans for a whole neighbourhood or region take years or even decades.
Strategic choices and interventions are made to respond to anticipated developments in the long term at these higher levels. This involves measures to maintain the vitality of the whole city and region. The relationship between these various types of land development in scale and time also means that multiple players are involved with different views and interests to adapt the environment. An approach is therefore needed that connects the top-down approach - from a strategic perspective, a larger scale and a longer-term horizon - with a bottom-up approach - focused on achieving concrete results on the short term and on a smaller scale (Van Gameren, 2011).

There are different approaches to urban development. Areas can be transformed in a systematic project-oriented way and in a more organic process oriented way. In case of project-oriented developments fixed plans are made for a fixed desired final situation, while more organic process oriented developments leave room for changing the plan while developing by which decision-makers are able to respond on a changing context (Van Gameren, 2011). These are two extreme approaches to urban development, and many methods exist in between. Faludi and De Ruiter (1978) for instance distinguishes a third approach, the strategic choice approach, which reconciles previous methods, by taking into account that some things need to be predetermined to realise and ensure consistency, but no more things should be determined than is necessary at the time.

Sometimes large-scale projects are realised at once, but recently especially small-scale gradual developments in phases are taking place. By executing the last approach developers are bearing less risk. They only start the construction phase when enough buildings of the plan are sold.

As it is not possible that different plans with different scales, timeframes and from various domains are developed simultaneous or sequential, there is a permanent catch-up and joint situation between different plans. This causes many intermediate anticipation and coordination activities between different (parts of) governments and civil society groups. In the Netherlands, this way reaching a consensus, whereby stakeholders are working together and making concessions, is indicated as the ‘polder model’.

The decision-making culture can differ between an integral decision-making process and a sequential process. For example, in a sequential design process the infrastructure is designed firstly, subsequently the green and public spaces, then the buildings, thereafter the parking places and finally the water structure. In this order it appears that there was too little space for water storage in the plan. Therefore, a new design round will be started with increasing the space for water, than green and public spaces, the infrastructure, the buildings and finally the parking places. After the second design round, it appears that there was too little space for parking. Subsequently the plan appears to be financially infeasible, and so on. The design process will end when a plan is made that is acceptable to all stakeholders. Therefore, this sequential design process is an approach to problem solving by satisfaction. Many planning support systems are based on this approach to creating an urban plan. It is a heuristic method based on trial and error. Characteristics of this approach are that it quickly achieves the first results; preconditions are explored while designing; and the turnaround time depends on the complexity of the spatial problem. However, one does not gain insight into if the best possible solution has been found and whether a feasible plan can be made.

An integral design process is an approach to problem solving through a non-sequential process, as also explained in the theoretical framework on page 21. It promotes a transparent and verifiable process, equal contribution of every team member, and it demonstrates when the total of all objectives is not achievable. An integral design process is therefore usually an open design process. A sequential process is generally a closed design process, as the design and decision-making process remains, at least to the interested outsiders, largely a black box in this traditional approach.

Van Gunsteren and Van Loon (2000) point out that by executing the classical approach only a limited group of experts is consulted; therefore, this type of design process is indicated as expert design. In general, this limited group of experts does not reflect the wishes of all stakeholders, causing dissatisfaction of these stakeholders. Additionally, Van Gunsteren and Van Loon (2000) mention that the perception of being excluded reduces the acceptance of the expert design by these stakeholders. The emergence of process managers should prevent this dissatisfaction by making sure that all interests are incorporated into the plan as well as possible. However, as stakeholders need to achieve a compromise,

"this approach brings along that a series of sub-optimum design decisions leads to a total sub-optimum design in which, again, a lot of wishes are not fulfilled (Van Gunsteren & Van Loon, 2000, p. 10)."

This is in contrast to an open design process, whereby any stakeholder having an interest in the outcome of the design process is allowed to influence the design (Van Gunsteren & Van Loon, 2000). The distinction between open and closed design process is also made by Argyris and Schön (1996). They indicate the closed design process as Model I, which is focused on achieving one's own objectives as opposed to the open design process as Model II, which is focused on open-minded, non-manipulative behaviour. An open design process will only work out, when all stakeholders agreed upon executing such process and are willing to commit them to it (Van Gunsteren & Van Loon, 2000). This is not taken for granted, as not every stakeholder benefits a transparent and open design process and an optimal plan. Because an open design process limits the possibility to manipulate data and the negotiation space for different stakeholders to reach consensus. Some stakeholders, for instance, prefer to use their powers or persuasiveness to come to an agreement. Van Gunsteren and Van Loon (2000, p. 22) explain that manipulation in whatever form is counterproductive in open design: "If the manager [or a stakeholder] tries to manipulate outcomes towards his own preferences or those of his constituencies, he or she will lose respect from other players involved and the whole process may come to halt."

In order to adapt urban areas private, public and societal interests need to be aligned. The multi-stakeholder approach is also necessary to cover the high investments related to urban development projects. Different stakeholders have different positions, objectives, means, and are active in different timeframes (Van Gameren, 2011). As Franzen et al. (2011, p. 11) state: *"The expertise, means and instruments of all the parties concerned (with their diverse interests, values, visions and specialist knowledge) should be employed in combination (for a certain duration) in order to reach a common goal."*
The means for realisation can be different types of capital like money, land and real estate, but also policies, legislation, knowledge, skills and power. Power is the ability to convince another to do things that another otherwise would not do (De Leeuw, 2002). Exercising power is accompanied by the use of power resources. Which may include: (physical) coercion, reward, persuasion and knowledge, but also: position, scarce resources, information, uncertainty, regulation and access to powerful people (De Leeuw, 2002).

According to Van Gameren (2011), delays in the planning processes are often caused by its political nature, the complex regulations, the dynamic context, and objection procedures. The different stakeholders, with different interests who need to agree with each other or whereby decisions need to be taken by at least a majority of stakeholders, particularly determine the political nature of the development process. Furthermore, the dynamic context causes the process to be vulnerable to errors (Van Gameren, 2011).

Involvement of citizens is essential in order to create public support, whereby their use of potential obstructive powers is attempted to be prevented. Public support helps in convincing the city council, and is therefore an important prerequisite for success. Without a majority in the city council, no positive decision can be made about a proposal, plan or project. Communication between the involved actors and stakeholders aims to create and maintain the public support for a plan (Van Gameren, 2011).

According to Van Gameren (2011, p. 51) involvement of citizens and private parties have next to creating public support many more benefits: (1) Initiatives of citizens and private parties often include private investment. This enables the municipality to have a facilitating role, as a partner, instead of having a proactive role by which they can limit their financial contributions and risk; (2) also by involving the civic society and private parties the independence of citizens is encouraged by which the workload of the government is also decreased. Many ideas from citizens and entrepreneurs can be facilitated on the scale of a street or neighbourhood, whereby no policy frameworks are needed, and; (3) engagement of the civil society contributes to the quality of the plan. These citizens have valuable local knowledge that can be used to enrich the plans. Besides, initiatives that do not fit the current policies can be seen as feedback on these policies.

The engagement of those directly involved by the plans differs per situation. These dissimilarities per situation can be caused by: (i) differences in local regulations on public consultation; (ii) differences in the way key stakeholders and involved actors agree with each other, or arrange the participation with each other; or (iii) by differences in the working culture of stakeholders. The direct involved actors are usually not (yet) organised around the issue in question. The organisations in which they have been united are for example: a committee of tenants, an owners association, a merchants associations or a parent committee. This means that they have to organise themselves around this, for them, new task in order to be able to participate in the project.

Clear agreements are needed on the nature of the involvement, and on which position the direct involved actors and their representatives can take in order to achieve a successful participation (Van Gameren, 2011).

Urban development includes different phases as is shown in figure 16: initiation phase, design phase, construction phase, and the maintenance phase. During the initiation phase, the need to transform or adapt an urban area is translated into an initiative and a statement of requirements. This statement of requirements is incorporated into the design during the design phase. As soon as the different stakeholders reach a consensus for executing this design, the construction phase will start. The realisation of the design is prepared and subsequently executed during this phase. After the realisation of the plan, the maintenance phase will start. The area will be used and subsequently new problems will arise in the area in the course of time. When these problems are severe enough, a new initiative will emerge that starts over the real estate development cycle.

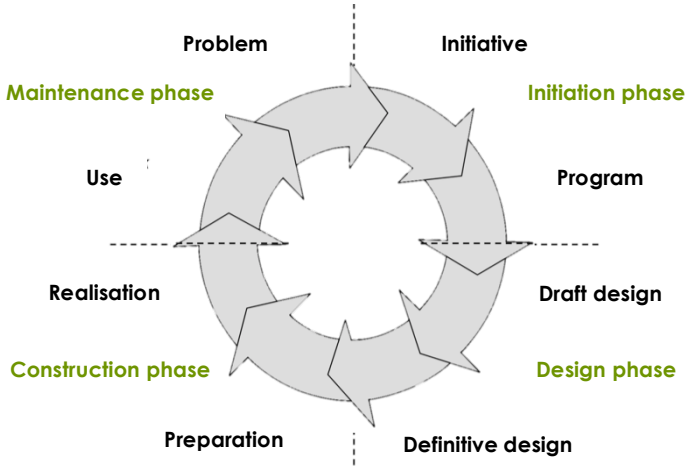


Figure 16 *Real estate development cycle (Den Heijer, 2003)*

The different phases of the development process need to be aligned to the content of the project. This real estate development cycle is an example of a design process. It is a creative process, whereby design thinking plays an important role. The knowledge required for executing the analytical tasks underlying this process is distributed over different disciplines and stakeholders.
Consultation, discussion and negotiation are needed to come from initiative to realisation during the different phases of the development process. The solution space, wherein an initiative can be translated into specific measures, is large at the start of the design phase. This solution space is decreasing after each phase, until a group decision can be made about executing the project. The increasing restriction of freedom of choice for the content of project proposals also means that the effects on the financial implications decreases during the planning process (van Gameren, 2011).

According to Van Gameren (2011), characteristics of this design process are: that it is divided into different phases; that each phase ends with a decision; and that each phase consists of a working process and a decision-making process. The working process includes activities such as conducting research, reporting, preparing contracts, designing, tuning, and preparing decisions. Work processes should generate proposals that are technical, legal, financial and timely feasible.
The decision-making process involves decision-making by the competent authority such as a steering committee, mayor and aldermen, city council, thereby preceded by consultation of stakeholders. The decision-making process must produce decisions that are socially, politically, and managerial feasible. The number of phases, or decision moments, depends on the complexity of the content of the task, the number of parties involved, and the difficulty of the force field; for example, by conflict of interests (van Gameren, 2011).

Conclusion
To conclude, urban development is seen as a complex task often related to ill-defined problems in a dynamic context. It requires an integral approach (Bruil et al., 2004, p. 397), as different spatial scales, development phases, policy domains, spatial scales and disciplines need to be aligned with each other. This alignment takes place within complex decision-making processes in inter-organisational networks (Bruil et al., 2004, pp. 19-20). Hence, it is characterised by complex relationships between societal, economic-financial, technical, political, environmental, legal, and spatial factors.

PSS AND HOW THEY WORK

2. What are PSS and how do they work?
    a. What kind of functions are included in the PSS?
    b. What are benefits of the PSS?
    c. What are constraints of the PSS?

With the raise of digitally available spatial data, geo-information systems play an increasingly important role in the daily practices of planners (Klosterman, 1999). As Huisman and de By (2009) outline, Geo-information systems or GIS are computer-based systems that can be used for data capture and preparation; data management, including storage and maintenance; data manipulation and analysis; and data presentation. According to González et al. (2013, p. 110) based on (Antunes et al., 2001; João, 1998; Vanderhaegen & Muro, 2005) "GIS can contribute to: (i) objective, accurate and quantifiable impact prediction and assessment; (ii) evaluating the spatial and temporal variability of impacts; (iii) predicting cumulative and large-scale effects; and, ultimately; and (iv) presenting all relevant information in geographic and visual form. During the 1990s, researchers started to note that the application of GIS alone could not serve all the needs of planning (Couclelis, 1989; Harris, 1989; Harris & Batty, 1993). This has led to the development of planning support systems as geo-information systems that specifically support the planning tasks. As Harris (1989, p. 90) outlines: *"A true planning support system must have the capability to employ locational and spatial interaction models, both to produce parts of plans constructively and to provide diverse measures of planning effectiveness. Such a capability goes beyond the analysis of coincidence, contiguity, and proximity supported by standard forms of GIS."*
The need for planning support systems is further driven by the shift in approach to urban development by reducing government involvement and an increasing role for private parties and citizens, resulting in a greater amount of stakeholders.

Planning support systems are a type of planning support instruments. Planning support is defined as "dedicated information, knowledge, and instruments that people actively involved within formal [planning] practices can receive to enlighten... their planning tasks and activities" (Geertman, 2006, p. 864).

Planning support systems can be used to: enhance the communication and negotiation between stakeholders; raise awareness by sharing information; evaluate plans and policies; validate theories; explore alternatives and scenarios; and to simulate urban processes. Some authors argue that the use of planning support systems will increase the objectivity of the decision-making process. However, as Ackoff (1999) explains, decision-making is in key subjective. The interpretation of data is not neutral, just as the availability and disclosure of data. Furthermore, the selection of criteria and the way of measuring these criteria adds another subjectivity aspect to the decision-making process. In order to deal with this subjectivity, the content of planning support systems and the selection of criteria is often done in workshops with all stakeholders. It is important that these stakeholders represent the involved actors and disciplines and the related project objectives. With regard to the data used, it is important to note that data is interpreted differently and might be used strategically by participants. Hence, PSS that provide these data are not automatically accepted (De Wit et al., 2009).

Planning support can be offered by technology-based instruments, like computer models, and by non technology-based instruments, like board games. Planning support systems are defined by the first category of planning support instruments: it is "a subset of geo information-based instruments that incorporate a suite of components (theories, data, information, knowledge, methods, tools, etc.) that collectively support all of, or some part of, a unique planning task" (Vonk et al., 2005, p. 910).
PSS are able to structure and incorporate the increasing amount of available digital spatial data into the decision-making process in order to physically adapt a geographical area. As the definition clarifies, the planning tasks are central to the planning support systems. Therefore, it is essential to understand which planning tasks PSS support. Carton (2007) argues that the planning support tasks are design, analysis and negotiation.
Additionally, De Bruin et al. (2009) mentions validation, exploration and evaluation as planning tasks that are supported by PSS. All these tasks are incorporated into the evaluation framework as presented on page 37. These planning tasks can be linked to categories of users as illustrated by Carton and Thissen (2009) and as summarised in table 3.

Table 3 *Overview of most important aspects of the frames on map use (Arciniegas & Janssen, 2009, p. 2208; based on Carton, 2007; Carton and Thissen, 2009)*

	Design	Analysis	Negotiation
Group or actor	Design expert	Research expert	Stakeholder, expert in decision-making
Actor metaphor	Artist	Scientist	Politician
Emphasis on	Creation and presentation of options	Research and assessment	Interaction, problem framing, trade-offs
Map seen as	Design language	Research model	Decision agenda

Furthermore, a distinction can be made between descriptive, predictive and prescriptive (normative) planning support systems. Descriptive systems give stakeholders insight into the current situation, predictive systems give stakeholders insights in the possible future situations and prescriptive advise stakeholders how they should deal with the specific spatial issues.

Earlier research related to PSS

Vonk et al. (2007) was inspired by the overview of different frames on map use in policy making by Carton (2007). These planning tasks can be related to PSS functions covering the gathering of relevant (spatial) data, storage and retrieval of this data, visualisation, communication, analysis, modelling, and a combination of these functions. Accordingly, these functions can be related to different disciplines, like planners, executives, geo-information specialists, citizens, and professional stakeholders.

Te Brömmelstroet and Bertolini (2010) has made a clear effort to view the use of PSS in a process of learning according to the SECI model (Nonaka, 1994; Nonaka & Takeuchi, 1995) and the experiential learning cycle of Kolb and Fry (1975), as illustrated in figure 17.

Kolb and Fry (1975) state that experiential learning is conducted through an iterative sequence of interlinked activities that continuously shift between reflection and action. The integral approach to urban development can be seen as such learning process in which the different stakeholders learn from each other. Pelzer et al. (2013. 170) argue in that respect: *"learning occurs when a stakeholder in the planning process perceives a planning issue through a different lens"*.

This is based on the work of Schön and Rein (1994) who indicated that a change of frame, or the incorporation of other frames, leads to learning processes. Frames are according to Benford and Snow (2000), based on Goffman (1974, p. 21) *"schemata of interpretation that enable individuals to locate, perceive, identify, and label occurrences within their life space and the world at large."*

Figure 17 *SECI model of knowledge creation adapted by Te Brömmelstroet (2010a)*

However, frames tend to be rooted in the different rationalities of the stakeholders and therefore are not easy to change (Carton, 2007). Furthermore, the perception frame is inter alia determined by the working culture and educational background of the stakeholder, which differs widely in the multidisciplinary context of urban development.

The perception frame of stakeholders not only determines how they interpret the outcome of the planning support system, but also how they perceive the use of planning support systems in general. An urban designer would prefer to use a planning support system for designing a vision, while the environmental consultant would like to have insights into the effects of the plan on the neighbourhood. This is further outlined by Vonk (2006) in relation to the transfer approach.

These insights correspond with the soft systems approach and influenced the development of planning support systems in the sense that PSS should not only process hard and scientific knowledge, but also soft experience based knowledge. Hard scientific knowledge and soft experience based knowledge are also indicated as explicit and tacit knowledge (Polanyi, 1967). "Explicit types of knowledge are formal (ex. data, scientific formulas and general/universal principles and theories) and are therefore easily codified with a wide validity" (te Brömmelstroet & Bertolini, 2010, p. 87). In contrast to explicit knowledge, "tacit knowledge is deeply rooted in an individual's actions and experience as well as in the ideas, values, or emotions he or she embraces" (Nonaka & Konno, 1998, p. 42).

Due to tacit knowledge, "one can know more than one can tell" (Polanyi, 1967, p. 138). When tacit knowledge is written down, it becomes explicit knowledge. Accordingly to the shift to soft systems approaches, several authors emphasised that tacit knowledge plays an increasingly important role in the decision-making process (Gibbons et al., 1994; Innes & Booher, 1999; Khakee et al., 2000).

Nonaka and Takeuchi (1995) have based their SECI model, as illustrated in figure 17, on the experiential learning cycle of Kolb and Fry (1975).

As Te Brömmelstroet and Bertolini (2010) outline, socialisation is the interaction of tacit knowledge with tacit knowledge by sharing experiences, brainstorming or observing.

Externalisation is the interaction of tacit knowledge with explicit knowledge by writing down tacit knowledge for instance for creating metaphors, determining a shared set of indicators and models. Externalisation takes place in a dialogue with stakeholders who can explain the available explicit information in relation to its shortcomings and possibilities based on their experiential knowledge.

Combination is the interaction of explicit with explicit knowledge by combining explicit information, like combining data with indicators to create the planning support systems in order to compare alternatives.

And internalisation is the interaction of explicit with tacit knowledge by learning by doing (Nonaka & Takeuchi, 1995). This occurs when the output of the planning support systems is presented to the stakeholders by demonstrating the effects of alternatives through the determined indicators. This output needs to be explained and discussed to be useful for the stakeholders (Te Brömmelstroet & Bertolini, 2010). Therefore transparency is needed in order to enable internalisation.

This learning cycle creates a mutual understanding between stakeholders and changes in the perception framework of stakeholders when double-loop learning takes place. Argyris and Schön (1974, 1978, 1996) distinguish in their books single-loop and double-loop learning. During single-loop learning the values of the person remains unchanged, while during double-loop learning the observed effects of action are connected with the underlying strategies, as well as the values determining these strategies. In other words, during second-loop learning the perception framework of the person changes as well. In relation to planning support systems, this means that during single-loop learning only the input, the design alternatives, are changed on the basis of the output of the planning support systems, the feedback on these design alternatives based on a variety of indicators; while during double-loop learning the input, the design alternatives, are changed, as well as the value to judge these alternatives, the indicators.

Pelzer et al. (2013) relate the framework of Carton (2007) to different types of knowledge bases as is shown in table 4. Systemised knowledge is a term also used by (Healey, 2007) which refers to explicit knowledge; experiential is a type of implicit or tacit knowledge; and pragmatic knowledge is based on both explicit and tacit knowledge.

Table 4 *Frames about maps in planning (Pelzer et al., 2013, p. 172)*

Frame	Typical stakeholders	Knowledge base	Function of a map	Role of area-based environmental profiles
Analytical	Environmental analysts, transport planners, financial analysts, GIS specialists	Systematized	Research model	To integrate environmental values into spatial planning
Design	Urban designers, architects/ landscape architects	Experiential	Design language	To show environmental restrictions and opportunities of visual designs
Negotiation	Policy advisors, some spatial planners, politicians	Pragmatic	Decision agenda	As a strategic instrument in the planning process

The development of PSS

The first computer-based planning tools emerged as Geographical Information Systems (GIS) and Spatial Decision Support Systems (SDSSs) during the 1960s and 1970s. Spatial decision support systems (SDSS) are a category of decision support systems (DSS). According to the SDS consortium (2008) "Spatial decision support (SDS) provides computational or informational assistance for making better-informed decisions about problems with a geographic or spatial component. This support assists with the development, evaluation, and selection of proper policies, plans, scenarios, projects, interventions, or solution strategies." These systems often include multi-criteria analysis.

"Although these systems and models offered huge opportunities to support planning, they were not readily adopted by the planning profession (Geertman & Stillwell, 2003, p. 4)." Lee (1973) has indicated 7 sins blocking the widespread use of these large-scale models already in the 1970s. It appears that the first SDSSs developed from the 1970s onwards were expert-based technocratic models based on the hard systems approach (De Wit et al., 2009). These models were too complicated and too big to be user-friendly. During the 1980s and 1990s, these models improved by developments in geo-information systems and visualisation tools, but these models still appears to be not embraced by its potential users (Lee, 1994).

Next to the critical evaluations of Lee (1973; 1994), also other researchers concluded that "most of the tools are far too generic, too complex, too inflexible, incompatible with most planning tasks, oriented towards technology rather than problems and too focused on strict rationality" (Geertman & Stillwell, 2003, p. 5).

Shifts in ideas from the central, top-down approach of spatial planning towards a more bottom-up, holistic approach, called for new ways of supporting urban development processes. The former hard systems were not appropriate to the social aspects of the decision-making process and the complexity of urban planning. The response was therefore the development of collaborative planning support tools. These tools are actor-based, and socio-cratic in order to support participatory planning (De Wit et al., 2009). This is further illustrated by De Wit et al. (2009) in the following textbox:

"Whereas Geo-ICT developers have focused on quantitative data, spatial planners are increasingly applying qualitative methods. Out of the rational approach to spatial planning in the 1960s and 1970s, deriving plans mainly from physical characteristics of the present and the desired landscape (to be defined by planners), a planning practice has emerged which engages much more with people's opinions, values and interests, and which is searching for ways of involving the public in planning. Geo-ICT experts often develop tools based on a technocratic, rational image of spatial planning, which does not satisfactorily support the socio-cratic, political situation with which spatial planners are confronted. Because of this discrepancy, spatial planners do not accept Geo-ICT products which may in themselves be of good quality. At the same time, we must conclude that many planners make little effort to explore what Geo-ICT has to offer, probably due to their focus on process rather than data. They have little knowledge of the possibilities and do not feel motivated to invest in software, data and education." (De Wit et al. 2009)

The new generation of planning support systems were more focused on supporting communication and collaboration between the increasing amount of stakeholders in urban development processes. Klosterman (1999) refers to this as a shift from 'planning for people' to 'planning with people'. These planning support systems are closely related to GIS-supported collaborative decision-making tools and Group Decision Support Systems. The development of planning support systems over the last decades in relation to perspectives of planning is illustrated by Malczewski (2004) in table 5.

Table 5 *Stages in GIS development and changing perspectives of planning (Malczewski, 2004, p. 9)*

GIS development	Perspectives of planning	Land-use suitability analysis
Invitation (1950s–1970s)	Scientific	Computer-assisted overlay mapping
Integration (1980s)	Political	Cartographic modeling/MCDA
Proliferation (1990s)	Participatory/collective design	MCDA AI/Geocomputation Internet/Multimedia/Visualization

The terms for the different support tools mentioned above are closely related to each other. They are not mutually exclusive, but have certain distinguishing characteristics as is shown in table 6 by Li and Jiao (2013). While SDSSs and PSS are specific and focused on the tasks of the application, GISs provide generic solutions (Geertman & Stillwell, 2003).

Table 6 *The differences between GIS, SDSS and PSS (Li & Jiao, 2013)*

	GIS	**SDSS**	**PSS**
Users	GIS Analysts	Domain Experts	Planners
Key Points	A set of tools Spatial data Spatial analysis GIS algorithms General flatform	Short-term decision Spatial and Non-spatial Data Spatial problem solving Decision support models Domain oriented platform	Long-term decision Spatial and Non- spatial Data Uncertainty and scenario planning Urban planning models Public participation platform

However, despite the promising development of planning support systems from technology focused models towards participatory human-centred support, the application of planning support systems in practice is still lagging behind (Brail and Klosterman 2001; Geertman and Stillwell 2003; Uran and Janssen 2003; Couclelis 2005; Vonk 2006). Couclelis (2005, p. 1359) argues that this can be explained by the difference that planning is about policy, while the models are based on science.

Also Uran and Janssen (2003) identify the mismatch between the decision problem of end-users and the answers produced by the system as the main factor for this lack of success: technology-driven systems produce the correct answer to the wrong question at the wrong moment. Additionally, most schemes take into account only a small proportion of urban processes, which does not reflect the reality. A few years later, Geertman and Stillwell (2009) still confirm that "there exists a fundamental dichotomy between those systems that are demanded for use in practice by potential users and those systems supplied by systems developers according to their perception of what is required". After decades of development, it appears that PSS were still not transparent enough, neither flexible nor user friendly and therefore incompatible with the unpredictable and flexible nature of most planning tasks and information needs.

The reactions of these reviews are numerous. Different authors mention that the major challenge in this area is to better link the decision-support tools to the ways in which stakeholders use these tools. Petch and Reeve (1999) mention that a PSS tool should be demand-driven in orientation to be utilised in daily planning practices, and Schetke et al. (2012) argue that participatory methods during the development process should be utilised to better reflect stakeholders' needs for information in the design of the PSS.

Some reactions focus on improving PSS software by adding new functions to it; for example, PSS that are more integrated (i.e. 'What If' developed by Klosterman (1999)), more interactive (i.e. 'Urban Strategy' developed by TNO (2015a, 2015b)) or more user-friendly (i.e. 'UrbanSim' developed by Waddell (2002, 2011)). Others follow a more hardware-oriented path, such as 'MapTables', 'Sketchtables' and other visual gadgets. Additionally, there is the process-oriented line that focuses on bridging the human gap between the potential end-users and the PSS developers with more participative, iterative PSS development structures (Te Brömmelstroet & Schrijnen, 2010), like the serious gaming tool of Tygron.

These trends are also confirmed by De Wit et al. (2009): "'Traditional' GIS used to focus on expert users. Now, more attractive visualisation, increasing attention to aspects of communication and easier accessibility of data and applications are making Geo-ICT more accessible to the public and enhancing the interaction between Geo-ICT experts, planning practitioners, decision makers and the public. Applications are becoming more widely applicable and can be tailored by users to suit their own needs."

Relation literature review to theoretical framework

If we connect the background of PSS to the theoretical framework, we can define planning support systems as a deterministic system as these systems cannot make choices by themselves, but are related to how people use them. Ackoff has clarified that decision makers attempt to solve the problem as they conceive it (1979, p. 13). Planning support systems support decision makers in solving spatial issues, but if the interpretation of the problem is wrong, the planning support system will support the decision makers in giving the right answer to the wrong question. As clarified in this section, PSS have experienced a shift from the hard systems approach towards a soft systems approach during the last decades.
From the soft systems approach it is understandable that PSS are perceived differently by different stakeholders because of to their different perception frames. Therefore, it is important to take the users and context into account when studying the application of planning support systems in practice.

According to the soft systems approach, planning support systems are based on heuristic methods. A method always refers to an action that either aims at increasing knowledge, or in changing the world. These planning support systems are based on heuristic methods. This means that you are advised to take the outcomes of the planning support system workshop in consideration, but you do not have to abide by the result. Also, they do not guarantee a certain result. Planning support systems only support team members in reaching a consensus.

The result of the planning support workshop depends largely on how the PSS is used, and therefore they should be used thoughtful. PSS need to be used thoughtful as the user determines how the results are interpreted and which indicators are used for that specific spatial issue.
This is in contrast to algorithmic methods. An algorithm is a clear array of operations that must be handled in the indicated order, which is guaranteed to achieve a clearly defined type of outcome.
It can be explained by several reasons that users of planning support systems do not have to abide by the result. One reason is that not all constraints can be made quantitative. Indicators related to the gross floor area of a building for instance do not indicate how the building should look like (Micheels, 2014).

Another reason may be pursuing of more freedom in the decision-making process by stakeholders who do not benefit from an open decision-making process. Furthermore, it also corresponds with the soft systems approach as mentioned in the theoretical framework which promotes learning which leads to a decision to take certain actions: "knowing that this will lead not to 'the problem' being now 'solved', but to a changed situation and new learning" (Checkland, 1981, p. 17). According to Checkland (1981) soft systems methodology promotes a decision-making process in an ever-changing social world, that continuously is re-created by its members. This also corresponds to the learning theory behind design thinking as is outlined in the theoretical framework. New insights will change the perception of stakeholders of the spatial problem and their related objectives in the project.

Conclusion
Planning support systems are "a subset of geo information- based instruments that incorporate a suite of components that collectively support all of, or some part of, a unique planning task" (Vonk et al., 2005, p. 910). The planning tasks can be classified according to Carton and Thissen (2009) and De Bruin et al. (2009). As planning tasks are central in the use of planning support systems, these tasks are incorporated into the evaluation framework as mentioned on page 37. Furthermore, it has been clarified that PSS have experienced a shift from top-down, technocratic spatial decision support systems and GIS tools from the 1960s, towards bottom-up, sociocratic, participatory planning support systems from 1989 onwards. Planning support systems seek to interact between quantitative object knowledge and qualitative process methods.

THE APPLICATION OF PSS IN URBAN DEVELOPMENT

3. How are PSS applied in urban development?

The previous section already outlined the development of planning support systems over the last decades and reactions on these developments. However, the first evaluations of planning support systems often did not incorporate empirical results by executing case studies, as the evaluations were focused on the tool instead of the process. Research that include case studies in the Netherlands are primary related to doctoral dissertations of Peter Pelzer (2015), Tessa Eikelboom (2015), Gustavo Arciniegas (2012), Marco te Brömmelstroet (2010b), and Guido Vonk (2006). These studies are further outlined in the below.

Guido Vonk is one of the first researchers who has systematically and empirically analysed the application of PSS in the Netherlands. His research started with a SWOT analysis of planning support systems through a literature review, a series of interviews, and a web-survey to gather views from developers, users and PSS experts. The barriers to the widespread use of PSS are further analysed trough a web survey.

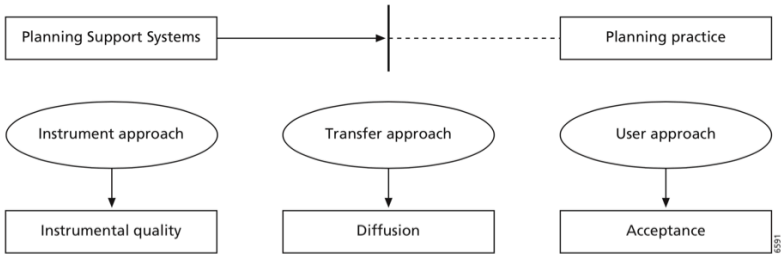


Figure 18 *Theoretical framework for reviewing PSS applications (Vonk, 2006)*

Guido Vonk (2006) has divided his analysis in an instrument approach, transfer approach and user approach as illustrated in figure 18. The instrument approach reviews the PSS in terms of fit between planning task, PSS technology and the user using the SWOT framework. The classification of planning tasks is done according to the work of Geertman and Stillwell (2003). The transfer approach looks at formal and informal deviant diffusion processes (Rogers, 2003). The user approach incorporates the technology acceptance model (Davis, 1989; Rogers, 2003) and uses the framework for innovation adoption after Frambach and Schillewaert (2002). Although he reached many users, developers and PSS experts through his web-surveys, he did not conduct a case study to analyse the wider context of the PSS in practice. Vonk argues that little awareness of the existence and purpose of PSS, a general lack of experience with them, and little intention in using them are main barriers to using planning support systems in practice.

Stan Geertman (2006) has evaluated worldwide practices of PSS on the basis of seven factors, as illustrated in figure 19:
(1) specific characteristics of information, knowledge, and instruments;
(2) characteristics of planning and policy process;
(3) dominant planning style;
(4) political context;
(5) user characteristics;
(6) content of planning issue; and
(7) dominant policy model.
Although these factors do influence the potential planning support role, the study does not include actual case studies whereby these factors are examined in practice.

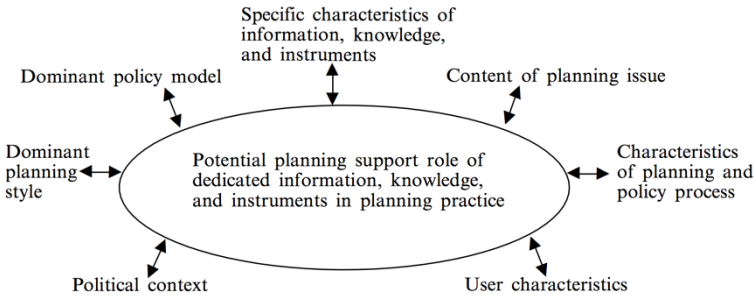


Figure 19 *Factors influencing the potential planning support role (Geertman, 2006)*

Marco te Brömmelstroet was the first PhD researcher who studied the application of planning support systems in the Netherlands in practice by executing case studies. To overcome the bottlenecks to the use of PSS in practice Marco te Brömmelstroet (2010a) proposed the Mediated Planning support framework: A framework of a series of different workshops. He applied the framework in three different cases: in Amsterdam, Breda and Eindhoven. He paid special attention to the workshop characteristics, applying a design research approach. He analysed planning support systems on its ability to support learning and to share different types of knowledge (tacit and implicit). Marco te Brömmelstroet has based his evaluation framework on the SECI model of knowledge creation of (Nonaka, 1994; Nonaka & Takeuchi, 1995) and the experiential learning cycle of Kolb and Fry (1975), which is outlined in the previous section.

Gustavo Arciniegas (2012) researched map-based decision support tools for collaborative land use planning. He has developed, implemented and tested a set of spatial tools that support the integration of stakeholder knowledge for designing and evaluating land use plans. Furthermore, he applied the tools in a collaborative workshop setting within two case studies; one land-use planning case in Bodegraven, the Netherlands, and one marine-planning case in Mull of Kintyre, Scotland.
Special attention was paid to the effectiveness of different kind of maps by executing an experiment with students. The tools were evaluated on the bases of usefulness, clarity and impact. Three different workshops were designed: a design workshop, analysis workshop and negotiation workshop.

Tessa Eikelboom (2015) has developed and evaluated spatial decision support tools supporting the development of regional adaptation strategies. She has organised different workshops with the MapTable in Texel, Zevenblokken (Province of Drenthe) and Friesland. She has linked the different tasks of spatial decision support systems to the adaptation framework of Willows and Cornell (2003) as is shown in table 7 and figure 20. This framework will be used in this thesis as it illustrates the circular and iterative character of the development process and is therefore further explained on page 39.

Eikelboom (2015) divides PSS in three categories on the basis of its function: evaluation, drawing and simulation tools. Drawing tools enables stakeholders to give comments on the map and to sketch polygons and lines. This is often followed by simulation tools which enables stakeholders to add or adjust non-spatial information to the drawn polygons, like land use function. This information is input for the calculation of criteria. The evaluation tool values the criteria, and possibly aggregate criteria and ranks different alternatives in a multi-criteria analysis (Eikelboom, 2015).

`**Table 7** *Matrix that couples tasks, tools and the stages in the adaptation framework for spatial adaptation (Eikelboom, 2015)*

Stage	Task	Tool
Stage 3 Assess risk	Analysis	Evaluation
	Validation	Drawing, Simulation
Stage 4 Identify options	Exploration	Drawing
	Design	Drawing, Simulation
Stage 5 Appraise options	Evaluation	Evaluation
	Negotiation	Drawing

Figure 20 *Adaptation framework of Willows and Cornell (2003)*

Peter Pelzer (2015) designed three types of workshops based on the tasks of carton (2007): exploration, selection and negotiation. Support can be provided by the PSS in the sense of communication support and analytical support. Next to a survey and semi-structured interviews, he has conducted case studies as well. His case studies were inter alia the Cartesiusdriehoek, Utrecht, supported by Urban Strategy, and Rijnenburg, Utrecht, supported by community Viz and the MapTable. He has determined the usefulness of PSS by determining the utility through the task-technology fit (as also executed by Vonk, 2005) and the usability trough indicators based on literature review.

The application of planning support systems in the development process

As mentioned in the first section of this chapter, the involvement of citizens has many benefits for the development process. However, according to Van Gameren (2011) the positive involvement of actors suffers quite often from: (i) the obscurity and long timespan of the planning process; (ii) the obscurity of the force field, correspondingly the differences in interests between the many involved actors; and (iii) the uncertainty about the opportunities for personal contribution and the impact of it on the decision-making process. Therefore, the chance that an initiative develops into an executable project is highly dependent on the quality of the communication between the involved actors and stakeholders. Planning support systems can help in these processes to enhance the communication and involvement of actors. Often PSS are used during workshops with the involved actors.

Te Brömmelstroet and Schrijnen (2010) were one of the first researchers that have set up a workshop structure to organise the participation of users with planning support systems in a systematic way. Soon after, also Arciniegas & Janssen (2012) acknowledged the importance of planning support workshops by paying attention to the organisation of these workshops in their research. Later on, Pelzer and Geertman (2014) and Eikelboom and Janssen (2015) have incorporated workshops in their research as well. All the studies concluded that the organisation of the workshop heavily influenced the usefulness of planning support systems in practice. Different types of workshops are often connected to each other in the planning process, whereby the prior workshop will deliver input for the following workshop. Nonetheless, collaborative workshops are not new in planning practice. Before the adaptation of computer technologies, these workshops were supported by large hard copies of maps with tracing paper. As Longley et al. (1999) mention "with the arrival of Geographical Information Systems (GIS), the transparent tracing map sheets were replaced by map layers presented within the GIS on a computer screen." Additionally, Sieber (2006) acknowledges that the involvement of stakeholders has increased over the years whereby a shift is apparent from an emphasis on communication to active involvement through participation methods. Also Dragicevic and Balram (2006) recognise that the focus of stakeholder involvement currently is on collaboration, whereby stakeholders are actively working together to reach the best promise. According to Arciniegas & Janssen (2012) planning support systems has evolved along with this development.

There are a wide variety of applications of PSS and MCDM in practice mentioned in literature, like topics:

- Regarding to simulation of multi-actor spatial planning (Ligtenberg et al., 2004);
- Regarding to strategic environmental assessment, like the BRIDGE tool (Carsjens & Ligtenberg, 2007; González et al., 2013);
- Regarding to urban infrastructures (Coutinho-Rodrigues, 2011);
- Regarding to land-use evaluations for site selection of parking in Tehran or of a park in Italy (Jelokhani-Niaraki & Malczewski, 2015; Zucca et al., 2008);
- Regarding to monitoring, evaluating and even simulating urban growth (Anthony Gar-on Yeh & Xia Li, 2007; Shen et al., 2009, Hana et al., 2009; Ying et al., 2009);
- Regarding to analysis of patterns of spatial occupancy (Marusic, 2001; 2012).

An overview of different models mentioned in international literature is shown on the next page. On the basis of this analysis, I can conclude that a wide variety of planning support systems exists, which is used in various fields. The models often focus on a particular aspect of area development by including a limited number of indicators. As a consequence, they do not present the complex and dynamic nature of decision-making in area development. Additionally, they usually do not support the participation of different stakeholders. Furthermore, it appears that these models are often not used in practice: they are mainly used to validate theories or simulate urban processes. Therefore, it is difficult to conclude what impact such models have on area development in practice.

Name model	City / region	Country	Type of model	Primary function	Relevance for UAD	The role of the model in the DM process	Suitable for comparison	Author	Year	Source: Title	Source: Publication
BRIDGE	Athens, Gliwice, Helsinki, Firenze and London	Multiple	MCDM: AHP	SEA	focus on environment and allignment with EU legislation			Ainhoa González, Alison Donnelly, Mike Jones, Nektarios Chrysoulakis, Myriam Lopes	2013	A decision-support system for sustainable urban metabolism in Europe	Environmental Impact Assessment Review 38 (2013) 109–119
FML	Iskandar Development Region (IDR)	Malaysia	AI: SD	CO2 emmissions	Non-holistic approach			Wee-Kean Fong, Hiroshi Matsumoto,Yu-Fat Lun	2009	Application of System Dynamics model as decision making tool in urban planning process toward stabilizing carbon dioxide emissions from cities	Building and Environment 44 (2009) 1528-1537
-	Polog Region	Macedonia	MCDM: OWA, AHP and fuzzy	Site selection: landfill (stortplaats)	Non-holistic approach			Pece V. Gorsevski, Katerina R. Donevska, Cvetko D. Mitrovski, Joseph P. Frizado	2012	Integrating multi-criteria evaluation techniques with geographic information systems for landfill site selection: A case study using ordered	Waste Management 32 (2012) 287–296
MAEAC	Georgia Basin	Canada	MCDM: SAW, TOPSIS, ELECTRE	Climate change impact assessment	Focus on climate change			X.S. Qin, G.H. Huang, A. Chakma, X.H. Nie, Q.G. Lin	2008	A MCDM-based expert system for climatechange impact assessment and adaptation planning: A case study for the Georgia Basin, Canada	Expert Systems with Applications 34 (2008) 2164–2179
MCPUIS	Coimbra	Portugal	MCDM: SAW, TOPSIS, ELECTRE	Planning of urban infrastructure systems	Non-holistic approach			Joao Coutinho-Rodrigues, Ana Simoo, Carlos Henggeler Antunes	2011	A GIS-based multicriteria spatial decision support system for planning urban infrastructures	Decision Support Systems 51 (2011) 720-726
-	Shanghai	China	AI: SD and CA	Simulating urban growth	Non-holistic approach			Ji Han, Yoshitsugu Hayashi, Xin Cao, Hidefumi Imura	2009	Application of an integrated system dynamics and cellular automata model for urban growth assessment: A case study of Shanghai, China	Landscape and Urban Planning 91 (2009) 133–141
(MCA-DSS)	Essen	Germany	MCDM: WLC	Sustainable land use evaluation	Focus on sustainable performance			Sophie Schetke, Dagmar Haase, Theo Kötter	2012	Towards sustainable settlement growth: A new multi-criteria assessment for implementing environmental targets into strategic urban planning	Environmental Impact Assessment Review 32 (2012) 195-210
-	Hong Kong	Hong Kong (China)	AI: SD	Sustainable land use evaluation	Non-holistic approach			Qiping Shen, Qing Chen, Bo-sin Tang, Stanley Yeung, Yucun Hu, Gordon Cheung	2009	A system dynamics model for the sustainable land use planning and development	Habitat International 33 (2009) 15-25
IPDSS	-	Cyprus	MCDM and AI	Land consolidation (ruil verkaveling)	Non-holistic approach			Demetris Demetriou, John Stillwella, Linda See	2012	Land consolidation in Cyprus: Why is an Integrated Planning and Decision Support System required	Land Use Policy 29 (2012) 131-142
(MC-SDSS)	Tehran	Iran	MCDM: OWA	Site selection: parking area	Non-holistic approach			Mohammadreza Jelokhani-Niaraki, Jacek Malczewski	2015	A group multicriteria spatial decision support system for parking site selection problem: a case study	Land Use Policy 42 (2015) 492-508
(FMCDM)	Harlingen	south Texas, USA	MCDM: AHP and fuzzy	Site selection: landfill (stortplaats)	Non-holistic approach			Ni-Bin Chang, G. Parvathinathan, Jeff B. Breeden	2008	Combining GIS with fuzzy multicriteria decision-making for landfill siting in a fast-growing urban region	Journal of Environmental Management 87 (2008) 139-153
Various								Gustavo Arciniegas, Ron Janssen, Piet Rietveld	2013	Effectiveness of collaborative map-based decision support tools: Results of an experiment	Environmental Modelling & Software 39 (2013) 159-175
								Gustavo Arciniegas, Ron Janssen	2012	Spatial decision support for collaborative land use planning workshops	Landscape and Urban Planning 107 (2012) 332-342
	Bodegraven polder	the Netherlands	MCDM: WLC	Land use evaluation				Arciniegas, G.A., Janssen, R., Omtzigt, N.	2011	Map-based multicriteria analysis to support interactive land use allocation.	International Journal of Geographical Information Science 25 (12), 1931-1947.
								Arciniegas, G.A. and Janssen, R.	2009	Using a touch table to support participatory land use planning	In: B. Anderssen et al., eds. 18th IMACS world congress – MODSIM09 International Congress on
-	Viena	Austria	AI: ABM	simulate new residential patterns				Veronika Gaube, Alexander Remesch	2013	Impact of urban planning on household's residential decisions: An agent-based simulation model for Vienna	Environmental Modelling & Software 45 (2013) 92-103
Vensim PLE	Dalian	China	AI: SD	Urban transportation system	Non-holistic approach			WANG Jifeng, LU Huapu, PENG Hu	2008	System Dynamics Model of Urban Transportation System and Its Application	Journal Of Transportation - Systems Engineering And Information Technology, 2008, 8(3), 8389.
(CA-MAS) in NetLogo	Salt Lake City	Utah, USA	AI: CA, MAS	Urban gentrification	Non-holistic approach			Paul M. Torrens, Atsushi Nara	2007	Modeling gentrification dynamics: A hybrid approach	Computers, Environment and Urban Systems 31 (2007) 337–361
in D-Sight software	Kampala city	Uganda	MCDM: PROMETHEE II	Water loss management	Non-holistic approach			Harrison E. Mutikanga, Saroj K. Sharma, Kalanithy Vairavamoorthy	2011	Multi-criteria Decision Analysis: A Strategic Planning Tool for Water Loss Management	Water Resources Management, November 2011, Volume 25, Issue 14, pp 3947-3969
SAORES	Yangou catchment of the Loess Plateau	China	MCDM: MOSO	Ecosystem services / management	Non-holistic approach			Haitang Hu, Bojie Fu, Yihe Lü, Zhenmin Zheng	2015	SAORES: a spatially explicit assessment and optimization tool for regional ecosystem services	Landscape Ecol (2015) 30:547–560
-	core region of Changsha, Zhuzhou, Xiangttan city cluster	China	AI: MAS, GA	Land use allocation	Non-holistic approach			Zhang, H. H., Zeng, Y. and Bian, L.	2010	Simulating multi-objective spatial optimization allocation of land use based on the integration of multi-agent system and genetic algorithm	Int. J. Environ. Res., 4(4):765-776, Autumn 2010
WePWEP	Norfolk	England, UK	MCDM	Site selection: of wind farm sites	Non-holistic approach			Ana Simão, Paul J. Densham, Mordechai (Muki) Haklay	2009	Web-based GIS for collaborative planning and public participation	Journal of Environmental Management 90 (2009) 2027–2040
MAS in REPAST software	Land van Maas en Waal (hyothetical case)	the Netherlands	AI: MAS	spatial planning: zoning	Non-holistic approach			Arend Ligtenberg, Monica Wachowicz, Arnold K. Bregt, Adrie Beulens, Dirk L. Kettenis	2004	A design and application of a multi-agent system for simulation of multi-actor spatial planning	Journal of Environmental Management 72 (2004) 43–55
STEPP	Nijmegen	the Netherlands	MCDM	spatial planning: zoning	Non-holistic approach			Gerrit J. Carsjens, Arend Ligtenberg	2007	A GIS-based support tool for sustainable spatial planning in metropolitan areas	Landscape and Urban Planning 80 (2007) 72-83
SWARM (in Arc/Info GIS)	Nijmegen	the Netherlands	AI: MAS, CA	Land suitability analysis:conflict management	Non-holistic approach			Jacek Malczewski	2004	GIS-based land-use suitability analysis: a critical overview	Progress in Planning 62 (2004) 3-65
					Non-holistic approach			Arend Ligtenberg, Arnold K. Bregt, Ron van Lammeren	2001	Multi-actor-based land use modelling: spatial planning using agents	Landscape and Urban Planning 56 (2001) 21-33
-	Dongguan, Pearl River Delta	China	MCDM	Land use evaluation	Non-holistic approach			Anthony Gar-on Yeh & Xia Li	2007	An integrated remote sensing and GIS approach in the monitoring and evaluation of rapid urban growth for sustainable development in the Pearl River Delta, China	International Planning Studies, 2:2, 193-210,
ILWIS (SMCE module)	Bergamo Province	Italy	MCDM: AHP	site selection: park	incorporation hypothetical view sta			Antonella Zucca, Ali M. Sharifi, Andrea G. Fabbri	2008	Application of spatial multi-criteria analysis to site selection for a local park: A case study in the Bergamo Province, Italy	Journal of Environmental Management 88 (2008) 752-769
BUDEM	Beijing	China	AI: CA	Urban development	Non-holistic approach			Long Ying, Mao Qizhi, Dang Anrong	2009	Beijing Urban Development Model: Urban Growth Analysis and Simulation	Tsinghua Science And Technology. pp 782-794 Volume 14, Number 6, December 2009
UrbanSim	Eugene-Springfield, Oregon	USA	AI: ABM: Bayesian	Urban development				Hana Sevcikovaa, Adrian E. Rafteryb, Paul A. Waddel	2007	Assessing uncertainty in urban simulations using Bayesian melding	Transportation Research Part B 41 (2007) 652-669
								Paul Waddell	2002	UrbanSim: Modeling Urban Development for Land Use, Transportation, and Environmental Planning	Journal of the American Planning Association, 2002, 68:3, 297-314,

Evaluation framework for planning support systems

The literature review of this chapter has resulted in the evaluation framework to analyse the cases in the following chapters. As many reviews of urban development processes and PSS have been executed previously I can use the evaluation frameworks mentioned in literature to execute the case study. Relevant frameworks for my thesis reviewing PSS in Dutch urban development processes are designed by Peter Pelzer (2015), Tessa Eikelboom (2015), Marco te Brömmelstroet (2013), Stan Geertman (2006) and Guido Vonk (2005). These researchers are also mentioned in the second section on page 31.

Especially the work of Peter Pelzer appears to be relevant for my research. I have therefore also based the semi-structured interviews with the users of PSS on the interview design of Pelzer. However, as I am focusing on the context, I have incorporated more process related indicators. The list of interviewees is shown in appendix A, the interview designs are shown in appendix B and C, and the interview transcripts are shown in appendix D.

Tessa Eikelboom (2015) made use of the adaptation framework of Willows and Connell (2003) in order to evaluate the use of planning support systems for designing regional adaptation strategies. This model, as is shown in figure 21, can be conceived as a non-sequential decision-making model. This framework is suitable for environmental planning, but also urban development in general. Related to urban development identifying options can be interpreted as designing alternatives. The framework of Willows and Connell (2003) is therefore linked to the real estate development cycle as illustrated in figure 20 (p. 36).

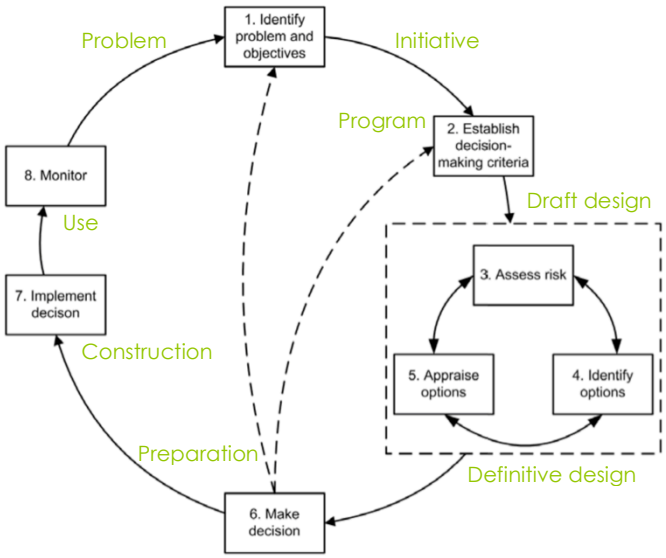


Figure 21 *The evaluation framework, based on Willows and Connell's (2003) adaptation framework and Den Heijer's (2003) real estate development cycle*

According to Carton and Thissen (2009) and Bruin et al. (2009) the tasks of a planning support system can be grouped into a total of six task categories: analysis, validation, exploration, design, evaluation and negotiation. Eikelboom has linked these tasks to phases 3 to 5 of the adaptation framework for evaluating PSS, as is shown in table 8.

Table 8 *Matrix that couples tasks, tools and the stages in the adaptation framework for spatial adaptation (Eikelboom, 2015, p. 39)*

Stage	Task	Tool
Stage 3 Assess risk	Analysis	Evaluation
	Validation	Drawing, Simulation
Stage 4 Identify options	Exploration	Drawing
	Design	Drawing, Simulation
Stage 5 Appraise options	Evaluation	Evaluation
	Negotiation	Drawing

Note that the design process is an iterative cyclic process, which means that the different tasks can be repeatedly executed by the planning support system and the order of actions can be in multiple directions.

Assessing risk can be interpreted as assessing the baseline situation of an area in relation to its constraints, opportunities and ambitions. The opportunities, ambitions and constraints are analysed during the analysis task. The validation task validates the available information based on the expertise and knowledge of stakeholders.

During the identification phase, different design alternatives are created and explored. Design refers to the actual development of possible spatial adaptations in an area, while exploration considers testing different measures and strategies in order to understand the planning support system and the effects of different measures on its environment.

Different design alternatives, or a design versus the baseline situation, are evaluated during stage 5. This will be the input for the negotiation between the different stakeholders in order to reach a consensus (Eikelboom, 2015). As mentioned earlier, the perspective of the stakeholder determines the weighting of different criteria and therefore the weighting of different alternatives. During the negotiation, it is important that stakeholders also share their tacit knowledge and incorporate qualitative and intangible aspects that could not be visualised in the PSS.

This model will be further used in this thesis as it suits the circular and iterative urban development process. It contains feedback and iteration to refine the problem, objectives, decision-making criteria and the design of alternatives or development strategies.

Conclusion
Planning support systems can be seen as deterministic systems in a social system of urban development. The social system of urban development contains also other social subsystems, as many different parties are involved in the decision making process for adapting a geographical area. These social subsystems contain animated systems (people) with their deterministic systems (like computers).

As planning support systems are closely related to the planning tasks of urban development projects, these systems have developed parallel to new approaches to spatial planning and urban development. As illustrated by the previous two sections, planning support systems have experienced a shift from technocratic models towards sociocratic models, while urban development has evolved from top-down centralised approaches to bottom-up holistic and integral approaches. These shifts can be related to systems theory as well. Currently, it is widely recognised that a soft system approach is more suitable for PSS, although initial planning support systems are developed from a hard systems approach.

Based on the literature review, I can conclude that a wide variety of planning support systems exists, which is used in various fields. The models often focus on a particular aspect of area development by including a limited number of indicators. As a consequence, they do not present the complex and dynamic nature of decision-making in area development. Additionally, they usually do not support the participation of different stakeholders. Furthermore, it appears that these models are often not used in practice: they are only used to validate theories or simulate urban processes. Therefore it is difficult to conclude what impact such models have on area development in practice. Research that include case studies in the Netherlands are primary related to doctoral dissertations of Peter Pelzer (2015), Tessa Eikelboom (2015), Gustavo Arciniegas (2012), Marco te Brömmelstroet (2010b), and Guido Vonk (2006). These studies suggest that different tools can be used for different purposes, and are suitable for different phases in the overall urban development process. They also mention that PSS are still not widely applied in practice. The researchers studied different aspects of the PSS in different ways, but they do have some overlap:

- Task-technology fit: researching the extent to which the technology fits the tasks of the stakeholders;
- Relations with decision-making theory and knowledge management.

Based on these studies an evaluation framework is determined, which makes use of the adaptation framework of Willows and Connell (2003) in combination with the real estate development cycle, and in relation to the matrix of Eikelboom (2015), based on Carton (2007) that couples tasks, tools and the stages in the adaptation framework for spatial adaptation.

5. CASE STUDIES

INTRODUCTION

The research question, "What is the role of PSS in urban development projects in the Netherlands in relation to Urban Strategy and the MKP-MapTable?" is outlined in this chapter in relation to the evaluation framework presented in the previous chapter and in relation to the theoretical framework concerning systems theory.

Four case studies were executed using two different PSS: the MapTable (of Mapsup), a PSS connected to a touch table, and Urban Strategy, a recently developed PSS by TNO.
The first two cases review the application of Urban Strategy in the 'Smart Urban Mobility Plan Tilburg' and 'Healthy Urbanisation Utrecht'. The cases of the MapTable describe and analyse the application of the MapTable in the Province of Utrecht at the Municipality of Woudenberg and Municipality Stichtse Vecht.
Unfortunately, no users of the serious games of Tygron consented to contribute to this research. Therefore, this case study is executed on the basis of semi-structured interviews with developers of Tygron and a secondary data analysis. This is further complemented by semi-structured interviews with Planmaat and Play the City.

The cases start with general information about the PSS, followed by the outcomes of the semi-structured interviews with the developers of the PSS. Subsequently, these results are analysed and discussed in the third section. Afterwards, the two case studies will be discussed into detail. The case studies start with a description of the project, and are followed by an explanation of the role of the tool in the process. This section will pay attention to the aim of using the PSS; the preparation for the workshops; and the content of the workshops. Subsequently the outcomes of the workshops are discussed. The indicators and data used for the workshops are outlined in the description of the tool. Afterwards, the user experiences are presented. These results are analysed and discussed, which ultimately leads to the conclusions. The conclusions cover a SWOT diagram of the PSS and recommendations for the developers and users of the tool.

CASES URBAN STRATEGY

INTRODUCTION

Urban Strategy is a planning support tool focused on visualising environmental effects of different spatial measures. A Dutch research institute, TNO, has developed the tool since 2005. Urban Strategy is developed to integrate different existing models, which were already in use by many municipalities in the Netherlands. These models are generally based on the statutory calculation methods. With their former traffic calculation model, TNO has discovered that there exists a high inefficiency in calculating the environmental impacts of a plan through different models, like calculation models related to noise, air quality, safety, energy use and costs. Because when one adoption to the plan was made, all the models needed to be adapted separately and the environmental effects needed to be recalculated. In order to solve this, TNO has built a medium that enables to connect the different existing models and databases with one interface. Urban Strategy is especially used for planning issues from a neighbourhood level to the regional scale. The 'Inter Model Broker' IMB communication framework forms the medium to combine the different models and databases, as is shown in figure 22, and is able to present the results of a wide variety of indicators in maps, graphs, and a 3D bird view (Te Brömmelstroet & Borst, 2012).

According to TNO, the medium and a strong computer is able to calculate the effects of an intervention way faster than existing models, allowing to answer questions immediately in an interactive workshop setting. Urban Strategy is mainly used by governmental organisations, but also by large construction firms like Arcadis, BAM and Dura Vermeer. Recently, the tool is regularly applied for mobility related planning issues.

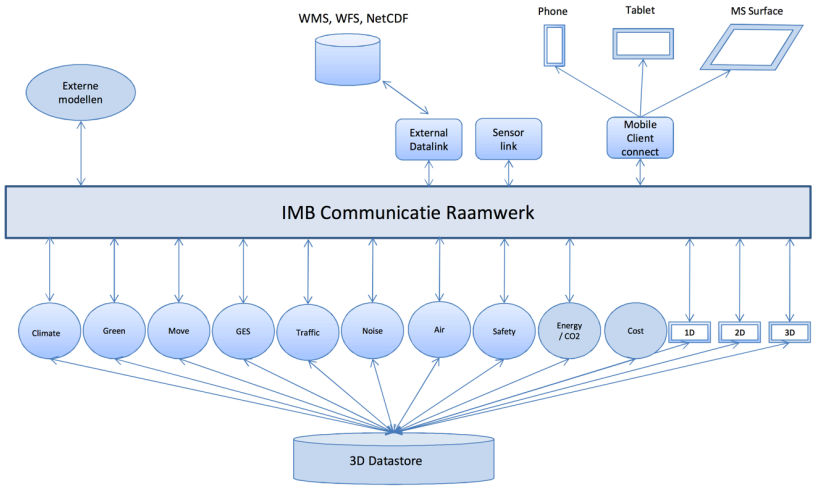


Figure 22 *Software architecture Urban Strategy (TNO)*

According to TNO, Urban Strategy is interactive, communicative, flexible, accessible and supports integral planning processes (TNO, 2015b):

- It is interactive as it presents the impact of measures immediately, whereby a multidisciplinary collaboration and a fast decision-making process is stimulated;
- It is accessible through workshops, tablets and computers;
- It is flexible as new indicators can be determined, and new models and databases can be integrated into the software architecture;
- It is communicative through the sophisticated visualisations via different mediums (graphs, maps and 3D view);
- And, it supports integral planning as impacts of different domains are shown in relationship to each other.

The tool is computer based, but the Urban Strategy software can also be offered in a light, web-based version when requested. This light version offers the basic functions of Urban Strategy and enables its users to consult the different map layers at a later stage.

The 3D interface of Urban Strategy generates, based on objects in the database, a 3D digital model of the urban environment. Different information layers can be added to this model, such as air quality contours, noise contours and groundwater levels. Additionally, the objects can be coloured according to their characteristics (function, energy use, CO_2 emissions, number of inhabitants, etc.). The 2D interface can be used by the end-user (or workshop facilitator) to add changes to the database. Objects can be added or removed, their location can be changed and the characteristics of the object can be adapted. The graphs show the measured indicators (TNO, 2015a). Examples of these different interfaces are shown in figure 23.

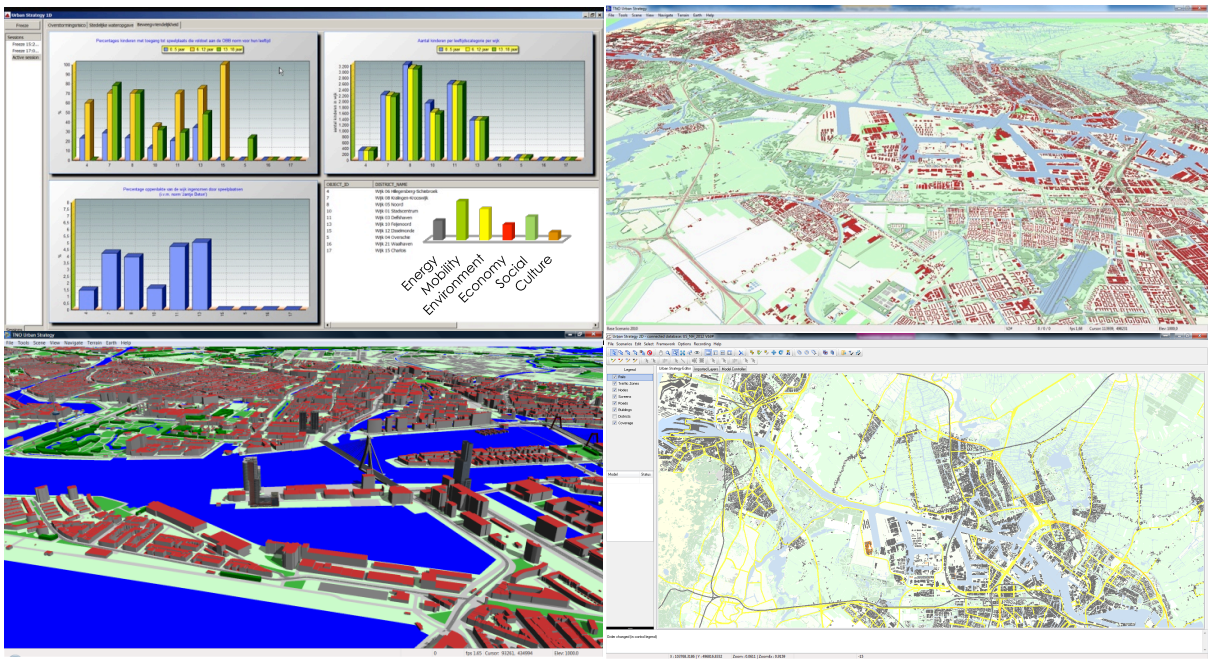


Figure 23 *Interface of Urban Strategy (TNO)*

RESULTS SEMI-STRUCTURED INTERVIEW DEVELOPERS

According to TNO, Urban Strategy is distinctive compared to other planning support tools by their speed, integrality and accuracy of the calculations. Urban Strategy is very accurate as it uses the statutory calculation methods with reliable governmental data. The results related to air quality are based on the same data and situation as the results related to noise nuisance. With the high calculation speed and with many different data sources linked to Urban Strategy, it is able to calculate and visualise many different scenarios and design variants in relation to different themes, enabling to answer questions immediately. This encourages stakeholders or different political parties to discuss the spatial topics, share their experiences and link different topics to each other. The integral approach of Urban Strategy facilitates different disciplines working together, while it is able to clarify truths and untruths of the discussions. The application of Urban Strategy is suitable for complex planning and policy-making projects. The complexity of projects is determined by its scale, project timeline, nature of the issue and the amount of stakeholders (Interview #11, Interview #15; TNO).

However, there are also a few constraints limiting the widespread use of Urban Strategy as mentioned by the research manager (Interview #9, Research Manager, TNO):

(1) Some urban planners see PSS like Urban Strategy, as a limitation to their freedom to use their creativity.
(2) Although the calculation time might take much longer, municipalities, consultants and other governmental bodies are already used to work with their own tool, with an own approach: They know how to succeed in decision-making by using these tools and might be contested to use new tools, as they might cause problems in the decision-making process and procedures.
(3) Furthermore, when people are familiar to their own tools, they might not want to work with a new tool, as they need to put effort in it in order to learn it. Furthermore, they might be afraid that they will loose their jobs, as the tool is able to calculate 1500 times faster than their own tools.

Also the Urban Strategy expert recognises the barrier for municipalities to get familiar with a new tool and a new way of working. Although there is a shift towards a more integral way of working, many municipalities are still working in a traditional manner whereby different disciplines are working separately at different departments (Interview #11, Urban Strategy Expert, TNO). Even though municipalities are aware of the benefits of a more integral and multidisciplinary way of working, it is not easy to change their work culture. As the Urban Strategy expert notes: "when people have attended a demonstration or workshop of Urban Strategy, they are often positive about it. But when they are going back at work in their working environment, they usually fall back in their old habits." Vonk (2006) pays attention to this barrier by using the Technology Acceptance Model.

According to the research manager, the best way to deal with these constraints is searching for 'early adopters': Parties who are willing to try something new and are able to increase their effectiveness and business by using Urban Strategy. In respond to such cases you can also convince other parties, ultimately leading to a snowball effect (Interview #9, Research Manager, TNO).

Besides the objections for applying Urban Strategy in practice, the tool also has some limitations. In order to calculate and visualise a wide variety of indicators over different themes and in different scenarios, much data is needed. It takes time to collect and load the data into the system, and the performance of Urban Strategy is dependent on the amount and quality of data available. However, because TNO is familiar with the calculation models used by the majority of Dutch municipalities, they are able to transfer the data from their calculation models into Urban Strategy in only a few days. Additionally, TNO knows which data is available at the municipalities and which data they need to run Urban Strategy. This data needs to be shared with TNO; consequently, TNO can adapt Urban Strategy to the specific spatial issue (Interview #15, Project Manager SUMP, TNO).

In addition to the statutory calculation methods, indicators are also made upon request of the client. Sometimes, new indicators need to be made in Urban Strategy in order to visualise specific topics. Before new indicators are processed into Urban Strategy, TNO and the client together need to make sure that enough and reliable data is available to measure the indicator, and that there is a clear connection between the measure and calculated effects. The creation of the mathematical connection between the data and indicator will take extra time, just as the collection and processing of additional data when this data is not already available (Interview #16, Project Manager SUMP, TNO).

As a limitation of Urban Strategy is that much data and preparation is needed to organise workshops and to match the tool to the specific project, TNO is trying to limit this preparation time by creating 'rules-of-thumb' or by applying rough assumptions when the effects of a measure cannot be quantified easily or when the data is not readily available. By using rules-of-thumb, questions can be answered by rough estimations, without the need for an extra bunch of data (Interview #15, Project Manager SUMP, TNO).
Often TNO can use the already available data to visualise extra indicators though.

Urban Strategy already exists for several years, yet TNO is still busy in maturing the software. Ambitions for further development of Urban Strategy are, next to the creation of more rules-of-thumb indicators, an increased online availability and increasing international applicability of the tool. TNO plans to increase the international applicability of Urban Strategy by also incorporating indicators related to foreign building legislation. When Urban Strategy would better online available, it can be connected to real-time data sources, by which it can form a city dashboard whereby politicians, civil servants, and potentially also inhabitants and private companies can get insight into the actual situation of a city. TNO experiences that municipalities are often not aware of what data is already online available and how they could use that data sources for policy making and planning.

Especially the link to real-time information is relevant, as in general cities are experiencing little issues when you are looking at annual standards. However, annual standards do not present peak loads and temporary traffic jams, while real-time data can provide insights into these issues. As the project manager of TNO (Interview #15, Project Manager SUMP, TNO) explains: *"Actually you want to know how we can translate these operational issues into different standards? And how can we solve these operational issues on a short term? This means that the different strategic and operational levels are getting more intertwined."*

As mentioned in the introduction the majority of projects that have been executed recently in Urban Strategy were mobility related projects. This can be explained by the financial crisis since 2008. Many urban area projects were cancelled, while the government kept investing in infrastructure by which they supported the construction firms who were experiencing tough times. Moreover, environmental related themes are an important constraint for infrastructure projects as they often result in a greater capacity for traffic, resulting in greater noise nuisance and air quality problems. Urban Strategy is well able to analyse these environmental challenges. The linked calculation models of Urban Strategy focus on grey environmental themes, like air quality, noise nuisance, traffic and external safety. These themes are often causing one of the core problems of spatial planning as you need to make sure that your plan achieves a certain environmental quality in order to abide the Dutch building regulations and get permission to build (Interview #9, Interview #11; TNO).

Much of the work TNO does, is related to giving advice on a certain spatial issue. The operation of Urban Strategy and the workshops organised with the stakeholders, form only a minor part of their job. Much of the decision-making takes place external to the workshops. Furthermore, TNO is often hired by only one stakeholder. This way, that stakeholder is better prepared in solving a certain issue, but as a result Urban Strategy does not cover the interests of all stakeholders. Most of the times TNO's clients are governmental bodies. Therefore, TNO experiences frequently that there are many political interests behind the questions politicians ask (Interview #11, Urban Strategy Expert, TNO). Urban Strategy is not per se related to top-down or bottom-up urban development processes. However, the research manager outlines that in case of top-down processes the finance of the project can be organised more easily (Interview #9, Research Manager, TNO).

Although, the calculation models of Urban Strategy are prominent, TNO has become aware that the tool is secondary to the process wherein the client uses it (Interview #9, Interview #11, Interview #15; TNO). The research manager explains that the research of Peter Pelzer and Marco te Brömmelstroet, made them aware of the importance of the design of the workshop. The workshop is guided by TNO by a workshop facilitator, an operator who operates Urban Strategy and some experts explaining the visualisations. Though TNO has the ambition to offer Urban Strategy as software on the market, by which parties can use the model by themselves.
At present, only large construction and consultancy firms like Dura Vermeer and Arcadis are making use of Urban Strategy independently of TNO. Whereas Arcadis is using Urban Strategy during the design phase to visualise the effects of a certain design, Dura Vermeer especially uses Urban Strategy during the construction phase; for instance, for making sure that the neighbouring people experience the least possible nuisance during the construction of buildings and infrastructure. TNO themself is using Urban Strategy mainly for visualising the current situation and prospected situation of an area during the initiation phase (Interview #11, Urban Strategy Expert, TNO).

Currently the question from the client is central, whereas TNO used to place the tool central in the workshop. Additionally, the touch table has created a more interactive setting: it encourages a different way of working by which stakeholders are getting more involved into the process (Interview #9, Research Manager, TNO). This made Urban Strategy also suitable for citizen participation, as the research manager explains about the western bank connection project in Rotterdam (Interview #9, Research manager, TNO): *"because we can calculate on the spot, people felt that they were being heard."*

ANALYSIS AND DISCUSSION

According to TNO, great savings can be realised by the way of working with Urban Strategy. Although the traditional way of working with different models versus working with Urban Strategy will deliver the same information in the end, working with Urban Strategy will speed up the process. However, Urban Strategy still requires significant preparation times.

The extent of interactivity and participation of users used to be limited as the workshop facilitator operates the tool. However, TNO became aware of the importance of interactive workshops by research of Peter Pelzer (2015) and Marco te Brömmelstroet (2010a). Currently, they use Urban Strategy in combination with a touch-table, which is comparable to the hardware aspect of the MapTable. This touch-table enables a more interactive setting. However, a facilitator and operator of TNO are still needed to use the software due to its complexity.
Another change in the workshop setting is related to the shifted focus on the process instead of the tool. This corresponds with critical evaluations of planning support systems, as mentioned in the literature review, stating that too much focus was put on the technology instead of the process.

Although Urban Strategy has a great accuracy in calculating the effects of measures, not everything can be visualised in Urban Strategy. Implementing new indicators and new calculation rules take a lot of time, just as the collection of the data into Urban Strategy. While a limitation of Urban Strategy is that the tool focuses on grey environmental themes, the incorporation of more themes will also have disadvantages. It will increase the complexity of the tool, the calculation speed and the preparation time to collect the needed data. Furthermore, extra indicators can be a distraction from the key problem of a certain spatial issue. It becomes less clear which indicators are more relevant than others in solving the problem. For (potential) clients, it is good to be aware that social and economic aspects are underexposed in Urban Strategy. One of the ambitions of TNO was to incorporate more economic indicators into the software. However, next to indicating the costs, it is also important to indicate the benefits of a measure in monetary value. This is very difficult as the costs and benefits are largely dependent on the specific project and the changing market conditions. Real-time data sources can provide a solution for this in the long term, as it can make comparisons between the project and similar projects in the neighbourhood feasible.

Although the guidance from TNO in using Urban Strategy offers many benefits, it is also a barrier for parties to use Urban Strategy in their projects. The tool is only accessible via TNO, whereby the use of the tool forms only a minor part of the total guidance and advice that they can deliver to you. Since it takes a lot of effort to adapt Urban Strategy to the specific situation and as TNO will guide the process and workshops, the costs of using Urban Strategy might be high. Therefore, it is essential to be aware of the benefits and limitations of using Urban Strategy, before you decide to use it. Additionally, some parties may not prefer including an external party in their process and will therefore not be eager to use Urban Strategy.

CASE 1: URBAN STRATEGY: 'SUSTAINABLE URBAN MOBILITY PLAN TILBURG'

DISCRIPTION OF THE PROJECT

During the initiation phase of the project, the Municipality of Tilburg has asked TNO to research the possibilities to adapt the municipal mobility and traffic plan to a Sustainable Urban Mobility Plan according to the guideline of the European Commission. The European Commission has started the Sustainable Urban Mobility Plan (SUMP) programme in 2010 in order to support cities in sustainable urban mobility and transport planning, resulting in a guideline for the development and implementation of Sustainable Urban Mobility Plans in 2013. A SUMP consists of the following elements:

1. Goals and objectives
2. A long-term vision and clear implementation plan
3. An assessment of current and future performance
4. The balanced and integrated development of all modes
5. Horizontal and vertical integration
6. Participatory approach
7. Monitoring, review, reporting
8. Quality assurance

These topics are already for a large extent covered by the municipal mobility and traffic plans (GVVP: Municipalitylijke Verkeers- en VervoersPlan) in the Netherlands. The Dutch municipal mobility and traffic plans can be improved on some parts, like themes related to climate policies and energy and the formulation of SMART (specific, measurable, achievable, relevant and time-bound) indicators. By using the SUMP guideline more policy fields are involved in creating the mobility plan leading to a more integral municipal mobility strategy and vision. This allows the traffic policy to be better integrated into other related policy fields, whereby objectives of different policies can be achieved at once. It is expected that the SUMP-compliance will eventually be a precondition for European co-funding.

THE TOOL IN THE PROCESS

Next to the content also the process for developing a SUMP is important. Citizen participation will form a significant aspect of this process. Citizens will be involved in setting up shared ambitions for the area, but also in evaluating the effects of different measurements by applying scenario analysis. The SUMP guideline involves the following steps (Eltis, 2015):

Step 1: Determine your potential for a successful SUMP
Step 2: Define the development process and scope of the plan
Step 3: Analyse the mobility situation and develop scenarios
Step 4: Develop a common vision
Step 5: Set priorities and measurable targets
Step 6: Develop effective packages of measures
Step 7: Agree on clear responsibilities and allocate budgets
Step 8: Build systems for monitoring and assessment into the plan
Step 9: Adopt the SUMP
Step 10: Ensure proper management and communication (when implementing the plan)
Step 11: Learn the lessons

Urban Strategy is applied for developing the first three steps of the SUMP. It has visualised the current mobility situation and expected future mobility situation of Tilburg in 2040. The relevant indicators are determined and the effects of possible measures to achieve the mobility vision are visualised. Subsequently these measures are prioritised and grouped to the different key themes of the vision. The key themes, possible measures and indicators are described in the notification of intent. This document will support the Municipality of Tilburg in the development of the SUMP by providing input to the city council, the SUMP steering committee, and probably also the inhabitants of Tilburg. It includes a wide range of possible measures and its predicted effects upon the city.
According to the SUMP guideline, the Municipality of Tilburg is planning to involve citizens, the university, and private companies in complementing the list of measures and selecting the suitable measures for Tilburg and in developing the vision further. It is not sure yet whether Urban Strategy will also play a role in these workshops, as it is dependent on the selected measures how suitable Urban Strategy is in visualising them and the notification of intent of TNO.

The SUMP project started for TNO at the beginning of June 2015 and the Urban Strategy workshop has been held on June 29, 2015. Due to summer holidays the closure of the project was planned on September 7. However, as some adjustments needed to be made in the notification of intent, the completion of TNO's part was delayed to the end of November. The closure of the project was delayed as Tilburg was not sure which steps they wanted to take and what they wanted to do with the notification of intent and the advice of TNO, but also because it took TNO much longer to finalise the notification of intent.

The Municipality of Tilburg has approached this project step-for-step. Based on the exploration of the mobility situation, the Future mobility situation, and the effects of possible measures, they will define the follow-up actions to develop the SUMP. When these follow-up actions are determined by the SUMP steering committee, they will decide which tools they need to execute these actions. This approach enables the municipality to be flexible and to respond on external factors. Just as the SUMP guideline advises, it is important to have a process-oriented approach in developing the SUMP in order to bring different parties and different disciplines together and reach consensus with public support. During the writing of the notification of intent, it appears that the (i) list of measures was too long, (ii) that some measures were not defined strictly enough, and that (iii) some effects of the measures were not visible in the calculations and visualisations as the effects were only visible at a local scale or at a certain time period. This needed to be adapted by TNO in consultation with the municipality (Interview #16, Project Manager SUMP, TNO).

There are several reasons why the Municipality of Tilburg has asked TNO to support them in starting up the SUMP development process. One reason is because of the integrality of Urban Strategy, as the SUMP guideline stimulates to integrate air quality and liveability into the mobility plan. Urban Strategy is able to incorporate these themes into the analysis, while OmniTRANS is not able to do that. The municipality could run their traffic calculation model and subsequently deliver it as input into their air quality model, but that will take much longer. Another reason is the political pressure on the project, as the alderman has committed himself to it. In such situations often external advice is desired in order to make sure that the project will be completed successfully. Furthermore, the Municipality of Tilburg earlier encountered positive experiences with TNO in earlier projects (Interview #17, Project Manager SUMP Tilburg).

THE AIM OF USING URBAN STRATEGY

The aim of using Urban Strategy was to research the possibilities to adapt the municipal mobility and traffic plan to a Sustainable Urban Mobility Plan according to the guideline of the European Commission. It has translated the strategic mobility vision of Tilburg into a list of specific potential measures of the Municipality of Tilburg in order to achieve that vision (Interview #16, Project Manager SUMP, TNO).

THE PREPARATION FOR THE WORKSHOPS

In preparation for the Urban Strategy workshop, the necessary data and maps are collected, loaded into Urban Strategy and analysed in relation to the mobility situation of Tilburg in 2015 versus the prospected situation in 2040. The Municipality of Tilburg delivers the data, as they have it already available. They have their own traffic calculation model, which is connected to Urban Strategy in order to present the same results as if they have been calculating the effects in their own model. It only takes a few days to run the traffic model in Urban Strategy, as the Municipality of Tilburg uses OmniTRANS Transport Planning Software just like the majority of Dutch municipalities. TNO is familiar with OmniTRANS and knows exactly which data they need in order to run the model in Urban Strategy. Urban Strategy is only able to calculate the effects much faster, it includes more indicators, and it is able to connect the effects of the mobility situation to other themes like air quality and noise nuisance.

After the first workshop, it appears that some measures could not be visualised in Urban Strategy, as there was not a clear connection between the measure and its possible effects or as there was limited amount of data available to calculate the effects. The data in Urban Strategy was largely transferred from the traffic model of Tilburg. Yet the current traffic model of Tilburg does not cover other modalities than car and truck traffic, which means that measures related to public transport, cyclists and pedestrians could not be visualised. However, more and more data about public transport and cyclists in Tilburg is becoming available, which could be used in Urban Strategy. These additional data needed to be gathered and loaded into Urban Strategy for the second workshop with the city council. Additionally, the Municipality of Tilburg had only data available looking forward to 2023 instead of 2040. When no, or not enough, data was available assumptions were made about the effects of the related measure.

THE CONTENT OF THE WORKSHOP

As stated in the mobility vision for 2040 of the Municipality of Tilburg, the sustainable approach to mobility and transport planning includes the following aspects:

- A system that can support the future economic structure;
- Optimal connections between different transport modes, both for passengers and goods;
- Increased use of green energy and a modal shift to more sustainable mobility possibilities;
- Minimising noise, odour and emissions as much as possible.

To visualise the effects of potential mobility measures, indicators are identified that can present these effects. During the first Urban Strategy workshop on June 29, 2015, potential measures for the SUMP are listed and prioritised with three experts of TNO and four experts of the Municipality of Tilburg. Secondary to the SUMP steering committee, the SUMP workgroup executes the tasks. The SUMP steering group communicates the status of the project towards the councillors and the department of traffic and transport. Expert groups in the workshop covered the areas transport, mobility behaviour, regional economy, air quality, and the environment.

The first workshop was an exploratory workshop with a brainstorm about the relevant indicators and measures. The second workshop was held with the city council and department of traffic and transport. Five experts of TNO attended the workshop and 12 councillors and experts of Tilburg. Martijn de Kievit is the project leader from TNO and facilitator of the workshop; the Urban Strategy expert attended the workshop as the operator of Urban Strategy; and three experts of TNO in the field of air quality, mobility behaviour and economics attended the workshop. The second workshop aimed to inform the councillors about the content of the SUMP process; the aim of Urban Strategy in this process; and the state of affairs of the notification of intent. After a demonstration of Urban Strategy of the used indicators and the already visualised measures, councillors got the opportunity to ask questions, to devise additional measures and to discuss the project with the experts. The second workshop was quite interactive as the councillors of the Municipality of Tilburg were able to use the touch table themselves leading to discussions about the usability of Urban Strategy, opportunities for the SUMP and potential measures that can be evaluated with Urban Strategy. The experts were only presented in the background to comment on questions or when political interests leaded to unfeasible ideas. The intention of the workshop was not to discuss the topics with experts, like in the first workshop, but with politicians (Interview #15, Project Manager SUMP, TNO).

To limit the calculation time during the workshops, the calculations are based upon Top10NL data. The calculations before and after the workshop are based upon BAG data (key register for addresses and buildings).

THE OUTCOME OF THE URBAN STRATEGY WORKSHOPS

The workshops have clarified the mobility situation of Tilburg and the opportunities for mobility and transport in the future. It appears that there were no major mobility related problems in Tilburg at the moment, which enables the municipality to improve the transport network above standards (Interview #16, Project Manager SUMP, TNO).

The list of measures and indicators that is appointed during the first Urban Strategy workshop is shown in appendix J. The measures are grouped per aspect; are prioritised with a score between 0 to 8; and are checked whether the effects of these measures can be calculated and visualised in Urban Strategy. The list of measures covers all aspects of a sustainable traffic and mobility system: sustainable transport, transport behaviour, ICT, and logistics and economy. The sustainable transport aspect covers the measures for sustainable transport modalities and facilities for sustainable vehicles; transport behaviour covers the measures aimed at influencing choices of motorists and businesses; ICT involves measures aimed at unlocking data, service development and provision of information to users; and logistics and economy covers the measures aimed at logistics, the accessibility and economic performance of Tilburg.

The effects of these listed measures are visualised in Urban Strategy during the second workshop. Based upon these measures, different scenarios are visualised and additional measures were calculated. Urban Strategy especially gave insights into the relation between air quality, noise nuisance and traffic. Furthermore, TNO has tried to clarify the relation between traffic and economic vitality.
Martijn de Kievit for instance explains: when the travel times between certain areas will increase due to mobility measures, the accessibility will decrease, which often means a decline in the economic attractiveness of that area (Interview #15, Project Manager SUMP, TNO).

After this workshop, TNO has written a report, a notification of intent, including advice how the Municipality of Tilburg can adapt their municipal mobility and traffic plan to a Sustainable Urban Mobility Plan and about what are the constraints and opportunities of Tilburg to improve the sustainability of their mobility situation. The notification of intent also covers a kind of catalogue of possible measures and their predicted effects. This created a translation of policy making from the strategic level to the operational level. It increased the insight of Tilburg into their possibilities to deal with the traffic and transport through their city and into which part of the liveability of the city they are able to influence and which part not. For instance, the air quality depends not only on the mobility situation and the measures of the municipality, but also on other factors.

A PC-based interface of Urban Strategy Light is installed, by which the municipality can consult the used maps and visualisations of different measures. Urban Strategy Light can also be used during meetings with citizens and private parties of Tilburg during the next phase of the SUMP development process. It is not sure yet whether the Municipality of Tilburg desires an online version of Urban Strategy Light, instead of a PC-based version. This web-based version can be publicly available by which the citizens and private parties are also enabled to consult the maps and visualisations of different possible measures (Interview #16, Project Manager SUMP, TNO).

DESCRIPTION OF THE TOOL

In Urban Strategy especially the indicators related to traffic, air quality and noise nuisance are used. In relation to air quality the NOx, PM10 and CO emissions are calculated and visualised in relation to different measures and scenarios. The CO_2 emissions could not be visualised as data to calculate CO_2 emissions were not available.

USER EXPERIENCES

The SUMP project manager (Interview #17, Project Manager, SUMP Tilburg) has experienced Urban Strategy as a great tool to visualise the mobility situation of Tilburg and to translate the impacts of different measures to different disciplines and people with different backgrounds. Additionally, he recognised that the city councillors were impressed by the possibilities of Urban Strategy. The political background of the councillors was evident during the workshop, but as Urban Strategy was able to show them the effects of different political choices, the councillors gained an increased understanding on which points they share interests whereby they are able to make a considered decision. Also TNO mentioned this in the interview (Interview #15, Project Manager SUMP, TNO). Furthermore, the use of Urban Strategy stimulated discussions between different disciplines about the mobility and livability situation, by which an integral approach to the SUMP was encouraged. They were able to discuss what the results in theory would mean for Tilburg in practice, as everyone was present in one room. At last, the visual presentation of the measures and different indicators were easily comprehensible and clear.

According to TNO, councillors are not per se experts in spatial planning, but represented citizens from the society who are performing all kinds of roles. Some councillors therefore have more knowledge in spatial planning and mobility than others. Therefore, the councillors can learn new things during the workshop (Interview #15, Project Manager SUMP, TNO). TNO tried to avoid political discussions and tried to explain the mobility situation objectively during the workshops. Martijn de Kievit argues that councillors should have political discussions with each other in the council chamber, but not at an Urban Strategy workshop (Interview #15, Project Manager SUMP, TNO). Moreover, in order to use the limited time as efficient as possible, TNO has asked the attendees to assume that the indicators are measured correctly and that Urban Strategy is based on reliable data (Interview #15, Project Manager SUMP, TNO). However, this contradicts the experience of the users.

The SUMP manager for instance argues that the second workshop could have been organised more interactively: "It was a shame that TNO was trying to convince the councillors of the benefits of Urban Strategy more over just using it interactively. TNO was steering the workshop too much, while it would be better to just ask the councillors if they have any questions about the mobility situation of Tilburg." (Interview #17, Project Manager, SUMP Tilburg).

Additionally, the finalisation of the report of TNO took much longer than expected. The value of the document decreased by this delay, as city councillors cannot remember clearly anymore what has been discussed during the workshop. The greatest challenge in writing the document seemed to translate the technical details into a comprehensive story that is understandable to both experts, city councillors and inhabitants.

Furthermore, some presented indicators were not convincing and raised questions of the traffic experts of the Municipality of Tilburg, whereby the experts of TNO were not always able to answer those questions. Therefore, the interim SUMP manager had the feeling that the tool was still in development. Also TNO foresees improvement of Urban Strategy in sharpening the indicators and adapting the tool to the needs of the client (Interview #15, Project Manager SUMP, TNO).
Despite the fact that the Municipality of Tilburg had not enough data readily available to calculate the expected effects of the measures up to 2040, TNO could deal with that by using their experience-based knowledge and rule-of-thumbs. This was valuable input for the process (Interview #17, Project Manager, SUMP Tilburg).

According to the interimmanager, it would have been better if the municipality had asked several parties for advice to compare their offers before deciding to contract TNO for it. The municipality has asked TNO for an offer based on earlier experience, but they should pay more attention to what exactly they wanted to achieve with Urban Strategy before deciding to apply the tool in their process (Interview #17, Project Manager, SUMP Tilburg).

ANALYSIS AND DISCUSSION

Despite TNO was able to visualise the situation of Tilburg in 2040 by rules-of-thumb and experience-based knowledge, it is wise to ask yourself what is the relevance of looking forward to 2040 instead of 2023. Due to the dynamic context of the spatial environment, it is difficult to predict the future. Therefore, it is evident that the predictions in the far future will be much less reliable by which things might happen differently than predicted. It differs per municipality how far they will look forward to determine their strategy. In this case, the Municipality of Tilburg wanted to look forward to 2040 to 51lign the SUMP to their strategy for Tilburg 2040.

Although the calculation models of Urban Strategy are quite complex, it can be concluded that the users understood the way in which the indicators are measured. This is partly caused by the choice of TNO to show primarily explicit indicators that are clearly visible and easy understandable. Additionally, although their list of indicators and possible measures is long, they only show a few relevant indicators during the workshop. TNO chooses not deliberately which indicators are shown during the workshops. This is rather based on their experience that showing fewer and more explicit indicators will limit the discussions about irrelevant topics. When users had questions about the way the indicators are being measured, TNO was able to explain this to them, though this was not always convincing.

In this case study it became appearant that the workshop was only a minor part of the work that TNO has done for the Municipality of Tilburg. The users' experience of TNO was negatively influenced by the long delay of the notification of intent. This highlights that the context wherein the tool is used, has a crucial role in how the users experience the PSS.

CASE 2: URBAN STRATEGY: 'GEZONDE VERSTEDELIJKING UTRECHT'

DISCRIPTION OF THE PROJECT

Healthy Urbanisation ('Gezonde verstedelijking') is a research project executed by Rijkswaterstaat, by order of the Ministry of Infrastructure and Environment.
In the meanwhile, the programme is changed to Smart and Healthy City ('Slimme en Gezonde Stad'). Healthy Urbanisation is one of the five connecting themes between the Environment branch of the Ministry (formerly VROM) and the Infrastructure branch (formerly V&W). The Ministry of VROM (housing, spatial planning and environment) and the Ministry of V&W (Traffic and Water Management) are merged into the Ministry of Infrastructure and Environment in 2010. The research project studies the health of Dutch cities in general, and the accessibility, safety and liveability of these cities in particular. The research started in 2011, resulting in a report in 2012. As illustrated in figure 24, many actors were involved in realising this research project (De Bont et al., 2013). As the research was still quite abstract new pilot projects were organised around this theme in Schiedam and Utrecht.

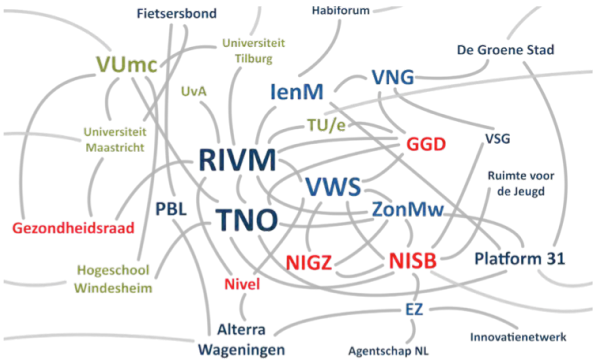


Figure 24 *A network of the involved actors (De Bont et al., 2013, p. 29)*

The project comprises different subprojects, including Healthy Urbanisation Utrecht. Rijkswaterstaat is the Directorate-General for Public Works and Water Management and the executive government agency of the Dutch Ministry of Infrastructure and Environment. For this case study, Rijkswaterstaat has used Urban Strategy for the design of urban principles for the redevelopment of the second phase of the railway station area and trade fair area ("Jaarbeurs") of Utrecht.

Urban Strategy was used during the initiation phase for gaining insights into the impacts of different urban designs upon health related indicators, like water, soil, energy and materials, ecology and biodiversity, land use, social relevance, welfare, accessibility, investments, business climate, and establishment climate for the population. The project resulted in an inspiration document and a toolbox with urban principles enhancing the health of cities.

For Healthy Urbanisation Utrecht, TNO is collaborating with other knowledge institutes active in Utrecht: RIVM, Deltares, Utrecht University and KNMI. Together they form the Knowledge Centre Healthy Urban Living (KC HUL). KC HUL plays a supporting and integrating role in policy issues around health and urbanisation of the Ministries of Infrastructure and Environment, Health, Home Affairs, and Economic Affairs. KC HUL is asked to participate in this programme in order to apply the knowledge of Healthy Urbanisation in practice.

On June 5, 2014, KC HUL has organised a morning around the theme Healthy Urbanisation to connect the supply of knowledge to the demand of knowledge. Rijkswaterstaat and the Municipality of Utrecht presented the pilot Healthy Urbanisation Utrecht during this event, and it appears that Urban Strategy fits the knowledge question around the pilot in Utrecht. After a demonstration of Urban Strategy at Rijkswaterstaat, the stakeholders were positive about the application of Urban Strategy. Especially when the Knowledge, Innovation and Strategy Directorate appears to be willing to finance the application of Urban Strategy for Healthy Urbanisation Utrecht. As Rijkswaterstaat executed the research pilot in Utrecht, TNO had close contact with them. The project area covers a part of the 'Stationsplein', the 'Jaarbeurs' area and the 'Westplein'. As shown in figure 25, this area covers a large part of Utrecht and is situated adjacent to the historical city centre.

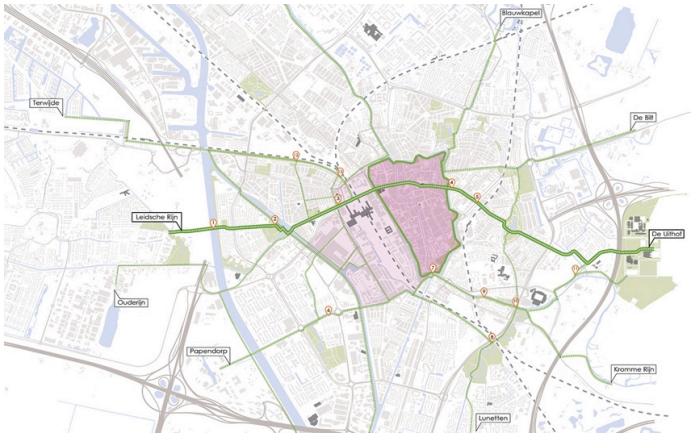


Figure 25 *Plan area city centre Utrecht (Posad, 2015)*

THE TOOL IN THE PROCESS

At first sight TNO would support the Municipality of Utrecht by including healthy urbanisation indicators in the development of a spatial strategy for phase 2 of the Central Station Area. This phase aims to connect the western side of the railway station with 'Westplein' and the Jaarbeurs area to the old city centre on the eastern side. However, there are many objections of citizens and private parties against the plans of the municipality, especially around the traffic situation at Westplein. Between 2010 and 2012 the Municipality of Utrecht has collaborated with citizens and private parties, who are represented by the development group 'Lombok Centraal', in order to develop a spatial strategy for the area. This has resulted in the spatial vision 'Lombokplein en Omgeving' in May 2012. Three different scenarios were sketched for the traffic situation of Westplein in this vision: a situation with a tunnel underneath a square, one without, and one situation with a combination of both variants. In the spatial vision of the Municipality of Utrecht, 'Utrecht Centre: a Healthy Urban Boost', which is published in March 2015, the municipality has chosen to not realise a tunnel, but a square with limited traffic to limit the costs of the project. This has led to many objections of the inhabitants and established companies in the area, who preferred to realise a tunnel.

The project with Urban Strategy in Healthy Urbanisation Utrecht ran from September 2014 until September 2015. The pilot project would include four elements:

1. An inspiration document in collaboration with KC HUL;
2. An urban draft design or toolbox;
3. A 3D virtual environment of the railway station area of Utrecht Central based upon the urban draft design;
4. A virtual excursion through the railway station area.

During the first workshop for Healthy Urbanisation Utrecht in January 2014, when Urban Strategy had not been applied yet, Rijkswaterstaat had organised an excursion to the station area with civil servants, citizens, companies and knowledge institutes. During that excursion, the project leader of Rijkswaterstaat noticed that the area was quite empty. Consequently, it was hard for the attendees to form a picture of what Healthy Urbanisation could mean for the station area of Utrecht. Hence, the project leader of Rijkswaterstaat wanted to organise a virtual excursion. Another thing that was noticed during that workshop was that people did not speak the same language; everyone considered Healthy Urbanisation from their own perspective. Therefore, KC HUL was asked to create an inspiration document to clarify in which ways you can look at Healthy Urbanisation. Additionally, Urban Strategy would be used to support the creation of the urban draft design and the virtual excursion. The research project Healthy Urbanisation Utrecht was planned to run parallel to the development of the spatial strategy for the second phase of the Central Station Area in Utrecht.

However, the spatial development strategy for the second phase of the Central Station Area was delayed, due to objections and because the Municipality of Utrecht was not sure how to organise this development process since they also wanted to involve citizens and businesses in the development of the spatial strategy.
This meant that TNO was not able to evaluate the urban draft design on the basis of health related indicators. Additionally, too little budget appears to be available to design different interpretations of Healthy Urbanisation Utrecht. Rijkswaterstaat had first high ambitions for sensing the different urban interpretations during a virtual 3D excursion with civil servants, citizens and private companies, but this idea was financially infeasible. There was only enough budget for the development of one urban design. But the Municipality of Utrecht was against the creation of a single urban design, as that will create the impression that that design will be realised. Furthermore, some design variants were already made for the area. Consequently, the Municipality of Utrecht has refrained themselves from actually making a new urban design related to the programme Healthy Urbanisation.

This also meant that the selected urban design firm Posad could not design an urban plan anymore. Instead, they were asked to design a toolbox with urban principles that promote a healthy environment and a healthy lifestyle. The difference between an urban design and urban principles is that the urban principles are not mapped on a certain area. Therefore, Posad did not design any floor plan of the area; they only created impressions of possible urban principles in the Central Station Area. As the calculations in Urban Strategy are dependent on the location and neighbouring areas of that location, TNO was not able to calculate the health effects of the design principles. Since Urban Strategy could not evaluate the urban principles, TNO tried to give the stakeholders insights into the effects of different possible measures in relation to healthy urbanisation in the station area. Additionally, the 3D virtual excursion could not be organised, as an urban design was not desirable. Therefore, TNO has organised a workshop with stakeholders of Healthy Urbanisation Utrecht wherein Urban Strategy is evaluated.

The application of Urban Strategy can be described in four phases:
The relevant health indicators are determined and described in Urban Strategy during the first phase. This task has taken place in collaboration with Posad. It appears that many of the relevant indicators were already available in Urban Strategy, like geo-information related to land use, green, water, buildings and infrastructure. This phase ended with the inspiration document of KC HUL.
The second phase identified obstacles and measures for healthy urbanisation. As the Municipality of Utrecht decided to refrain from designing an urban plan, urban strategy was not able to optimise a plan. Instead, TNO has optimised together with Posad the urban principles in relation to the project area. During the third phase, the usability of the indicators and measures are evaluated in a workshop with stakeholders. The fourth phase concluded the project with a report about the application of Urban Strategy for Healthy Urbanisation Utrecht to the Ministry of Infrastructure and Environment and other involved parties like the Municipality of Utrecht, Rijkswaterstaat and KC HUL. This report covers the usability of the urban principles for healthy urbanisation, including a description of used indicators and concerns around the further development of these indicators and urban principles.

THE AIM OF USING URBAN STRATEGY FOR HEALTHY URBANISATION UTRECHT

The aims of this pilot project were to collect design principles promoting a healthy environment and a healthy lifestyle, and to gather input for the spatial development of the railway station area in particular and for healthy urbanisation in general. The objectives of the application of Urban Strategy in this pilot were (1) to gain insight into the current situation of the Utrecht Central Station Area in relation to health indicators, (2) to gain insights in the effects of the possible design principles upon the Utrecht Central Station Area related to health indicators, and by doing that (3) also contributing to tools for Healthy Urbanisation in general.

THE PREPARATION FOR THE WORKSHOPS

New indicators were developed on the basis of 'Gezond Ontwerp' (De Bont et al., 2013) and the inspiration document of KC HUL (2015). Especially for this project slow traffic and modal split were incorporated in Urban Strategy, just as the accessibility in relation to the public transport stops. Furthermore, indicators related to the parking of bicycles, heat stress and shadow covered areas, and the accessibility of buildings for disabled people were determined as well. To visualise these indicators, new data needed to be gathered and provided by the Municipality of Utrecht. It took quite a lot of time to gather and process this data.

THE CONTENT OF THE WORKSHOPS

TNO has organised two workshops, next to the different demonstrations of Urban Strategy and the different meetings with Posad, in order to evaluate the effects of different possible measures on health indicators. Different people attended the workshops. During the first workshop the operation of Urban Strategy is demonstrated and the indicators are determined for measuring the health of urban plans. The used indicators are related to the clean city, safe city, exercising city, mobile city and green city.

During the second workshop the effects of the different measures on the project area were evaluated. This resulted in insights into the suitability of these measures in relation to healthy urbanisation for the station area. The following nine stakeholders have attended the second Urban Strategy workshop: a traffic expert of the Province of Utrecht, a Liveability advisor of the Province of Utrecht, the project leader of Rijkwaterstaat, a traffic advisor of Rijkswaterstaat, an advisor Mobility and Environment of the Municipality of Utrecht, a Traffic Noise advisor of the Municipality of Utrecht, the project leader of TNO, an account manager Smart Cities of TNO, and an Urban Strategy advisor and operator of TNO. The focus of the workshop was on mobility related aspects, as many of the attendees have a background in mobility, and as many health aspects are related to mobility. For instance, the consideration to walk or cycle to a facility instead of using a car or public transport depends on the accessibility of the facilities. After a short introduction, the project manager of TNO explained the role of Urban Strategy in the project and the Urban Strategy expert demonstrated the operation of Urban Strategy. Subsequently, the attendees discussed the usability of Urban Strategy for the Municipality of Utrecht, Province of Utrecht and Rijkswaterstaat. The workshop ended with follow-up steps.

THE OUTCOME OF THE URBAN STRATEGY WORKSHOPS

The Urban Strategy workshops have generated three main outcomes: (i) The knowledge question related to the criteria and tools was identified; (ii) insight into the impact of the urban principles upon the indicators related to Healthy Urbanisation was provided; and (iii) the usefulness of Urban Strategy for Healthy Urbanisation and other indicators like traffic was evaluated in a workshop with the stakeholders. The impact of the urban principles were analysed in collaboration with the Urban Planner from Posad. These outcomes were reported to the Ministry of Infrastructure and Environment, Rijkswaterstaat and KC HUL. The tangible results of the project were the inspiration document of KC HUL and the toolbox of Posad.

DESCRIPTION OF THE TOOL

The concept of Healthy Urbanisation can be structured on the basis of figure 26. The concept of Healthy Urbanisation is divided into four themes. The first theme pays attention to the preconditions for a healthy living environment: the clean city, the safe city and the climate adaptive city. The second theme pays attention to the organisation and structure of a city. This is an important theme that can encourage healthy behaviour: like the lively city, mobile city and green city. The third theme tries to improve the circularity of processes in the city, like waste, energy and food. Finally, the fourth theme looks at the liveable and economic vital city.

Figure 26 *10 archetypes of healthy cities (Platform Gezond Ontwerp, 2013)*

The 10 different examples of cities clarify the four different themes and offer inspiration in which way you can realise Healthy Urbanisation. Based upon the 10 archetypes of healthy cities, ambitions can be formulated, tasks can be inventoried, design principles can be established and spatial plan variants can be developed and evaluated (Platform Gezond Ontwerp, 2013).

For the pilot case in Utrecht, Urban Strategy especially paid attention to five archetypes of the first two themes: the clean city, safe city, liveable city, mobile city and green city. The majority of indicators were already available in Urban Strategy. Indicators that are used for the clean city are related to noise, air quality and other environmental indicators. The safe city covers indicators related to external safety, traffic safety, and social safety. The liveable city pays attention to the accessibility of facilities. The mobile city covers public transport, car and truck traffic, cyclists and pedestrians. And the green city pays attention to the amount of green and water in the area.
An overview of the indicators and a description of those that are used in Utrecht can be found in appendix K. The most important indicators for this project were related to the environmental quality of the area, like the air quality and noise nuisance, and the modal split of different means of transportation.

USER EXPERIENCES

The attendees of the workshop were gently excited about the comprehensive nature of Urban Strategy and about the visualisation possibilities of the effects of measures in Urban Strategy. Urban Strategy is seen as an added value for decision-making in mobility and health related themes. Urban Strategy enabled the stakeholders to quickly evaluate 20 variants and subsequently eliminate variants until the three best variants were remaining. The digital visualisations were seen as a benefit in relation to a stack of paper. Furthermore, the potential of applying Urban Strategy in co-creation with citizens or for citizen participation was recognised, as well as the accelerated decision-making and increased interaction between different disciplines. In general, Urban Strategy is experienced as a tool to address joint projects and to promote collaboration between Rijkswaterstaat, the Municipality of Utrecht and the Province of Utrecht.

The stakeholders were gently excited, as they desired some additions and adjustments to Urban Strategy. They would like to gain insights into the modal split, slow traffic streams and public transport like cyclists, pedestrians and bus transport. For instance, by having insight into the modal split the effect of a large bicycle parking upon the amount of cyclist versus public transport can be visualised. The traffic models and main roads needed to be updated as they were based on obsolete data from 2012-2013. During the evaluation workshop, TNO has used obsolete data to limit preparation time while still being able to show the stakeholders the possibilities of the tool as a ‘proof of concept’.

The stakeholders desired to have a greater insight into how the models work by organising a session with the traffic experts of different organisations, and how these models can be connected to each other. Additionally, they shared opportunities to improve the process of using Urban Strategy in practice. They stated that the tool should be easily accessible and useful to the users; the application of Urban Strategy should be embedded at the management level by showing them use-cases; and an alliance should be created between Rijkswaterstaat, the Province of Utrecht and the Municipality of Utrecht in order to be able to jointly work in one tool. Furthermore, the data streams can also be better aligned between the municipality, province and Rijkswaterstaat. Lastly, enhancing the insight of experts in the working of Urban Strategy was mentioned to stimulate them to use it.

Furthermore, because of his background, the project leader of Rijkswaterstaat (Interview #20, Project Leader GVU, Rijkswaterstaat) experienced Urban Strategy especially valuable for supporting the communication between different parties as it can visualise the impact of different measures upon their environment quickly.
This creates an interesting discussion between citizens, companies and the government as it creates awareness of the complexity and interdependence of different topics. For instance, when the speed limit of a road is decreased from 30 to 50 km/hour, the traffic will likely choose alternative routes that can lead to additional nuisance in other neighbourhoods; hence, it might be not a desired solution.

According to the project leader, the discussions about the spatial environment are often held between citizens and the government, while citizens should discuss with each other about possible solutions. Therefore, Urban Strategy is not only valuable for supporting the communication between politicians and civil servants, and between citizens and governmental parties, but also between citizens themselves. However, so far only experts have been attending the Urban Strategy workshops. Therefore, it would also be interesting to use the tool as simple as possible without the experts and only with the citizens and businesses from that area.

The project leader also notes that parties are often aware of the added value of using a tool like Urban Strategy, but that they are usually not willing to hire TNO for using the tool in their projects. In his interview he stated that: *"what might be problematic is that it costs quite a lot of money; TNO is not a cheap party"* (Interview #20, Project Leader GVU, Rijkswaterstaat).
However, it is understandable that it is expensive to use Urban Strategy, as it takes much time to gather the data and to adapt the tool to the specific spatial issue (Interview #20, Project Leader GVU, Rijkswaterstaat). Therefore, an improvement can be made by automatically gathering and processing data to limit the preparation time and to be able to adapt the tool to the specific case with minimal efforts.
Moreover, the project manager of TNO commented on this that "what perhaps might be behind such comments is that Urban Strategy might execute tasks that are normally executed by that department." These experts might have developed and operated their own model. Hence, they might not appreciate a new tool. Therefore, a tension exists between using Urban Strategy or their own tools. However, when clients have more faith in their own tools, Urban Strategy can also be connected to them (Interview #18, Project Manager GVU, TNO).
Likewise, the project leader mentions, in accordance with the SUMP project leader:
"When you want to use Urban Strategy, it is important to know beforehand for what purpose you want to use it and what you want to do with it, as that enables you to ask TNO more specifically for input, while they can limit the preparation times by only visualising the required input." This is something we still need to learn to do better (Interview #20, Project Leader GVU, Rijkswaterstaat).

At the beginning, Posad, together with TNO, ambitiously tried to use Urban Strategy to visualise the effects of different measures. But when it appears that it was impossible to make an urban design, Urban Strategy became actually much less useful for creating the toolbox. For instance, Posad looked at different types of users of the city and the way in which they use the urban environment. This was hard to visualise in Urban Strategy. Additionally, the inspiration document took somewhat longer than expected and was therefore of less valuable input for Posad (Interview #19, Urban Designer, Posad).

Futhermore, the urban designer experienced that it was a bit unclear what data were included in Urban Strategy and what data were not included: many indicators and data were not readily available and the data were often incomplete or not updated (Interview #19, Urban Designer, Posad).
TNO tried their best to fill the model with more data when needed, but that takes time. Additionally, he was missing financial indicators, for instance to determine the added real estate value of a building when a park will be realised adjacent to it (Interview #19, Urban Designer, Posad). When you can also present the financial feasibility of a design, the tool would be much more convincing. This way, an alderman can quickly understand what it means for him (Interview #19, Urban Designer, Posad).

As an urban design is made on a larger scale in comparison to a building design, it is sufficient to have insight into the costs and benefits on a larger scale. These costs and benefits are dependent on the project with its specific location and market situation. By benchmarking the project to similar projects on similar locations, an indication about the costs and benefits can be provided. Benchmarking can be done automatically by using online available real estate data (Interview #19, Urban Designer, Posad). However, this project was about the influence of an urban design upon health related indicators. So discussing the amount of costs to realise the urban design might distract the attention from analysing the effect of the urban plan upon health (Interview #19, Urban Designer, Posad).

Though TNO has shared some useful insights with Urban Strategy. The urban designer notes that Urban Strategy together with the touch table can encourage interaction between groups of designers. However, designers often prefer to first think independently of others about a possible solution and the way in which that solution can work out, before they share it with others (Interview #19, Urban Designer, Posad).

According to the project leader, Urban Strategy is particularly suitable for difficult processes with many stakeholders, as it provides insight into the fact that the overall problem is bigger than their individual interest. Whereas people are normally against or in favour of a plan, the application of Urban Strategy stimulates a discussion between stakeholders. The speed of the tool is a great benefit as it provides insights into many different aspects with different stakeholders. When they understand each other's interests and problems, it will lead to support to realise a solution (Interview #20, Project Leader GVU, Rijkswaterstaat).

However, according to the urban designer, the tool is not very useful for creating different design variants: *"It does not work as good as using sketch paper. They need to adjust quite a few settings for every action, and with Urban Strategy you are dependent on the digital medium. Therefore, I think that sketching is the fastest way to communicate an idea and also for just organising your own thoughts. You can have many tools available, but if you do not know what you want to do with it, you cannot get any results. The ideas are generated by a connection between design and analysis in your head. You cannot use a tool to make design proposals."* (Interview #19, Urban Designer, Posad)

Nevertheless, the urban designer also mentions that Urban Strategy was valuable to visualise the possibilities and constraints of an area at the beginning of the project and for evaluating design variants or scenarios after they had been created. Whereas designers currently try to visualise the future with renders, Urban Strategy can visualise the effects of a design in greater detail. Additionally, Urban Strategy is able to quickly connect different sources to each other by placing layers on top of each other at the beginning of the project.

Hence, it is valuable for presenting certain layers of information, which can clarify the constraints and opportunities of an area. It is important to do this at the beginning of the process, as this enables the designers to take the available data and information into consideration.
When the current situation is quickly visualised, the designer can use the same data for designing possible solutions and for evaluating the design by Urban Strategy at a later stage. This way, the designer can understand more accurately the spatial issue of a certain place and is therefore better able to design a suitable solution. It is important to use Urban Strategy repeatedly during the process in order to organise the use of data consequently during the whole process. Otherwise, you are evaluating the design in different ways on different moments (Interview #19, Urban Designer, Posad).

Furthermore, the urban designer experienced the traffic model as a strong element of Urban Strategy, whereby the influences of different measures related to mobility are quickly visualised (Interview #19, Urban Designer, Posad). But, in general, the use of Urban Strategy has not had a great impact on the results of Posad. However, as the urban designer states: *"You never know by what things you are triggered during the design phase. I think brainstorming and watching what is possible, have created a greater understanding of the smart moves and impossibilities. But it was not of decisive importance for the design of the toolbox."* (Interview #19, Urban Designer, Posad). Additionally, he mentions that it was good to try the use of Urban Strategy in order to find out if it is useful for you: "I think we have got a good impression on what the tool has to offer us" (Interview #19, Urban Designer, Posad). He also foresees that everyone will be working with tools like Urban Strategy in the near future, just as he would like to use it in other projects as well. Yet, usually Posad is not in the position to hire TNO; TNO is typically hired directly by the client, and as advice from TNO is costly, only big projects with enough financial resources are qualified (Interview #19, Urban Designer, Posad).

According to the project leader, Urban Strategy can be used in different types of projects, because the tool is very versatile. Just as the urban designer, he points out that Urban Strategy can be used at different phases of the process: during the exploration of the spatial issue and during the construction phase. This way, the tool will be much more accepted by the stakeholders, as it is more interwoven in the process and as people are becoming more familiar with the tool, by which they might also use it independently of TNO. According to him, a project team member for instance could manage the data in the tool. And as Rijkswaterstaat has a capacity of noise, traffic, air quality and also GIS experts, it might be possible to educate people in operating and managing Urban Strategy (Interview #20, Project Leader GVU, Rijkswaterstaat). The project manager of TNO recognised this interest and noticed that this is often an important question of users (Interview #18, Project Manager GVU, TNO).

Rijkswaterstaat also owns MapTables. The project leader notes that attendees of information meetings or workshops are very interested in the MapTable and that it encourages a dialogue between the attendees. However, He did not think about using the MapTable instead of Urban Strategy as the financing of Urban Strategy was offered by another party (the Knowledge, Innovation and Strategy Directorate).

Although the project leader has high ambitions in using Urban Strategy, he is aware that the most important aspect is the way you approach a project: that the citizens are involved and regularly informed about the progress, and that the discussion will take place between citizens instead of citizens and the government. The project leader notes that the mutual game approach is well suitable for this kind of discussions. Currently, projects need to deal with a peak of reactions and objections after formal moments of communication; for instance, after the publication of an urban design. Instead, this discussion might be held continuously online in the future.

This way, civil servants can react on the discussion of civilians by delivering input when a certain topic is unclear. Therefore, the project leader concludes that: *"So I think that the perception of the role of the government and the way to discuss spatial issues between different parties is way more relevant than a PSS"* (Interview #20, Project Leader GVU, Rijkswaterstaat).
Additionally, it is important to decide to which extent you want to involve citizens. Besides, when more parties are using PSS it is important to align these models to make sure that the different models used are producing the same results (Interview #20, Project Leader GVU, Rijkswaterstaat).

ANALYSIS AND DISCUSSION

It has become clear that the political environment of spatial planning and policy making heavily influences the project of SUMP Tilburg. The process is quite complex because of the many external influences, like the delay of the urban development strategy, but also due to the many involved actors. Although the Knowledge, Innovation and Strategy Directorate has contracted TNO for the application of Urban Strategy and even though the project was executed in relation to a development project of the Municipality of Utrecht, they had the closest contact with Rijkswaterstaat because of the research programme. It appears that some health indicators were difficult to measure, like comfort. As the inspiration document emphasised: Health is not only influenced by the environment of people, but also by their lifestyle. It is therefore questionable whether Urban Strategy was the right tool to visualise health effects of urban designs, as their calculation models are especially related to environmental indicators. Additionally, it is recognised that social and economic indicators are underexposed in Urban Strategy, while these indicators do play a major role in Healthy Urbanisation. For instance, two out of four proposed quadrants by KC HUL related to Healthy Urbanisation are associated with a social living environment and the regional economy.

Another remark is that Posad did not know beforehand that they were expected to collaborate with TNO and to use Urban Strategy to improve their toolbox. The inspiration document of KC HUL was meant to deliver input for the toolbox. However, this document was completed fairly late in the process. Therefore, Posad could not really anticipate on it. As both TNO and Posad agree, it would have been better if their tasks had been more intertwined.

According to the project manager of TNO, the moment at which Urban Strategy is used, at the beginning of the process, was beneficial, as normally plans are only evaluated in relation to health and environmental indicators at the end of the design phase when the possibilities to change the design are limited (Interview #18, Project Manager GVU, TNO). By applying Urban Strategy at an early phase of the process, the ambitions of the project are evaluated in a comprehensive manner and the urban design can be still adapted by which a more thorough design can be realised. However, when looking back at the process it appears that the application of Urban Strategy was not very useful as there was no design to evaluate yet. However, TNO did not know beforehand that the design of the urban development strategy of the area would be delayed. Also, when the urban development strategy will be completed soon, Urban Strategy can be used quickly as the data and indicators to evaluate the design are readily available. Furthermore, Urban Strategy did add value to the project by creating insight into the current situation, whereby the constraints and opportunities of the area are visualised. Additionally, it was a great opportunity for TNO to show the possibilities of Urban Strategy to a wide range of stakeholders: the municipality and Province of Utrecht, Rijkswaterstaat, Ministry of Infrastructure and Environment,and KC HUL partners. This might lead to new projects for TNO. Hence, The project manager of TNO was satisfied about applying Urban Strategy for Healthy Urbanisation Utrecht, although he recognised that a specific implementation of the tool was missing in the project (Interview #18, Project Manager GVU, TNO).

The discussion of the toolbox at a workshop at the Municipality of Utrecht ('Ruimte ontmoet Gezondheid') illustrated that by visualising the connection between spatial development and health, different disciplines became more aware of their impact on each other (Interview #20, Project Leader GVU, Rijkswaterstaat). According to the project leader, the application of Urban Strategy was too limited to draw any conclusions on whether it really has supported the connection between spatial development and health in the research programme compared to the toolbox of Posad.
TNO has supported Posad in the development of the toolbox, but both parties agreed that they could have offered each other more support when the process was executed differently. However, the project leader intends to use Urban Strategy at a later stage when the spatial development strategy of the municipality is ready and when the 3D virtual excursion can still be organised (Interview #20, Project Leader GVU, Rijkswaterstaat). However, it is questionable if enough resources will be available to realise this at a later stage.

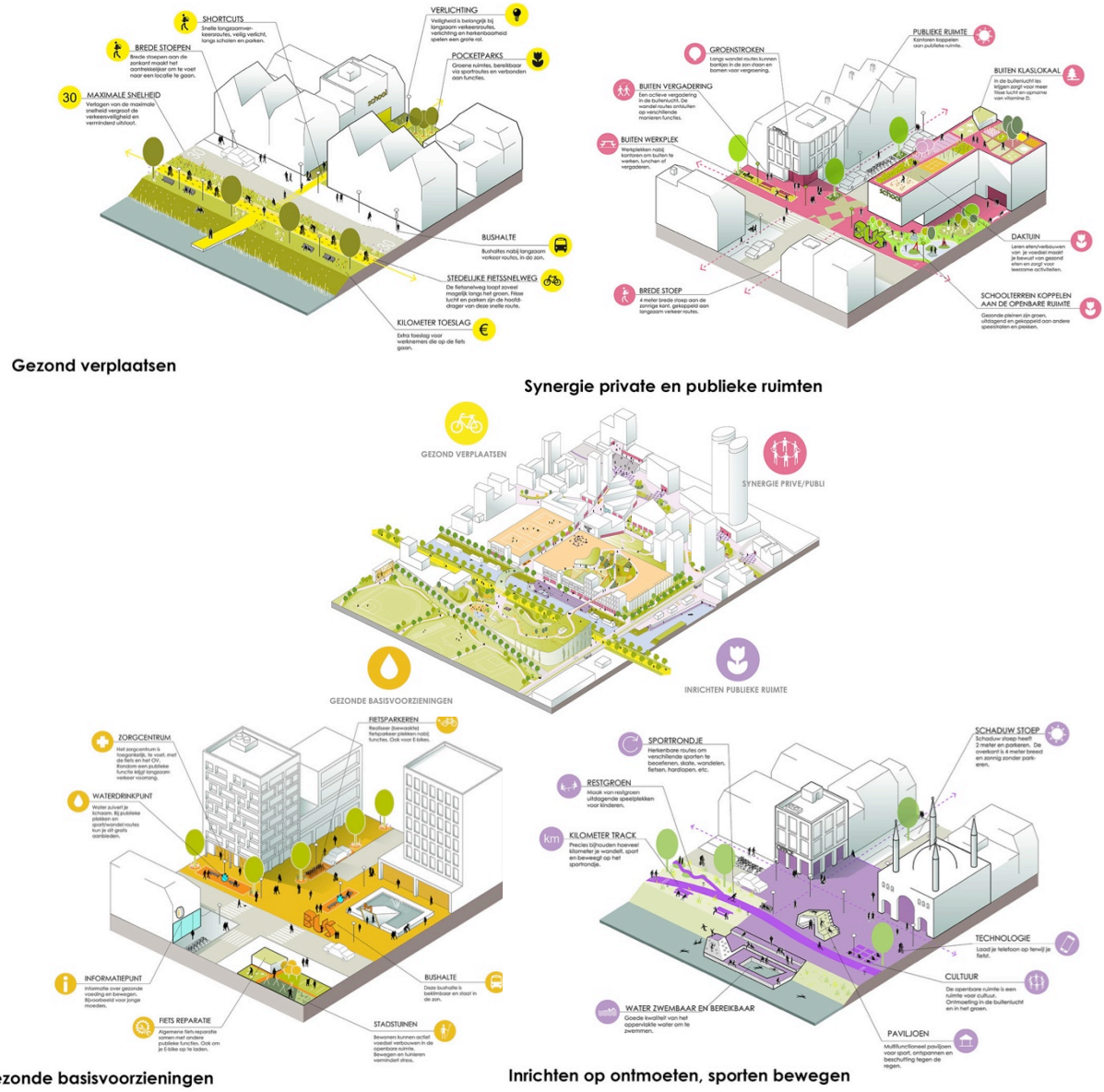


Figure 27 *Outcome of the project: design principles supporting healthy urbanisation (Posad, 2015)*

CONCLUSION CASES URBAN STRATEGY

Urban Strategy is a planning support tool developed by TNO since 2005 that focuses on visualising environmental effects of different spatial measures. A SWOT analysis of the tool based upon the two case studies is mentioned below.
Urban Strategy is particularly suitable for difficult processes with many stakeholders as it provides insight into the fact that the overall problem is bigger than their individual interest. Whereas people are normally against or in favour of a plan, the application of Urban Strategy stimulates a discussion between stakeholders about the effects of a plan upon their interests, which creates a mutual understanding of a problem and encourages acceptance of the plan when it takes all interests into consideration.

Urban Strategy can be used at the different phases of the process: (i) during the exploration of the spatial issue; (ii) during the initiation phase by determining relevant indicators and the necessary data; (iii) during the design phase by evaluating different designs and executing scenario analysis; and (iv) during the construction phase by planning and monitoring the building process, and by informing the involved actors about the progress of the project. TNO would like to apply Urban Strategy as early as possible in the development process. The tool can be more extensively used this way, enabling TNO to generate a greater business result. Especially mobility related projects are interesting to evaluate in Urban Strategy, as traffic flows generate data about, among others, the crowdedness, the related noise nuisance and the air quality.

However, during the exploration phase a tension exists between the application of the tool whereby much data is needed and the unavailability of this data as not much is known yet at the beginning of the project. The availability of data is a precondition to work with Urban Strategy. In case of Healthy Urbanisation Utrecht, the final report was actually completed too late in the process. Posad was therefore not able to incorporate the results of the report into their toolbox anymore.
As the completion of the report took too long to be useful in the process, it is better to give quick insights that are less accurate, than accurate results that take too much time. It is better to conduct an accurate analysis later on in the process when more things are known and when more data are available.
Nevertheless, it is valuable to introduce Urban Strategy at the beginning of the process, enabling stakeholders to keep the possibilities of Urban Strategy in mind and to have a greater insight into the current situation, as Urban Strategy is able to clarify the constraints and possibilities of the area.
By applying Urban Strategy repeatedly during the process, stakeholders are getting used to work with the tool. This way, the tool becomes more intertwined into the process, resulting in a greater impact of the tool in the process.

The two case studies illustrate that it takes much preparation time to load all the needed data correctly into the system and to adapt indicators to the specific situation. Therefore, it is costly to apply this tool in practice. The costs of using Urban Strategy seem to many parties a major barrier. Nevertheless, in case of Healthy Urbanisation Utrecht and the SUMP in Tilburg, it was not really clear beforehand what the stakeholders wanted to do with the advice of TNO and if the support of Urban Strategy would be crucial for the process.
While it is understandable when parties do not have money available to hire TNO, it also means that the priority of using such a tool is not perceived high enough. In order to limit the costs by limiting the preparation time, Urban Strategy can be improved by an online connection to real-time data streams. Although more data become available online, these data are not yet collected and processed into the tool automatically.
Furthermore, users often prefer to be able to use the tool independently. Therefore, TNO can offer a web-based version of Urban Strategy. However, it is not possible to use the tool entirely independent of TNO: a facilitator and an operator are needed to operate the tool and to structure the workshop.

Another limitation is that Urban Strategy presents a simplified model of reality: It is not able to visualise all the effects influencing urban processes and the complex relationships between different urban processes. Some aspects are difficult to measure and so they are difficult to quantify: For instance, there is no consensus about the way in which aspects can be measured and the relation between an action and consequence might be unclear. For some aspects much data is needed in order to simulate them and are therefore not feasible to implement in Urban Strategy.
Although theoretically it is possible to measure preferences, it is infeasible to internalise all tacit knowledge into explicit knowledge. Urban Strategy only covers explicit knowledge, though explicit knowledge is the tip of the iceberg of all knowledge that is available.

As illustrated by the case studies, many decisions have a political interest or individual interest that can be explained from the individual perception framework of stakeholders.
Strengths of Urban Strategy are that the calculation model provides reliable and fast results based on primarily statutory calculation methods. Urban Strategy enables interactive workshops, as it is able to present results quickly. The connection of Urban Strategy to the touch table enhances the interactivity of the workshop. Because the different themes are related to each other, Urban Strategy stimulates an integral and multidisciplinary approach.

Table 9 *SWOT analysis of Urban Strategy (Own ill.)*

STRENGTHS	WEAKNESSES
• Calculation model: – Reliable statutory calculation methods; • Speed; • Visualising relation between different themes; • Especially mobility related themes are well represented.	• Focus on 'grey' environmental themes; • Accessibility: available via TNO; • Data intensive: large preparation time needed; • Level of interactivity: – Limited user-friendliness: operator is needed.
OPPORTUNITIES	**THREATS**
• Rule-of-thumb indicators; • Online availability; • Internationalisation; • Maturing of the software.	• Competitive tools; • Awareness of the tool of potential users; • Potential users are accustomed to traditional workflow or see PSS as a threat to their job; • Fear for differences in results and rejection of the results produced by the PSS; • PSS might be seen as a limitation of the design freedom.

Recommendations
The application of Urban Strategy is interesting in projects with a high level of complexity. When stakeholders are interested in using Urban Strategy into their project, they should determine the purpose of using Urban Strategy beforehand. Subsequently, a demonstration can give stakeholders insight into the possibilities with Urban Strategy. The stakeholders need to be aware that out-dated data might be used, when the data is not readily available. This demonstration will give insight into the current situation of the project.

Subsequently, ambitions for the project can be determined and translated into indicators. Before determining whether Urban Strategy is suitable to use in the project, it should be examined whether:
- Those indicators are already available in Urban Strategy;
- The necessary data related to those indicators are already available;
- It is feasible to collect and process the unavailable data.

This checklist allows stakeholders to make a deliberate choice to apply Urban Strategy when it suits the spatial issue, the ambitions and indicators, the type of process, and if there is already a large amount of data available.

During the design phase, Urban Strategy can support the stakeholders by evaluating the draft design(s) and final design. The rate of recurrence should depend on the complexity of the project, as explained in the literature review on page 29, and the extent to which the draft design meets the ambitions of the project.

During the construction phase, Urban Strategy can be used in planning the building process, limiting the nuisance for neighbouring people, and for monitoring the planning process.

CASES MKP-MAPTABLE

The MapTable is a digital touchscreen running different types of software for different purposes. The MapTable itself is hardware and is delivered by different companies in the Netherlands, like Mapsup, Diz and Prestop. Recent case studies of the MapTable were executed in the Netherlands by several researchers (Arciniegas, 2012; Arciniegas & Janssen, 2009; Arciniegas & Janssen, 2012; Arciniegas et al., 2011; Arciniegas et al., 2013; Pelzer, 2015; Pelzer et al., 2013; Pelzer et al., 2015; Pelzer & Geertman, 2014; Pelzer et al., 2014a; Schatz et al., 2013; Vonk & Ligtenberg, 2010). For this research two cases are studied in the Province of Utrecht: one at the Municipality Woudenberg and one at the Municipality Stichtse Vecht.

For these cases the MapTable of Mapsup was studied running ESRI ArcGIS, a well-known GIS software, with Community Viz Scenario 360 in combination with Environmental Quality Profiles rating the sustainability of a plan according to 8 to 20 different themes ('Milieukwaliteitsprofielen' or 'MKP'). Community Viz Scenario 360 is an extension of ArcGIS specifically designed to support land-use planning. It adds interactive analysis tools and a decision-making framework to the ArcGIS platform and supports regional and local planners in viewing, analysing and understanding land-use alternatives and impacts. Scenario 360 is a component of Community Viz 5.0 (Placeways LLC, 2015).

The MapTable is a large (116 cm diagonal) touch table. Its screen can be rotated, tilted, and adjusted in height. The MapTable can be operated with a digital pen (or stylus), finger multi-touch gestures, or a wireless mouse and keyboard. It supports a wide range of group tasks to which maps are central, including visioning and idea sketching, the structuration of local knowledge, and real-time calculations. The table is mobile, despite weighting approximately 100 Kg, as it stands on multidirectional wheels (Mapsup, 2013, 2015).

INTRODUCTION

The MapTable supports interactive decision making with different stakeholders for spatial planning and urban development projects. The main characteristics of an area can be visualised, spatial claims can be inventoried from different perspectives, and effects of potential spatial choices and actions are defined in an interactive design process.

The Environmental Quality Profiles were developed in 2008 in collaboration with IVAM, a research and consultancy agency supporting governments, societal organisations and companies in realising their sustainability ambitions. IVAM and TNO already had developed the 'Sustainability Profile of the Location' (SPL, or DPL; 'DuurzaamheidsPrestatie van een Locatie' in Dutch). This is a calculation tool that measures the sustainable performance of a location. SPL can be used for greenfield and renewal area developments. It is a computer model which can be used independently and in relation to other models. For instance, the input of the model can be connected to other instruments like 'EPL', 'EPC', 'GPR gebouw', 'CAR', 'GES' and legal regulations. SPL uses 24 criteria divided in 11 themes related to people, planet and profit. SPL can be used at different stages of the area development process and is especially useful for drafting the ambitions for a plan at the beginning of the process and for evaluating different alternatives on the basis of these ambitions later on (DHV Groep, 2010).

In relation to the incentive programme 'Klimaat op Orde', running from 2008 to 2011, the Province of Utrecht developed the 'Sustainability Assessment Framework' (In Dutch: 'Afwegingskader Duurzaamheid'). For the project Rijnenburg in the Municipality of Utrecht the SPL is combined with this framework and the MapTable in order to develop a strategic sustainable plan (Provincie Utrecht, 2011). This integration resulted in the 'Duurzaam Ontwerpen' tool and the 'Sustainable Development tool' (Hoffmans et al., 2009). The development of the sustainable development tool was financed by the incentive programme 'Sustainability, Energy and Climate' of the Province of Utrecht in 2008. The project was executed between November 2008 and August 2009 by 'Klimaatatelier Rijnenburg', a cooperation of the Municipality of Utrecht, Mapsup, IVAM UvA, MWH-global and Grontmij.

Stakeholders have been drawing the plans together on the MapTable, whereby the sustainable effects of the plan alternatives were immediately visible. The tool especially focused on the spatial related sustainability aspects. Social and economic sustainability aspects are largely excluded by the tool and the instrument works best when there is already a draft design for the area (Puylaert & Werksma, 2011, p. 30). In this way, the draft design can be compared to the baseline situation and the ambitions for the project in order to optimise the design further. According to Mapsup, the stakeholders experienced the use of the MKP-MapTable positively. By using the MapTable the team was able to satisfy the project objectives and reach a high sustainable performance (Mapsup, 2008). For instance, Dymph Hoffmans, Project leader 'Environment and Sustainability' of the Utrecht City Planning Department mentions:

"Sustainable design with Scenario 360 and the MapTable offers an interesting way to have multiple stakeholders think and talk about their ambitions. It works as an important communication tool by giving a spatial language for a discussion about sustainability and climate change." *- Dymph Hoffmans (in Mapsup, 2008)*

The project of Rijnenburg is also outlined in the doctoral thesis of Peter Pelzer (2015) and in Pelzer et al. (2013). According to Pelzer et al. (2013, p. 168) the inclusion of environmental values in urban development is part of the concept of environmental policy integration (EPI). EPI aims to incorporate environmental objectives into all stages of policy making and aggregate environmental consequences into an overall evaluation and policy, while minimising contradictions between environmental and other policies (Lafferty & Hovden, 2003). This is also why the Province of Utrecht has developed their own tool. As municipalities play a key role in the operation of the policy of the overarching province, the Province of Utrecht offers support to their municipalities in sustainably developing areas in order to realise their sustainable ambitions. The realisation of their sustainable ambitions was first supported by the 'Sustainable Assessment Framework', and later on by the 'Sustainable Development Tool'. As employees of the Province of Utrecht already were familiar with their own 'Sustainability Assessment Framework' before the development of the 'Sustainable Development Tool that was applied in Rijnenburg, the province decided to continue to work with their own tool in combination with the MapTable. This tool was updated in 2013 from 8 to 20 sustainability criteria and was renamed as the 'Milieukwaliteitsprofielen' (MKP, Environmental Quality Profiles in English).

Although it is justifiable to incorporate environmental aspects in the decision-making process around spatial issues, economic and social indicators are less represented in the tool. As the Environmental Quality Profiles do not support a holistic approach to sustainable urban development, some stakeholders may benefit more from using the MKP-MapTable than others. Consequently, stakeholders may oppose against the use of the MapTable in their development projects.

The Province of Utrecht used to hire the MapTable of Mapsup, but they have their own MapTable since June 2014. The tool is changing over time as a result of new regulations and new policies that required new criteria to measure the performance of design alternatives in relation to these policies. Hence, it should be noted that the indicators of the MKP used in the cases in this thesis differ from the Rijnenburg case as studied by Pelzer (2015). The GIS department of the Province of Utrecht maintains the MapTable and the software.
Next to the Environmental Quality Profiles with ArcGIS, other drawing software is installed on the MapTable like Phoenix as well. The MapTable is next to the municipalities within the Province of Utrecht, also used by the different departments of the province for different purposes. All the regional maps that are available at the province are also accessible at the MapTable.

The MKP-MapTable supports on three different aspects in creating sustainable and integral policies and plans: (i) in analysing the area in relation to the spatial issue; (ii) in formulating sustainable and liveability ambitions; and (iii) in processing these ambitions into the planning process by evaluating different alternatives in relation to those ambitions. In order to make the right assessments in transforming an area, it is important to understand the specific situation well, to know which problems need to be solved and what opportunities arise in solving these problems.

For analysing the area, the physical environment is divided into three layers: the subsurface layer, the infrastructure layer, and the occupation layer. Each layer has its own functions, properties, and development rate. It is therefore important connect interventions in one layer to the consequences in other layers. The subsurface layer consists of soil information, information related to the (ground)water system, and information of cultural historical elements and structures. The infrastructure layer consists of road-, rail-, and waterways, complemented by pipeline and energy networks. And the occupation layer consist of different types of land-uses, like residential, commercial, industrial, leisure, nature and agricultural uses. These land-uses need to be aligned to the infrastructure layer and subsurface layer. Also,within the occupation layer a balance needs to be created between environmentally harmful functions, like industries and road infrastructure, and environmental vulnerable functions, like dwellings, hospitals and schools.

Strengths and weaknesses in relation to opportunities and threats are analysed in the MKP-MapTable, especially in relation to 'grey' environmental themes like noise, air quality, soil (pollution), odour, external safety and water quality. Subsequently, within the restrictions and possibilities for an area, the best possible plan is pursued. In this, 'best' means more towards a design whereby each stakeholder can accept how their interests, as well as those of the other stakeholders, are honoured (Micheels, 2014, p. 394).

The Environmental Quality Profiles of the MKP-MapTable are related to different types of areas, like an agricultural area, inner city area, or a business park as is shown in appendix E. Appendix F shows the way in which the Environmental Quality Profiles are measured. The performance of each indicator is expressed in a 1 to 10 scale. A 6 expresses a minimum performance and 10 expresses an optimal performance.
The minimum performance is often linked to Dutch legislation. Some indicators, like the water safety and bearing capacity of the ground, have mainly a warning function that is determined by local physical and geographical circumstances. A score below 6 occurs for these indicators regularly. The grades are primarily intended to give an indication and it is not compulsory to only obtain satisfactory grades. A 7 or 8 score expresses basic quality. This quality level is considered to be appropriate for the specific type of area, but includes a (substantially) higher quality level than the legal minimum as this is also related to the sustainability policies of the Province of Utrecht. The optimal performance of a 10 score basically encompasses the maximum achievable environmental quality level for the specific type of area.

The different criteria are not aggregated into one total score. Therefore a multi-criteria analysis, in which different criteria are weighted, is not explicitly applied. Eventhough, different criteria are evaluated and different alternatives are compared to each other. By not presenting a total score, the Province of Utrecht tries to maintain the transparency of the decision-making process. This way, also low performances cannot be compensated by high performances.

The types of areas are determined by its occupation with its degree of mixed-use, density and level of activity, and the effects these functions have on their environment. The distinction between different types of area is not made on a small level of detail, but on a neighbourhood level. This means that it covers an average image of the area, wherein deviations exist. However, distinctive characteristics of an area as a whole in relation to other areas from an environmental perspective matter.

Figure 28 shows different levels of detail for different purposes: the different types of areas can be determined on a neighbourhood scale as illustrated in figure a; the land uses can be drawn within these different types of areas as is shown in figure b; and additional functions and information can be added to the drawing, like solar panels, wind turbines, energy labels and sustainable ratings, public transport stations, seasonal thermal energy storage, green roofs, a biomass plant, etc., as is shown in figure 28c.

Figure 28 *Different levels of detail depending on the aim for using the MKP-MapTable (Mapsup, 2013).*

For a successful deployment of the MKP-MapTable, reliable and actual information is needed concerning the specific (re)development project. The Province of Utrecht has the majority of data available to use during the planning process with the MKP-MapTable, but these data need to be checked by the municipality for completeness and correctness. Not only do the objectives for an area differ per situation, it is also dependent per project which criteria are the most relevant and are used. Furthermore, the aim of using the MKP-MapTable determines the requirements of the used information, for instance the level of detail, the size of the considered area, and the actuality of the information.

Next to the development of the tool the Province of Utrecht also supports the municipalities in using the MKP-MapTable by organising workshops, writing reports on the application of the MKP-MapTable at the different projects and through a guide for sustainable area development called 'Leidraad Duurzame Ontwikkeling' (Provincie Utrecht, 2015c). The guidelines in 'water and the environment in spatial plans' ('Leidraad Water en Milieu in ruimtelijke plannen') of 2006 together with the Environmental Quality Profiles formed the basis for this guide. The guide for sustainable area development is part of the support programme sustainable area development which is in operation since 2010.

In general, the MKP-MapTable is used in two workshops. A facilitator of the Province of Utrecht leads the workshops. The first workshop aims to give the stakeholders insights in the opportunities and barriers of the area in relation to the desired spatial development. This workshop takes place at the beginning of the initiation phase, preferably as early as possible.
The baseline situation is determined during the first workshop; for instance, the environmental impacts of the main roads are mapped whereby constraints and possibilities are visualised.
The result of this workshop will be the input for the statement of requirements, in which the requirements, constraints, ambitions and necessary measures are defined. The workshop enables stakeholders to specify their ambitions in relation to the different Environmental Quality Profiles.

The aim of the second workshop is to determine the sustainable performance of the proposed design in relation to the baseline situation and in relation to the ambitions of the project. The stakeholders are free to explore different alternatives and opportunities during the workshop. Direct feedback in relation to the different criteria is shown on the MKP-MapTable. This enables the stakeholders to optimise the design. This workshop is preferably executed during the programme phase at the end of the initiatial phase, in which the programme requirements are defined. The results of the workshop will be the input for the design phase, in which the brief will be translated into a spatial solution.

Municipalities with sustainable ambitions for transforming an area are eligible for making use of the MKP-MapTable. Additionally, it is essential that the project is executed in an integral way, whereby the different domains are involved from the beginning of the process and onwards. Furthermore, it is desirable that the project is in an early stage of the planning process in order to make incorporation of the sustainable policy into the plan possible.
The workshops are organised in collaboration with the municipal project leader and the advisor Spatial Planning and the Environment (the municipal representative in environment and sustainability). Representatives from the various municipal domains, the project management, the council, and possibly the developer should be present at the workshops. The workshops require preparation from the municipality, in particular regarding to the collection of the specific environmental and sustainability data. These data usually concern traffic, noise, air and external safety calculations that are outsourced to an external agency or the environment service region Utrecht (ODRU) (Province of Urecht, 2015). The assistance of the spatial planning and environment municipal consultant amounts approximately to 25 working hours per project. However, he tasks that need to be executed to prepare the workshops need to be done in a traditional planning process ; these tasks only need to be executed earlier in the planning process.

Although many municipalities have incorporated the Environmental Quality Profiles into their policies, they are often not aware of the possibilities and constraints of using the MapTable in their planning processes. Some projects that are supported by the MapTable are 'Het Kwadrant' in Maarssenbroek, Municipality Stichtse Vecht, Woudenberg Oost in Municipality Woudenberg, Maarsbergen Oost in Municipality Utrechtse Heuvelrug and Rijnenburg in Municipality Utrecht. Amongst others, the municipalities Veenendaal, Wijk bij Duurstede, and Zeist have used the MKP-MapTable for incorporating the Environmental Quality Profiles into their spatial planning and environmental policies.
As 'Het Kwadrant' and 'Woudenberg Oost' are two of the few cases recently executed, these cases were the most suitable for my research.

RESULTS SEMI-STRUCTURED INTERVIEW DEVELOPERS

To introduce the opportunities of the MKP-MapTable by municipalities, the Province of Utrecht has developed three project phases: During the first phase, the working of the MKP-MapTable was demonstrated at the different municipalities. Additionally, you are taught in several courses how areas can be developed in a sustainable way. During the second phase, the Province of Utrecht has encouraged the municipalities to incorporate the Environmental Quality Profiles in their policies. And during the third phase, municipalities were stimulated to apply the MKP-MapTable in practice. A new guideline is just finished; once it is printed, the municipalities will receive it. The case studies outlined in this research were still working with the old guidelines. The new guidelines incorporate more sustainable related themes, while the old guidelines were primarily focused on the grey environmental themes (Interview #21, Interview #24; Province of Utrecht).

The development of the MKP-MapTable
Over the past couple of years, the MKP-MapTable has undergone a great development. As the advisors of the Province of Utrecht explain: "In the beginning there were some teething problems. For instance, the system crashed or the table was overheating. The MapTable has gradually improved by trial and error, and currently it is running quite trouble-free. As the tool is developed by trial and error, the software is cobbled together resulting sometimes in strange behaviour. Therefore, the GIS department of the Province of Utrecht is examining the working of software to determine if it works the way we want it to work." (Interview #21, Advisors Sustainable Urban Development, Province of Urecht)

Additionally, one of the advisors Sustainable Urban Development comments:
"I always have imagined visiting municipalities with the MapTable to develop an area, whereby people can literally draw on the MapTable as the software calculates the effects of it on the background; that information is gathered and presented automatically enabling to draw and consult the table instantly. But up to now, that was very difficult to realise. We always need to do some adjustments and update information. The GIS department is currently analysing whether improvements can be made in that field." (Interview #21, Advisors Sustainable Urban Development, Province of Urecht)
The other advisor Sustainable Urban Development agrees with him and adds to this that preparation is always needed: the information needs to be inspected and the working of the MapTable needs to be checked (Interview #21, Advisors Sustainable Urban Development, Province of Urecht). The facilitators of the MKP-MapTable workshop also experience this problem: "it quite often happens that values are measured incorrectly" (Interview #24, MKP-MapTable facilitators, Province of Utrecht).

Although an increasing amount of MapTables are used in practice (Interview #14, MapTable Expert, GEO-col), the MKP-MapTable is not yet used regularly at the Province of Utrecht. The MapTable is used for 8 different projects at the moment. Additionally, around 10 municipalities have been using the MapTable in the past and have incorporated the environmental quality profiles into their policies. This limited amount of executed projects is also related to the financial crisis; not many urban development projects are realised in the Province of Utrecht in general in the last few years (Interview #21, Advisors Sustainable Urban Development, Province of Urecht).
Furthermore, the facilitators of the MKP-MapTable workshops mention that it is sometimes hard to get in contact with the right people at the municipalities; therefore, it is hard to find projects when they are still in the initiation phase (Interview #24, MKP-MapTable Facilitators, Province of Utrecht).
The facilitators add to this that a first indication of the financial feasibility is often already determined at the start of the project. According to the facilitators, usually a draft design is made in order to determine this financial feasibility. Often this draft design is the basis for the urban design and hardly changes during the development process (Interview #24, MKP-MapTable facilitator, Province of Utrecht).
It also depends on the working culture of the Municipality, whether the application of the MKP-MapTable is suitable, as it requires an integral and open approach to urban development. One of the facilitators adds to this that, municipalities only contact the Province of Utrecht for using the MKP-MapTable when they face problems in the development process (Interview #24, MKP-MapTable facilitator, Province of Utrecht). Additionally, the majority of developed areas are initiated by the land owner. Therefore, only little freedom exists in determining the areas that are the most suitable for sustainable urban development. Moreover, the Province of Utrecht does not support private parties directly in creating sustainable urban development plans (Interview #24, MKP-MapTable Facilitators, Province of Utrecht).
The facilitators of the MKP-MapTable workshops used to be critical in the selection of suitable cases, but currently they are glad when they can support a project. Although one of the facilitators experienced that presently municipalities are chosing more deliberately to use the MKP-MapTable in their projects, they still organise more demonstrations than real MKP-MapTable workshops: "from a commercial point of view the use of the MKP-MapTable is not profitable" (Interview #24, MKP-MapTable facilitator, Province of Utrecht).

Despite the participants of the MKP-MapTable workshops are often enthusiastic about the tool, they do not apply the MapTable automatically again in the next project. The Province of Utrecht needs to stimulate the application of the MapTable in practice; otherwise the advisors Sustainable Urban Development do not think that the municipalities would take initiative to use the MapTable.
Nevertheless, the physical MapTable has made a great difference in the process of using the Environmental Quality Profiles and the guideline as the MapTable made it more accessible to the municipalities to apply the Environmental Quality Profiles in practice (Interview #21, Advisor Sustainable Urban Development, Province of Urecht). However, the MKP-MapTable is not used so far in order to compare different designs with each other. Usually only one urban design is evaluated and compared to the baseline situation (Interview #24, MKP-MapTable Facilitator, Province of Utrecht).

Threats
Currently, there are also some threats to the widespread use of the MKP-MapTable. For instance, the advisors Sustainable Urban Development and the facilitators noticed that the relationship between the Province of Utrecht and the municipality partly determines whether the municipality wants to use the MapTable in practice (Interview #21; Interview #24, Province of Urecht).

Furthermore, the MapTable cannot be easily operated. Although people can operate the system by themselves, they need assistance in finding the right buttons the first time. Additionally, the small municipalities do not have the money and capabilities available to operate a MapTable independently. Especially as municipalities are not making development plans regularly, and are therefore not using the MapTable regularly, people do not develop a routine in working with the tool. Consequently, the Province of Utrecht is offering the MapTable as a service to them with a facilitator to organise the workshop.
Another aspect is that people need to get used to working with a tool like the MapTable as it encourages an integral way of working (Interview #21, Advisor Sustainable Urban Development, Province of Urecht). During the workshop the stakeholders are discussing the plans on an equal basis with each other. However, stakeholders might not like it to discuss the plans in an integral and open way as also mentioned in the literature review.

Moreover, the advisors Sustainable Urban Development and the developer all mention that the system needs to work flawlessly. As Geert Janssen explained: "If you go to the municipalities, they expect you to show them interesting things immediately. Participants of the workshops are sometimes sceptical at the beginning. Hence, it is a bad turn when the system does not work properly. In that case, they will give up the technology quickly" (Interview #21, Advisor Sustainable Urban Development, Province of Urecht).

The advisors Sustainable Urban Development and the facilitators also mention that, as the MapTable is used during the initiatial phase, not much data are readily available and the municipality is not always willing to provide the needed data. Even though the new Environment and Planning Act ('Omgevingswet') will dictate governmental bodies to manage their data in an organised way, it is often a threshold to gather the data earlier in the process. Geert Janssen argued that the data needed to calculate the Environmental Quality Profiles need to be gathered anyways. But these data might become obsolete during the planning process leading to extra time to update the data or the plans might be cancelled. Furthermore, one of the facilitators of the MKP-MapTable workshops explained that it is hard to change the working procedures, as the municipalities are not used to gather data earlier in the process (Interview #24, MKP-MapTable facilitator, Province of Utrecht). Partially due to these threats to the application of the MapTable, the PSS developer (interview #10, MapTable Developer, Mapsup) notes that: *"Although the tool generally impresses people, my biggest competitor is a sheet of paper"*

Strengths
One of the strengths of the MKP-MapTable is that it is connected to both a touchscreen and a calculation model. This enables stakeholders to draw upon the touch table, while the calculation model is calculating the effects of that action; hence, the results are immediately visible (Interview #21, Advisor Sustainable Urban Development, Province of Urecht).

Although the Province of Utrecht uses the MapTable primarily in combination with the Environmental Quality Profiles, the MapTable could also run other kinds of software. This enables stakeholders, that are communicating in varying ways, to choose to work in different programmes. When the programmes are connected to each other, the urban designer can use drawing software, while the economist can get insights into graphs and calculations in Excel. According to one of the developers, this way of working increases the flexibility and possibilities of the MapTable (interview #10, MapTable Developer, Mapsup). According to Gustavo Arciniegas, expert in the application MapTables with an obtained PhD about "Map-based decision support tools for collaborative land use planning" (2012), a great strength is that the tool encourages people to discuss the things they see and to be actively involved in the workshop. Supporting the communication between stakeholders is a major task of the MapTable.
As people are working collaboratively around one table in one room, information is exchanged between different disciplines, but also between politicians and citizens. This generates new insights and new knowledge; the participants can often learn a lot from each other" (Interview #14, MapTable Expert, GEO-col).

Also the advisors Sustainable Urban Development recognise the added value of the MKP-MapTable in supporting the communication between different parties. Although it is possible to communicate with each other around sketching paper and maps, the MapTable is more interactive and is able to also calculate the effects of designs.

According to Joop Machielse, "using the MapTable makes it easier to invite more people to a meeting. Not only civil servants are working together in the MapTable, the urban designer and developers are often invited as well" (Interview #21, Advisor Sustainable Urban Development, Province of Urecht). Geert Janssen adds to this that the different themes that are incorporated into the Environmental Quality Profiles widen the discussions and cause an integral way of working (Interview #21, Advisor Sustainable Urban Development, Province of Urecht). He also states, "as the MapTable can provide insights into the different themes, less expert advice is needed and attention is drawn to themes that would otherwise not be discussed. Furthermore, the assessment process is becoming the responsibility of the whole group by using the MapTable collaboratively" (Interview #21, Advisor Sustainable Urban Development, Province of Urecht).

Weaknesses
According to Geert Janssen (Interview #21, Advisors Sustainable Urban Development, Province of Utrecht), the compactness of the tool is a disadvantage: *"The tool weighs hundred kilos; you cannot carry it. So if we have a session on another location, we need to hire a courier service."*
Note that the MapTable of the Province of Utrecht is different than the most recent version of Mapsup; the table cannot be tilted, and it weighs more compared to the table of Mapsup. To solve this issue, the Province of Utrecht has bought a tablet that is able to do almost the same as the MapTable (Interview #21, Advisor Sustainable Urban Development, Province of Urecht).

Another weakness of the MapTable is the limited availability of the data needed in order to calculate the environmental quality profiles. This data are not always digitally available or recently updated; Often it takes extra time to gather the right data (Interview #21, Interview #24; Province of Urecht).
In the prospect of the Environment and Planning Act ('Omgevingswet') this might be improved in the near future.
Additionally, the facilitators of the MKP-MapTable workshop mention that the themes of the MKP-MapTable are related to each other and to the underlaying maps. Therefore, the Environmental Quality Profiles demand the full calculation capacity of the MapTable. When different actions are executed in the MapTable at the same time, this can lead to significant calculation times (Interview #24, MKP-MapTable facilitators, Province of Utrecht).

Furthermore, Joop Machielse mentions that the MapTable can be a black box to some people, when they do not understand how the grade is calculated. Although it is possible to show them how grades are calculated, sometimes they are still wondering whether it is measured correctly (Interview #21, Advisor Sustainable Urban Development, Province of Urecht). Geert Janssen also perceives this as a benefit, "the technical expert often wants to know how the grades are calculated, but for project leaders, politicians and citizens it easy to understand that the design has improved when it obtains a higher grade" (Interview #21, Advisor Sustainable Urban Development, Province of Urecht).

Opportunities
An opportunity in the application of the Maptable is according to Joop Machielse and the facilitators of the MKP-MapTable workshops, to expand the list of indicators; currently, many indicators are related to environmental themes (Interview #21, Interview #24; Province of Utrecht). However the facilitators of the MKP-MapTable workshops mention that, "It is sometimes a challenge to measure new indicators or to translate the indicator to the score at a 0 to 10 scale. Therefore, if stakeholders do not agree with the way in which indicators are measured, this can be adapted in the MKP-MapTable. We have an additional technical guideline that indicates and justifies how the different themes are measured. We can share this technical guideline with the stakeholders of a project when that is desired." (Interview #24, MKP-MapTable Facilitators, Province of Utrecht)

The developer of the MapTable also foresees a greater role for applying the MapTable for citizen participation. Furthermore, he states that, "when citizens are involved in the project, it is important that the decision-makers also take their input into consideration. As the decision-making often takes a lot of time, it is usually unclear to citizens what decision-makers have done with their input. When decision-makers do not want to do anything with the input of citizens, it also does not make sense to involve citizens. In case it appears that the input of citizens is not feasible, it is important to communicate that to them by explaining why the decision-makers have chosen another alternative." (Interview #10, MapTable Developer, Mapsup)

Furthermore, the PSS developer believes, just as the project leader of Healthy Urbanisation Utrecht, that the discussion should be held more between citizens instead of between citizens and the government (Interview #10, MapTable Developer, Mapsup).

Process
Jaap de Kroes and Gustavo Arciniegas highlighted that it is not about the hardware, but about the working method: "The MapTable, the process and appropriate software are crucial to deal with the complexity of area development projects" (Interview #14, MapTable Expert, GEO-col).
Jaap de Kroes thereby mentions, "it is often about public support and confidence into the solution. Therefore, a common learning process and a mutual understanding of the project is important" (Interview #10, MapTable Developer, Mapsup).
They both also mention that the MapTable has a greater effect when it is repeatedly used in the process. Furthermore, Jaap de Kroes mentions that it is important that participants of the MapTable workshop are able to make changes or comments on the MapTable by themselves as it increases the involvement of the participants by the feeling that they have contributed to the development process (Interview #10, MapTable Developer, Mapsup).
Another point made by the developers is that it is important that the participants of the MKP-MapTable workshops have decision-making powers, as you need to come to a decision together during the workshops. Additionally, it is important that stakeholders are willing to collaborate transparently. However, Gustavo Arciniegas mentions that decisions are often not made by the experts or an advisor, but by politicans, "So far, the MapTable is not regurally used by politicans" (Interview #14, MapTable Expert, GEO-col). This partially explains why sometimes the results of the MapTable workshops will not be executed in practice.

Suitable type of project
The MapTable is not cheap; therefore, it is not feasible to only use it in one project. According to Joop Machielse, the MapTable is primarily used for greenfield developments, as these developments need to deal with a blanco situation whereby many different spatial possibilities exists. This is in contrast to the spatial structure of redevelopment projects, which is often based on the existing structure constraining the variation possibilities of new designs (Interview #21, Advisor Sustainable Urban Development, Province of Urecht). Geert Janssen adds that the amount of greenfield developments executed with the MapTable might also be explained by the fact that urban redevelopment projects are executed less frequently and in general on a smaller scale compared to greenfield developments in the Province of Utrecht (Interview #21, Advisor Sustainable Urban Development, Province of Urecht).
The indicators related to the limitation of noise appear to be mostly used. Other themes that are often important for the feasibility of a development are the 'grey' environmental themes like air quality, external safety, soil quality, and energy (Interview #21, Advisor Sustainable Urban Development, Province of Utrecht).

Although the Province of Utrecht uses the MapTable internally for policymaking, the Maptable is mostly used by the municipalities. Joop clarifies that, "we have tried to promote the use of the MapTable amongst the municipalities, but it is up tot hem to contact us when they want to use it for their projects. However, when we hear about an upcoming development, we will contact them to ask if they want to use the MapTable in some cases" (Interview #21, Advisor Sustainable Urban Development, Province of Urecht).

According to Gustavo Arciniegas, the MapTable is especially suitable to apply in projects that have much spatial data available and that have a high need for knowledge exchange (Interview #14, MapTable Expert, GEO-col).

Moment in het process
According to the Province of Utrecht, the best way to use the MapTable is as early as possible in the development process in order to select a suitable location for urban development and in order to support the selection of possible land-use functions in that area: "MapTable workshops are suitable for the initiation phase as the MapTable is not accurate enough to evaluate plans at a later stage in the development process" (Interview #24, MKP-MapTable Facilitator, Province of Utrecht). Furthermore, at the beginning of the process there is still enough design freedom to change the plans. Because stakeholders are less willing to change the design later in the process as money is then already invested in the development of the design and the execution of analysisses (Interview #21, Advisors Sustainable Urban Development, Province of Urecht; Interview #10, MapTable Developer, Mapsup). However, the advisors mention that, "municipalities are often not ready to use the MapTable at the beginning of the process, as the needed data is usually not yet available" (Interview #21, Advisors Sustainable Urban Development, Province of Urecht).

Therefore, Jaap de Kroes and Gustavo Arciniegas stated that the tool should be as simple as possible at the beginning of the process (Interview #10, MapTable Developer, Mapsup; Interview #14, MapTable Expert, GEO-col). Furthermore, Gustavo Arciniegas clarified that, "especially the stimulation of communication and collaboration between the stakeholders is important at the beginning of the process; the stakeholders first need to get to know each other and understand each other's interests" (Interview #14, MapTable Expert, GEO-col). According to Gustavo Arciniegas, the tool can be made more complex later on in the process to evaluate design alternatives (Interview #14, MapTable Expert, GEO-col).

ANALYSIS AND DISCUSSION

The Province of Utrecht has related the Environmental Quality Profiles to empirical reference points as is shown in appendix F. This is a mathematically approved way of measuring indicators. However, it also implies a normative approach, by which the municipalities are stimulated to achieve at least a 6 for all relevant indicators. Despite the criteria are not weighted and aggregated into one total score, the stakeholders tend to rank the criteria according to their own interest in their minds, by which the multi-criteria analysis is implicitly incorporated in the decision-making process.
Furthermore, I see a contradiction: on the one hand the Province of Utrecht do not aggregate results to retain the transparency of the model, while on the other hand they do translate the empirical reference points into scores which decreases the transparency of the model. This can be justified by stating that 0 to 10 scores are easily understandable to all stakeholders.
However, this approach still leaves room for manipulation. As stakeholders are not obliged to reach at least a 6 for every indicator, stakeholders can agree to achieve a low performance for an indicator that does not correspond to their interests, or they can even ignore indicators which are, for instance, politically sensitive. By ignoring indicators, a manipulated impression is given about the sustainability of a plan. All stakeholders determine the sustainability targets for the specific project during the first workshop. Therefore, according to the interests of the stakeholders, also less sustainable plans can be achieved by using the MKP-MapTable.

As mentioned in the theoretical framework, decision-making is in essence determined by subjective behaviour. The decision-making process can only be made more transparent by using a MKP-MapTable. The way decisions are made influences the outcome of a decision, as is illustrated by Micheels (2014, pp. 400-401). Choosing to use the MKP-MapTable is already a subjective choice, as the MKP-MapTable especially pays attention to environmental indicators and less to social and economic aspects. The weighting of criteria is subjective, just as the selection of criteria incorporated in the workshops and the translation of ambitions into environmental quality profile target values. This explains why some municipalities might not want to use the MapTable in their planning processes.

As mentioned by the advisors Sustainable Urban Development, the MapTable is primarily used for greenfield developments. However, the MKP-Maptable can also be used in redevelopment projects. Although Joop Machielse mentions that the spatial structure of the existing situation in redevelopment projects allows less design freedom, these projects usually need to deal with a high complexity caused by many involved actors and the existing situation. Transformation projects often need to deal with environmental challenges, like soil pollution. A good analysis of the baseline situation of the area is therefore crucial. Additionally, the MKP-MapTable could also be used in mobility related spatial problems when more traffic indicators will be available.
Although the new Environment and Planning Act creates opportunities to better structure and organise the data sources, private parties and civil society increasingly take Initiatives in urban development projects instead of governmental bodies (Heurkens, 2012), as mentioned in the literature review. Furthermore, development projects are typically smaller, and are realised in more phases since the financial crisis of 2008. As long as the Province of Utrecht only supports their municipalities, they will have a hard time finding suitable projects for applying the MKP-MapTable in practice.

The use of the MKP-MapTable can be very helpful in structuring the development process and dealing with environmental challenges, not only by sharing information, but also by increasing the collaboration between the involved actors.

Furthermore, the developer and advisors of the Province of Utrecht mention that they desire to use the MapTable as early as possible in the development process when there still is a high design freedom. However, besides the fact that data is often not available at the beginning of the process, municipalities may also prefer to wait with the use of the MKP- MapTable in their projects until the risk of cancellation of the project is decreased after the start of the project. As mentioned in the theoretical framework, little is known at the beginning of a design process, and therefore there is a high risk that the project will not be executed, for instance, when it appears to be infeasible to realise.

CASE 3: MAPTABLE: WOUDENBERG-OOST, MUNICIPALITY WOUDENBERG

DISCRIPTION OF THE PROJECT

On the 30th of June and the 3rd of September 2014, two workshops with the MKP-MapTable have taken place to support the greenfield development of a residential area in Woudenberg-Oost, located in the Municipality Woudenberg. This neighbourhood was later renamed to Hoevelaar. The east border of the plan area is defined by a former railway embankment; the west border is defined by the 'Zegheweg' and an old canal; and the south border of the plan area is defined by the N224 main road with connected dwellings and businesses. According to the housing policy (Municipality Woudenberg, 2013), approximately 875 new dwellings are needed in the period 2013 to 2030. The plan area should cover this need. The land is partly owned by the Municipality Woudenberg.

Figure 29 *Plan area Woudenberg-Oost (Province of Urecht, 2014b)*

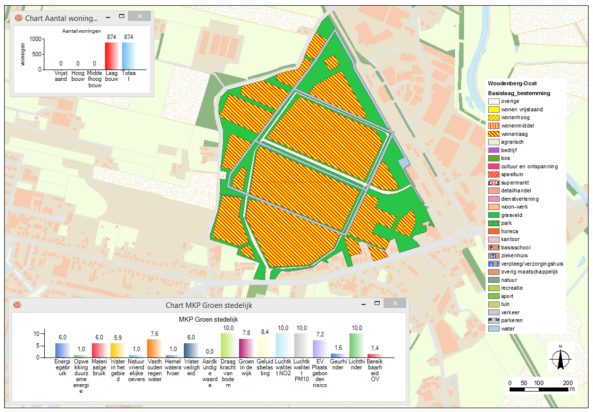


Figure 30 *Screenshot of the MKP-MapTable Workshop Woudenberg-Oost (Province of Urecht, 2014b)*

THE TOOL IN THE PROCESS

The tool was used during the initiation phase for analysing the possible environmental problems and opportunities, and for accordingly determining the spatial and sustainable ambitions for the project. The environmental quality performance of the first urban draft design was determined and was subsequently used for creating the Masterplan Hoevelaar.

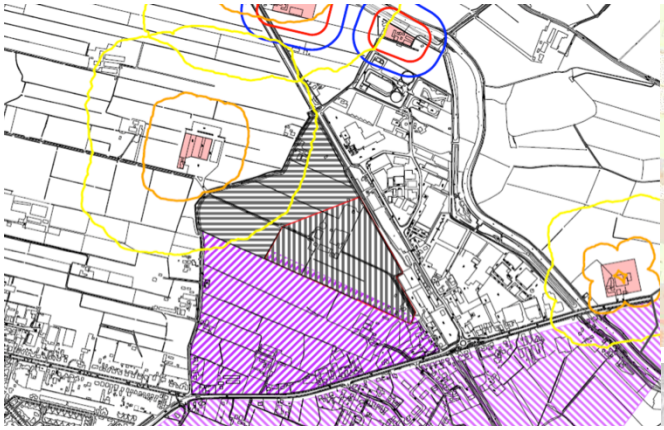
12 participants were present at both workshops. From the Municipality Woudenberg the following eight people were present: the municipal project leader, an consultant Spatial Planning and Environment, a civil servant Environment, an economic advisor, a traffic expert; a consultant Water Management, a strategic policy consultant Spatial Planning; and a policy advisor Housing, Welfare and Health Care. Additionally, the urban designer has attended the workshops, just as an MapTable expert and facilitators from the Province of Utrecht for operating the MKP-MapTable. A new workshop was to be planned to validate the final Masterplan. However, this workshop has not taken place; and as the users were not very positive about the MKP-MapTable, it is unlikely that this workshop will take place in the near future.

THE AIM OF USING THE MKP-MAPTABLE

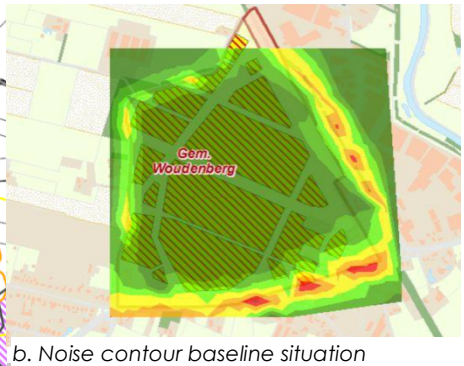
The objective of using the MKP-MapTable was to visualise the current environmental impacts upon the project area, and to subsequently analyse the opportunities and constraints for the desired development. The objective of the second workshop was to determine which environmental quality could be achieved based on a first urban draft design.

THE PREPARATION FOR THE WORKSHOPS

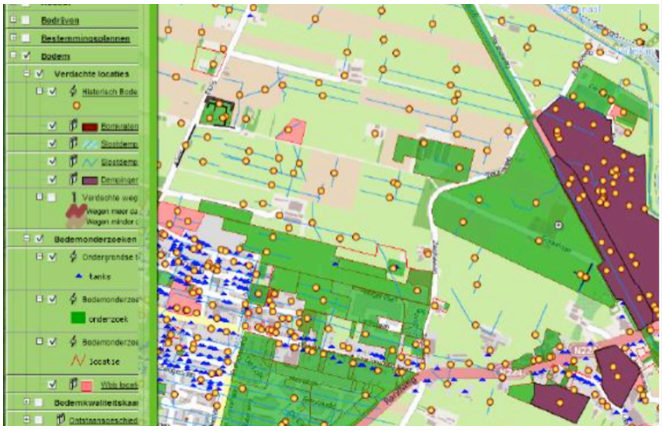
The following activities were performed in preparation for the MKP-MapTable workshops: (i) Gathering and analysing the necessary environmental information in relation to the project. An overview of the used information is presented in appendix G; (ii) Loading maps into the MKP-MapTable related to the specific plan area and selecting relevant maps of the plan area illustrating the current environmental situation versus the situation in relation to the first urban draft design; And (iii) updating the themes of noise, external safety and odour in preparation for the second workshop as it appears that much of the gathered information was not entirely up to date during the first workshop.



a. Odor contours caused by farms in future situation

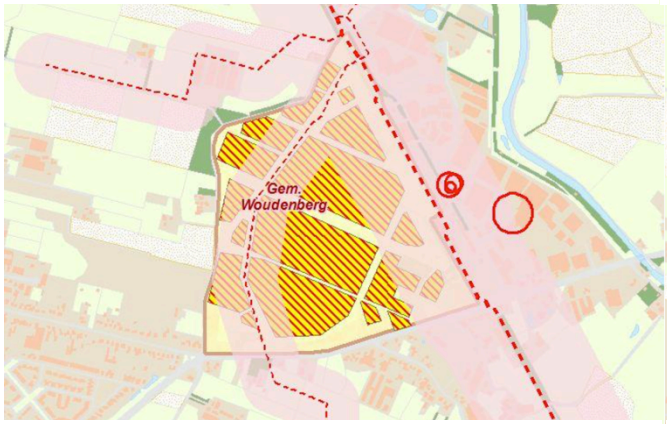


b. Noise contour baseline situation

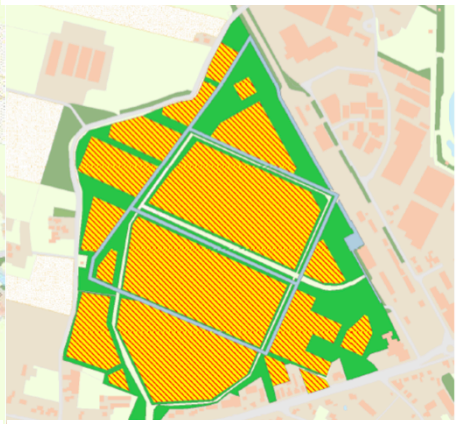


c. Soil polution

d. design principles after first workshop



e. Local risk contour of the external safety



f. Urban draft design

Figure 31 *Different themes are visualised of the MKP-MapTable workshop Woudenberg (Province of Urecht, 2014b)*

THE CONTENT OF THE WORKSHOPS

The stakeholders validated the available environmental data during the first workshop. Based on these data the main environmental possibilities and weaknesses were determined for the project area. A list of missing or out-dated data was composed and agreements were made about gathering these data.

Before the second workshop, the missing data from the first workshop and a first urban draft design were loaded into the MKP-MapTable, just as the draft urban design. This information was used to determine the environmental performance of the draft design in relation to the Environmental Quality Profiles. The illustrations on page 72 give an overview of the different themes covered during the workshops. As can be derived from these figures, the infrastructure was strongly influenced by the external safety indicator as no dwellings were allowed to be built above gas pipelines. The level of noise and air quality did not provide considerable constraints to the plan area, as green along the eastern and southern border will limit the noise from the adjacent roads. One important aspect that became apparent during the second workshop was that the draft design did not consider the odour limitation of a farm at the northwestern part of the plan area. As many new data were loaded into the MKP-MapTable for the second workshop, a significant part of the workshop was devoted to analysing these data. Therefore a number of themes have not been addressed during this workshop, like the themes renewable energy, water management and ecological main structure (Provincie Utrecht, 2014b). Furthermore the MKP-MapTable did not work properly due to technical issues.

THE OUTCOME OF THE MKP-MAPTABLE WORKSHOPS

It appears that the baseline situation of the overall project area obtained a high environmental performance. This high environmental performance makes it possible to realise a high quality living environment in Woudenberg-Oost, when the design takes into account a number of matters. The conclusions, that were drawn per theme as a result of the first workshop, are shown in appendix G. Based upon the baseline situation, spatial principles were determined that formed the basis for the first urban draft design. Based on the results obtained from the first workshop, the sustainability ambitions, as also presented in appendix G, were determined during the second workshop. Ultimately, the project resulted in the creation of Masterplan Hoevelaar (Van der Velden et al., 2015).

DESCRIPTION OF THE TOOL

The level of noise, air quality, external safety, odour nuisance, bearing capacity of the ground, the accessibility by public transport, the ecological main structure, water safety and water management, light pollution, rainwater retention, rainwater drainage, eco-friendly canal banks, energy use and material use, and generation of renewal energy, are indicators that are visualised during the MKP-MapTable workshops. The resulting Environmental Quality Profiles of the urban draft design are illustrated in figure 30 on page 71 and a list of the data that is used is presented in appendix G.
The functions that are used during the workshops are primarily related to the simulation and evaluation tasks, whereby different maps are selected, indicators are visualised, and the environmental quality profiles are calculated. During the second workshop, the MKP-MapTable crashed while trying to adapt the draft urban design plan. Therefore the drawing tasks executed are negligible.

USER EXPERIENCES

It appears that the Municipality Woudenberg was disappointed in the use of the MKP-MapTable in Woudenberg-Oost, as the MKP-MapTable did not fulfil their expectations. Although the first workshop was interesting, the incorrect data of the first workshop was not well updated in the second workshop. Additionally, the MKP-MapTable crashed during the second workshop. The workshop attendees were therefore not able to use the MKP-MapTable by themselves and gain a good insight into the working of the tool. However, the foremost reason why the municipality Woudenberg was disappointed was caused by the inadequate communication between the province and the municipality for using the MKP-MapTable in Woudenberg-Oost. According to the consultant Spatial Planning and Environment and the project leader of the Municipality Woudenberg, the Province of Utrecht dit not respond well to the needs of the municipality in organising the development project Woudenberg-Oost.

This negative experience caused the attendees of the workshop to be more sceptical about the use of the MKP-MapTable in the next project. “As many attendees were asked to join the workshops, it was rather a waste of time” (Interview #22, Consultant Spatial Planning and Environment, Municipality Woudenberg). Therefore, the consultant Spatial Planning and Environment mentions that the municipality should make beter agreements with the Province of Utrecht about the use of the MKP-MapTable next time.

Although, the municipality has briefly discussed the aim of the project and the use of the MKP-MapTable in their project with the Province of Utrecht, this should be discussed more thoroughly. The consultant Spatial Planning and Environment mentions that, "it was not really clear beforehand, why the MKP-MapTable will be used, what the stakeholders can expect from the tool, and what they want to achieve in the project by using the MKP-MapTable" (Interview #22, Consultant Spatial Planning and Environment, Municipality Woudenberg). She furthermore states that it is crucial to have a clear view about the role of the MKP-MapTable in the project in order to be able to make a decent assessment whether the use of the MKP-MapTable can benefit the project or not. For this project she had the feeling that the Province of Utrecht primarily wanted that the municipalities use the MKP-MapTable in their projects, without critically assessing how these projects can benefit from the use of the MKP-MapTable (Interview #22, Consultant Spatial Planning and Environment, Municipality Woudenberg).

The consultant Spatial Planning and Environment also mentions that the MKP-MapTable could be used even earlier in the development process in order to also determine a suitable location in relation to the Environmental Quality Profiles, as the location of the greenfield development and many other aspects of the plan were already determined before the first workshop. However, she acknowledged that it is quite difficult to have the data correctly in the system: "It takes a lot of time to load the data into the MKP-MapTable and it is questionable whether the stakeholders are willing to spent time to prepare the workshop already in an early phase of the project" (Interview #22, Consultant Spatial Planning and Environment, Municipality Woudenberg). She additionally states that, at the beginning of the project, you may not want to discuss the project in too much detail (Interview #22, Consultant Spatial Planning and Environment, Municipality Woudenberg).

Although the use of the MKP-MapTable did not greatly benefit Woudenberg-Oost, the Municipality Woudenberg did also recognise the possible advantages of the tool. The consultant Spatial Planning and Environment mentions that the tool can be useful to visualise the different aspects of the plan in order to share information between stakeholders and to visualise the constraints and opportunities of an area in order to create a mutual understanding of the spatial issue (Interview #22, Consultant Spatial Planning and Environment, Municipality Woudenberg).

Also the urban designer recognised these benefits and the need to use the MKP-MapTable even at an earlier stage of the project (Interview #23, Urban Designer, Atelier Dutch). His urban design firm, Atelier Dutch, already combined the different information sources into one drawing to analyse the baseline situation of the project before the first workshop. In retrospect, it would have been more efficient when this baseline situation was already analysed in the MKP-MapTable before Atelier Dutch made an urban design for the area.
The urban designer additionally recognised that the expectations should be well communicated between the Province of Utrecht and the municipality. He compares the use of the MKP-MapTable to the use of Building Information Management (BIM) program in practice: "When you use a BIM program with different stakeholders, it is important to make good arrangements about the use of the tool. The same applies to the use of the MKP-MapTable" (Interview #23, Urban Designer, Atelier Dutch).

Although the urban designer acknowledged the disappointment of the municipality, as the MKP-MapTable did not work properly during the second workshop, he had an understanding that teething problems might occur when you are using innovative tools. In general, he advocated the development of the MKP-MapTable by the Province of Utrecht and the use of the tool by the municipalities. He stated that it was valuable that the MKP-MapTable confirmed that the urban design took all the environmental constraints in the area into account. Furthermore, he recognised that the evaluation of the urban design by the MKP-MapTable made the value of the design much more convincing to politicians. He emphasized that the MKP-MapTable is particularly helpful to provide insight into the urban plan to politicians, as they do not have background knowledge or less experiential knowledge in urban planning (Interview #23, Urban Designer, Atelier Dutch).

One of the disadvantages of the MKP-MapTable was, according to the urban designer, the unaccessibility of the tool due to its weight. Although he did recognise the aim of the physical table to enhance the collaboration between stakeholders, he suggests that the Environmental Quality Profiles should be accessible from every device or computer. Furthermore, as the Environmental Quality Profiles are currently not the only software available that is able to assess the environmental quality of an area, different software programs need to be able to exchange information (Interview #23, Urban Designer, Atelier Dutch).

Additionally, the urban designer indicated that the application of the MKP-MapTable in the project Woudenberg-Oost was suitable, because of the scale of the project that caused to a certain complexity. He explained that a workshop with sketching on paper suffice in small scale urban development projects, or development projects with limited amount of stakeholders; while digital tools are usefull for development projects at a larger scale or with a greater amount of stakeholders.
Just as the advisors Sustainable Urban Development of the Province of Utrecht, the urban designer mentions that the use of the MKP-MapTable is suitable for evaluating greenfield developments as there was not a spatial structure yet in the area. Also the variety of stakeholders with different disciplines made the application of the MKP-MapTable useful by clarifying each other's interests and objectives in the project. Therefore, according to the urban designer, the application of the MKP-MapTable creates a mutual understanding between the stakeholders and enchances the collaboration between the stakeholders (Interview #23, Urban Designer, Atelier Dutch). This can support the development process as he experienced that different disciplines fairly reguraly perceive the spatial issue only from their own perspective, thereby not taking the interests of other stakeholders into account (Interview #23, Urban Designer, Atelier Dutch). Although, the urban designer clarifies that, tools like the MKP-MapTable can successfully support the urban development process, it is still the question how stakeholders interpret the data and results. Therefore, the urban designer mentions that the creation of the urban design is still carried out by people with own perspectives, experiental knowledge and intuitions (Interview #23, Urban Designer, Atelier Dutch).

ANALYSIS AND DISCUSSION

As mentioned in the literature review, earlier studies (e.g. Pelzer, 2015; Eikelboom, 2015; Arciniegas, 2012; Te Brömmelstroet, 2010) concluded that the organisation of the workshop heavily influenced the usefulness of planning support systems in practice. A good preparation for the workshops is therefore crucial, especially as users have little tolerance when there are technical faults. This corresponds to the case in Woudenberg-Oost: Users have experienced the application of the MKP-MapTable negatively as data were out-dated and as the MapTable crashed during the second workshop.

The urban planner emphasised that the MKP-MapTable can encourage the creation of a mutual understanding between different frameworks. This statement can be explained by the SECI model of knowledge cration as mentioned in the literature review (page 32).
The urban designer furthermore mentions that it is still the question how stakeholders interpret the data and results produced by the MKP-MapTable. This is related to the different perception framework of the stakeholders as explained on page 31 in the literature review.

CASE 4: MAPTABLE: HET KWADRANT, MUNICIPALITY STICHTSE VECHT

DISCRIPTION OF THE PROJECT

'Het Kwadrant' is an undeveloped area located in Maarssenbroek, Municipality Stichtse Vecht. The area is located between three busy roads: the 'Floraweg', the 'Amsterdamse Slag' and the 'Zuilense Ring' (N230). Furthermore, the northwestern side of the area is adjacent to the 'Maarssenbroekse Slag'.

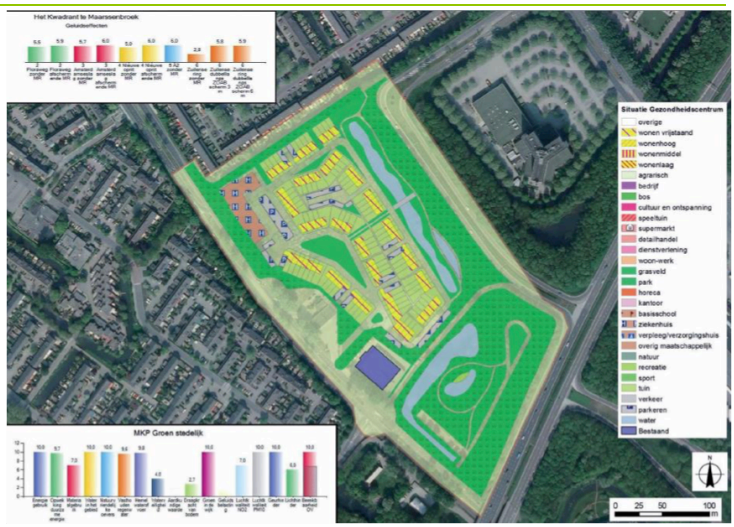


Figure 32 *Screenshot of the MKP-MapTable workshop Het Kwadrant (Province of Urecht, 2014a)*

Since 2004, intensive consultations were conducted between the project developers and the municipality to develop the area. Before the financial crisis, an office area of 25.000m^2 and a business park of 3.000m^2 were planned to be developed, next to the 1.500m^2 existing business area. This was adopted in the land use plan 'Maarssenbroek Werkgebied' in 2006.
During the crisis, it appears that there was no demand for extra office space anymore. Therefore, the developer wanted to realise a residential area instead. The land is primarily owned by the developer Bon Groep B.V. and Kondor Wessels Projecten, together forming Kwadrant B.V.

They work in collaboration with the Municipality Stichtse Vecht in order to get approval for a new land-use plan allowing the construction of 140 dwellings. It was hard to convince the city council that the realisation of a residential area would be feasible because the noise nuisance and air pollution play an important restriction in the area. The MKP-MapTable was used to convince the city council to change the land-use plan. The two workshops with the developers and municipality took place on May 27 and September 3, 2014.

The changes to the land-use plan have been adopted November 25, 2015 by the city council. The realisation of the neighbourhood was planned to start at the end of 2015. However, it appears that the urban plan as discussed during the MapTable workshop is not financially feasible. Therefore, the developer wanted to cut down on sustainability measures, like the realisation of net zero-energy housing. The municipality did not agree with cutting down on sustainability measures, as the plan was approved by the city council under the condition that it would become a sustainable neighbourhood. Therefore, the municipality and the developers are still in consultation about the desired development plan.

THE TOOL IN THE PROCESS

The tool is used during the design phase, for evaluating the environmental performance of the design, especially in relation to the level of noise.
17 participants were present at the first workshop. From the Municipality Stichtse Vecht the following four people were present: the municipal project leader, a consultant Spatial Planning and Environment, a traffic expert, and an economic advisor. Three people were present from the environment service region Utrecht (ODRU): a coordinator Environment, a consultant Noise and Air quality, and a consultant Climate, Energy and Sustainability. Additionally, four people were present from Kwadrant B.V. And finally, 5 people from the Province of Utrecht attended the workshops together with a MapTable expert from IVAM. The civil servants of the Province of Utrecht primarily attended the workshops to manage the meeting and operate the MKP-MapTable.

Since the execution of the last workshop and the approval of the city council to realise the neighbourhood of 'Het Kwadrant', it appears that the plan as examined by the MKP-MapTable was financially not feasible. A new workshop might be planned to check the environmental quality of an alternative design when needed.

THE AIM OF USING THE MKP-MAPTABLE

The aim of using the MKP-MapTable was to visualise the environmental quality and sustainability of the intended spatial plan for the city council in order to convince them that a residential area on this specific location is feasible, provided that measurements would be taken to limit the noise nuisance.

THE PREPARATION FOR THE WORKSHOPS

The necessary environmental information in relation to the project were gathered and the relevant maps were loaded into the MKP-MapTable, in order to be able to present the current environmental situation versus the situation in relation to the first urban draft design, in preparation for the MKP-MapTable workshops.

During the first workshop it appears that a level of noise could be achieved of 48 to 55 dB Lden by realising noise mitigation measures. After the first workshop, new design alternatives of noise walls were calculated to further reduce the noise nuisance to below 48 dB. The level of noise for these alternatives were calculated and loaded into the MKP-MapTable before the start of the second workshop.

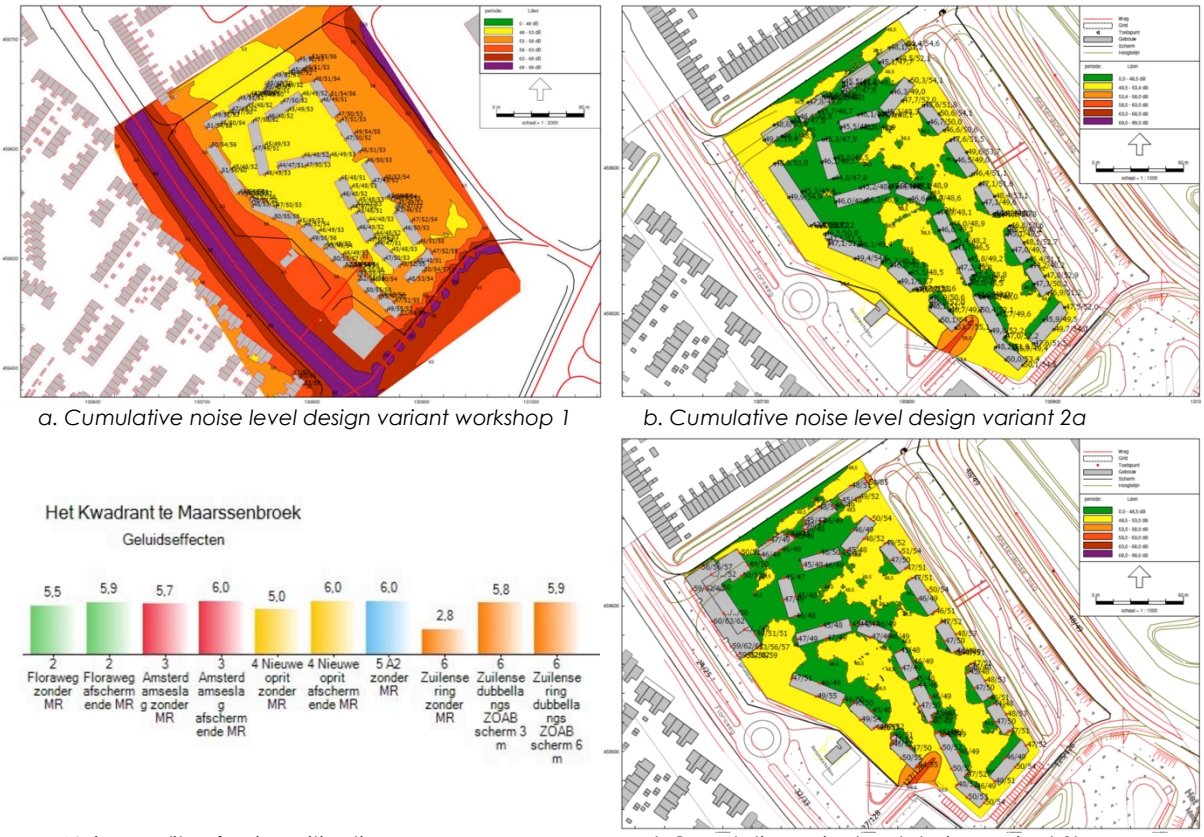
THE CONTENT OF THE WORKSHOPS

The first workshop took place with civil servants of the Municipality Stichtse Vecht and Kwadrant B.V. developers. In response to this workshop, the spatial plan was presented to the city council of Municipality Stichtse Vecht during the second workshop.

The municipality and the developer have determined the environmental and sustainable ambitions for the area and the environmental quality profiles for the desired urban plan, by using the MKP-MapTable during the workshops. In order to determine the environmental and sustainable ambitions, the opportunities and constraints of the area and possible solutions are visualised during the first workshop. Additionally, the feasible noise quality was determined and the environmental performance of the urban design is optimised by the exploration of the environmental quality profiles.

The feasible noise quality was determined in relation to predetermined noise measures, like silent asphalt and noise walls. Based upon the feasible noise quality, as is illustrated in figure 33, it is determined that the proposed housing was feasible within the legal framework considering noise and by withholding higher noise levels for the aimed housing ('Hogere Waarden Geluid'). In the Netherlands higher noise levels for housing are allowed, provided that the houses meet a number of measures to limit the noise nuisance inside the dwellings ('binnenwaarde'), like the construction of 'deaf facades' and extra acoustic isolation. Deaf facades do not have windows or doors that can be opened and are therefore not desirable.

Related to the mitigation of noise the impact of different noise mitigation measures were researched as is shown in figure 33c and as outlined in appendix H. The area is protected from noise caused by the local roads by noise embankments with a noise wall of in total 3m high. The level of noise caused by the provincial road, Zuilense Ring N230, is limited by 'ZOAB' asphalt, a type of quiet asphalt, and a 3m high noise wall. The area is exposed to a high noise nuisance ranging from 53 to 63 dB without these measures; while the level of noise nuisance is limited to 48 to 55 dB with these measures. Figure 33a shows the cumulative level of noise when these noise mitigation measures are applied.
The exploration and determination of the other environmental quality profiles is outlined in appendix H and illustrated in figures 34 and 35.



a. Cumulative noise level design variant workshop 1

b. Cumulative noise level design variant 2a

c. Noise quality of noise mitigation measures

d. Cumulative noise level design variant 2b

Figure 33 *Level of noise before and after the workshops by making use of the buildings and a noise barrier (Province of Urecht, 2014a)*

The conclusion of the first workshop was that a high environmental quality can be accomplished when the municipality and the developer realise their environmental and sustainable objectives, and when the Province of Utrecht is willing to contribute to the noise mitigation measures of the Zuilense Ring (N230). The high environmental quality can compensate the noise nuisance partially (Provincie Utrecht, 2014a).

A noise level above 48 dB Lden requires noise mitigation measures on building level according to the law of higher noise levels ('Hogere Waarden Geluid'). Therefore, new noise mitigation measures were calculated and loaded into the MKP-MapTable in preparation for the second workshop.
The noise wall at the side of the 'Floraweg' was increased locally from 3m to 3.5m high; the noise wall at the side of the 'Amsterdamseweg' was increased locally from 3m to 4m high; the noise wall at the side of the slip road to the 'Zuilense Ring' was increased locally from 3m to 4m high.

Figure 33 shows the noise nuisance at the start of the first workshop and at the end of the second workshop in which different measures to limit the noise nuisance were explored.

For the second workshop two design alternatives were evaluated: one with a health centrum (variant 2b) and one without a health centrum providing extra space for housing (variant 2a). The Municipality Stichtse Vecht prefers the design variant with the health centrum, as this variant also incorporates social housing above the health centrum.

These design alternatives are presented to the city council as well as the main findings from the first workshop. The extra noise mitigation measures that are incorporated into the new design improve the noise quality in the area substantially. The cumulative noise level in the entire area was decreased to under 53 dB, while the dwellings were exposed to below 48 dB Lden as illustrated for the two design alternatives in figure 33b and 33d.

THE OUTCOME OF THE MKP-MAPTABLE WORKSHOPS

It appears that the realisation of the residential neighbourhood was feasible when measures are taken to limit noise nuisance from the adjacent roads, as illustrated in figure 33. The use of the MKP-MapTable increased the insight of stakeholders into the comprehensiveness of the different environmental impacts of the plan on its environment. As a result, the MapTable convinced the city council in adopting changes to the land-use plan in order to allow housing instead of an office area.

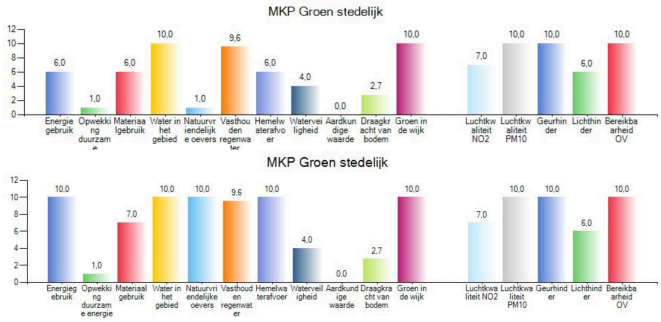


Figure 34 *The environmental quality profiles before and after the workshops (Province of Urecht, 2014a)*

DESCRIPTION OF THE TOOL

The level of noise, air quality, external safety, soil quality, bearing capacity of the ground, the accessibility by public transport, the ecological main structure, water management, and energy use were visualised during the MKP-MapTable workshops. The environmental quality profiles of the urban design before and after the workshops are illustrated in figure 34.
The used functions are primarily related to the evaluation tasks, whereby different maps are selected, indicators are visualised, and the environmental quality profiles are calculated. The noise mitigation measures needed to be pre-calculated and to be loaded into the MKP-MapTable as the noise calculations of the MKP-MapTable were limited. Also, it was not possible to draw different noise walls directly on the MKP-MapTable.

USER EXPERIENCES

The Municipality Stichtse Vecht decided to use the MKP-MapTable for this project as the decision-making was blocked, since the city council was not convinced by the civil servants and developer to change the land-use plan. For this project, it was not the question whether noise nuisance affects the area, but how they could limit the noise nuisance in order to make development of housing possible. The MKP-MapTable was able to convince the city council in making an adaptation in the land-use plan. Therefore, the municipality and the developers were satisfied by the application of the MKP-MapTable.

According to the project leader, images are usually easier to understand than large text documents (Interview #25, Project Leader, Municipality Stichtse Vecht). Furthermore, the MKP-MapTable was well able to provide the city councilors insight into the truths and untruths of the discussion and to compare the environmental impact of different designs with each other (Interview #25, Coordinator Environment, ODRU).
Also the traffic expert mentions, this as a major benefit: "It is possible to visualise a plan and integrally approach a plan in different ways, but by using the MapTable whereby the stakeholders were present in one room stimulated discussions. That has a greater value than asking an external party to present a new plan" (Interview #25, Traffic Expert, Municipality Stichtse Vecht).
According to the project leader, although the most city councilors changed their view upon the spatial issue after the demonstration of the MKP-MapTable, some city councilors believed that the results of the MKP-MapTable were not calculated correctly. This illustrates that even though you can theoretically underpin your findings, you still need to deal with people that are making the decisions (Interview #25, Project Leader, Municipality Stichtse Vecht).

The municipality did also experience some drawbacks of the tool. First of all, llittle possibilities were available to integrate noise mitigation measures in the plan in the MKP-MapTable. Consequently, the impact of these measures needed to be calculated by another model and subsequently loaded into the MKP-MapTable. It was therefore not possible to quickly adapt the noise mitigation measures during the workshop, for instance, by increasing the noise wall from 3m to 4m height. The facilitators of the MKP-MapTable workshops recognised this limitation: "MapTable workshops are suitable for the initiation phase as the MapTable is not accurate enough to evaluate plans at a later stage in the development process" (Interview #24, MKP-MapTable facilitators, Province of Utrecht).
Secondly, the municipality experienced the preparation time of the workshop as a disadvantage. The facilitators of the MKP-MapTable workshop were aware of this, and explained that it was partly due to the demand for accurate noise calculations ((Interview #24, MKP-MapTable facilitators, Province of Utrecht). Although the municipality was aware that the data cannot be uploaded automatically in the tool, it would be much more convenient when this will be made possible during the further development of the MKP-MapTable in the future.

Thirdly, the financial aspect of the plan is underexposed in the MKP-MapTable. Especially for this project, it was a shame that the financial feasibility of the plan was not assessed during the workshops, as it appears that the plan is currently not financially feasible. Furthermore, the possibilities to adapt the traffic situation in the MKP-MapTable are limited. According to the traffic expert, "it is important to just get an impression of these indicators, therefore, they do not need to be very precise" (Interview #25, Traffic Expert, Municipality Stichtse Vecht).

A benefit of the MKP-MapTable was that it clearly presents the impact of a plan upon the different environmental topics. Furthermore, it appears that the plan particularly scored high upon the soft indicators, like public transport. Normally the municipality would not visualise these topics, but it was interesting to also see the strong aspects of the plan.
Additionally, the Coordinator Environment mentions that many research was already executed before the use of the MKP-MapTable. Therefore, the impact of the plan upon the environmental indicators was not a surprise for the involved civil servants. The situation especially became clearer to the city council (Interview #25, Coordinator Environment, ODRU).

As the developer initiated the plan, already years ago and owns the majority of the land in the area, one can wonder why the municipality spends so much time on the development of a new land-use plan for 'Het Kwadrant'. According to the project leader, the municipality will lose their planning costs when the plan will not be executed. Furthermore, they need to realise additional housing within the municipality to fulfill the housing policy of the Province of Utrecht. As the municipality is situated next to the 'Groene Hart', a mayor green area between the largest cities of the Netherlands, they prefer to use empty areas within the urban fringe. Additionally, when the plan will be realised, also adjacent neigbourhoods will benefit the noise mitigation measures.

One of the strict conditions set by the city council was an extra slip road to the Zuilense Ring (N230) adjacent to the area. According to the municipality, this condition was not negotiable before the adaption of the land-use plan. The city council was convinced that the extra slip road was needed to deal with the traffic in the neigbourhood of 'Het Kwadrant'. However, the civil servants thought that this opinion of the city council was primarily based on intuition and not well justified by data. When this extra slip road will not be included in the plan, a better financial feasibility can be achieved.

In the end, the municipality does not think that the developer has been totally open about their interests and ambitions in the area. Although the developer was positive about the use of the MKP-MapTable in order to get approval by the city council, it is not surprising that the plan that was discussed appears to be financially infeasible. High investments already need to be made to limit the noise nuisance. During the workshop, the municipality already suspected that the high environmental ambitions would not be financially feasible, but the developers did not agree at that time. The municipality therefore concludes that the project is characterised by a political game of interests.

According to the municipality, the application of the MKP-MapTable was especially suitable for this project because of its political sensitivity. They will only use the MKP-MapTable in another project, when there is again a high political sensitivity; otherwise, the initiator of the plan unnecessarily need to make high costs, as they need to pay the research needed in order to create the plan.

The timing of the application of the MapTable in the process was also suitable, according to the municipality, as the decision-making was blocked at that moment. Although, the plan still needs to be adapted to make it financially feasible, the adaptation to the land-use plan limited the risks of the developers to spend money in the development of the plan: "We could not present the plan to the city council while at the same time suggesting to cancel their strict condition to build an extra slip road to the Zuilense Ring, as cancelling the slip road was not a point of discussion without the changed land-use of the area from offices to housing. The other way around, the developer desires to have a greater certainty that the municipality approves their plan so that they can develop the area. Therefore the adaptation to the land-use plan was crucial in order to convince the developers to continue the project" (Interview #25, Project Leader; Coordinator Environment & Traffic Expert, Municipality Stichtse Vecht).

Additionally the municipality mentions that they are used to work in an integral way with different disciplines in one project team. Therefore, this way of working was not new to them. According to the municipality, this seems to be the case in contrast to the Province of Utrecht. Although many advisors of the Province of Utrecht were attending the MKP-MapTable workshops, it took the municipality a lot of effort to convince the different departments at the Province of Utrecht after the MKP-MapTable workshops, that the resulting plan took the environmental quality profiles into account the best way possible (Interview #25, Project Leader; Coordinator Environment & Traffic Expert, Municipality Stichtse Vecht).

As changes need to be made to the plan in order to create a financially feasible plan, it is questionable wether an additional MKP-MapTable workshop is needed. The project leader explained that currently they have insight into the factors influencing the environmental quality of a plan: "In order to make the design financially feasible, primarily noise and traffic related measures need to be adapted. Therefore, I think it is quicker to execute the noise and traffic studies separately from the MKP-MapTable, as it takes a lot of effort to prepare another MKP-MapTable workshop" (Interview #25, Project Leader, Municipality Stichtse Vecht).

ANALYSIS AND DISCUSSION

Although the stakeholders experienced the use of the MKP-MapTable positevely, the MKP-MapTable was not able to succesfully support the project, as the spatial issue desired accurate calculations in relation to noise nuisance and traffic. Therefore another PSS might be more suitable to fulfil this type of demand.

The decision-making culture of this project was not really open. As mentioned in the literature review on p. 28 by Van Gunsteren & Van Loon (2000), an open decision-making process is not taken for granted, as not every stakeholder benefits a transparent and open design process. In the case of 'Het Kwadrant', it is understandable from the perspective of the developer that they first promoted a sustainable plan to convince the City Council, while they communicated after this decision that the plan was not financially feasible. Although this was beneficial for the developer, not being transparent appears to be counterproductive in this process: The stakeholders need to meet again to discuss how they could adapt the design in order to make it financially feasible. Furthermore, it is likely that the city council will look at it again as they gave permission to realise housing on other terms. This will take extra time.

Some city councillors had no confidence in the workpreparation of the civil servants and developers to create a new development plan for the area. Even after the demonstration of the MKP-MapTable, a few councillors did not have faith into the results. This distrust might be caused by political reasons, as they were not in favour of the development plans because they feared objections of the citizens against the noise nuisance or air pollution. Additionally, the city councillors set the split road to the Zuilense Ring as a strict condition, as they feared objections of neighbouring citizens that they have to take a minor detour. As the city council was already sceptical against housing, since this would also mean that the accessibility of Maarsbergen need to be compromised, they would not be in favour of the plan. The adaptation in the land-use plan has provided the developers a greater certainty that the municipality will approve their plan enabling them to develop the area. This highlights the importance of dividing the decision-making process into different phases.

CONCLUSIONS CASES MAPTABLE

This section has illustrated the application of the MKP-MapTable in two projects in the Province of Utrecht: Woudenberg-Oost in the Municipality Woudenberg and 'Het Kwadrant' in the Municipality Stichtse Vecht. The MKP-MapTable is a touch table that runs ESRI ArcGIS, a well-known GIS software, with Community Viz Scenario 360. The Province of Utrecht has developed the Environmental Quality Profiles that rates the sustainability of a spatial plan according to 8 to 20 different themes.

Through the combination of the software, hardware of the MapTable, and location specific information, stakeholders can gain insight into the environmental quality and sustainability aspects of a plan, which allows them to optimise different design alternatives.

The MKP-MapTable is an example of a sub-aspect system (De Leeuw, 2002, p. 104), as it only considers environmental themes related to urban development and as attention is paid to only a part of the existing relationships between within these environmental themes. The soft systems approach is recognisable in enabling the stakeholders to determine the aimed performance of the environmental quality profiles.
During the second workshop, all the chosen criteria from the first workshop are recalculated by every adaptation to the plan. As this presents the effects of one measure on all the relevant criteria, this approach can be indicated as purpose treatment ('doelverwerking') (Micheels, 2014, p. 371).

The Province of Utrecht has started the development of the MKP-MapTable to stimulate the municipalities to develop areas in a sustainable and integral way. Consequently, the translation of the measures of indicators into a score at a 0 to 10 scale implies a normative approach by which the municipalities are stimulated to achieve at least a 6 for all relevant indicators. These scores are not aggregated into one total score. Therefore, a multi-criteria analysis in which different criteria are weighted is not explicitely applied. The environmental quality scores are easily understandable to all stakeholders, however, technical experts usually prefer to have insight into the way in which these indicators are measured.

As mentioned in the theoretical framework, decision-making is in essence determined by subjective behaviour. The decision-making process can only be made more transparent by using a MKP-MapTable. The way decisions are made influences the outcome of a decision, as is illustrated by Micheels (2014, pp. 400-401). Choosing to use the MKP-MapTable is already a subjective choice, as the weighting of criteria is subjective, just as the selection of criteria incorporated in the workshops and the translation of ambitions into environmental quality profile target values. Furthermore, the MKP-MapTable especially pays attention to environmental indicators and less to social and economic aspects. consequently, some stakeholders may benefit more from using the MKP-MapTable than others.
Therefore, stakeholders might be against the use of the MKP-MapTable in their development projects.

However, the use of the MKP-MapTable does not bind stakeholders to choose for the most sustainable plan in relation to the environment. Micheels (2014, p. 371) gives a practical example whereby stakeholders also were not tied to their choices, illustrating that decisions can be made easier, when stakeholders know that this can be modified again at a later stage. This is not wrong in essence. In accordance with the soft systems approach, this method provides new insights that can be used to improve the plan.

The MKP-MapTable can be used at different moments during the planning process. However, it is advised to use it in at least two workshops in order to better integrate the tool in its process. Firstly, it can be used during the initiation phase by giving insights into the opportunities and threats in relation to the baseline situation with its environmental quality profiles. Secondly, it can be used during the programme phase in order to determine feasible ambitions and its related criteria. Thirdly, some scenarios, or rough draft design principles, can be made in the MKP-MapTable in preparation for the design phase. And lastly, the MKP-MapTable can be used during the design phase for evaluating (interim) designs or design alternatives in relation to the environmental quality profiles.

The developers prefer to apply the tool as early as possible, however the cases illustrate that the different tasks that are executed at different moments in the development process require different types of planning support. In order to apply the tool at the start of the project, the tool needs to be as simple as possible so that stakeholders can easily use the tool by themselves. Additionally, the preparation of the tool should not require too much time at the start of the project. Since the execution of the project is still unsure, at that phase of the project, leading to a high risk of wasting time when it appears that the project will not be executed. Contrary to the start of the project, more precise information is needed in order to evaluate the design at the final stages of the design process. The MapTable is less suitable to use at a final stage of the design process as the software is not accurate enough.

The case study in the Municipality Woudenberg illustrate that a good organisation of the workshop is crucial for a successful application of the MKP-MapTable. In this case the usefulness of the MKP-MapTable could be increased by using the tool earlier in the development process to support the analysis of the baseline situation of the area.

The functions that are used during the workshops are primarily related to the simulation and evaluation tasks, whereby different maps are selected, indicators are visualised, and the environmental quality profiles are calculated. During the second workshop, the MKP-MapTable crashed while trying to adapt the draft urban design plan. Therefore the drawing tasks executed are negligible.

The stakeholders of 'Het Kwadrant' in the Municipality Stichtse Vecht experienced the application of the MKP-MapTable positively as the tool convinced the city council to adapt the land-use plan. The used functions are primarily related to the evaluation tasks. The noise mitigation measures needed to be pre-calculated and to be loaded into the MKP-MapTable as the noise calculations of the MKP-MapTable were limited. Furthermore, for this project financial indicators were missing in the MKP-MapTable, as it appears in retrospect that the development plan is not financially feasible.

As it takes quite a lot of time to adapt the MKP-MapTable to the specific spatial issue, the tool is not suitable to be applied in every type of project. The projects need to have a certain complexity, which can be caused by the amount of involved actors and the scale of the project. The case-studies illustrate that it is crucial to communicate well beforehand for what reason the MKP-MapTable is desired to be applied in the project, what the stakeholders want to achieve with it, and how the MKP-MapTable can achieve that demand. Uptill now, the Province of Utrecht has not been very critical in the selection of projects wherein the MKP-MapTable can be applied. Although not many development projects are realised in the Province of Utrecht at the moment, it is advisable to still be critical in the selection of projects. When the application of the MKP-MapTable does not suit the demand or expectations of the stakeholders, they will experience the tool negatively. This leads to a sceptical attitude to the application of the tool and, therefore, resistence to use the tool again in another project.

While the facilitators of the MKP-MapTable workshops used to be critical in the selection of suitable cases, currently they are glad when they can support a project. The semi-structured interviews illustrated that the MKP-MapTable is not profitable from a commercial point of view. Although the new Environment and Planning Act creates opportunities to better structure and organise the data sources, private parties and civil society increasingly take Initiatives in urban development projects instead of governmental bodies (Heurkens, 2012). Furthermore, development projects are typically smaller, and are realised in more phases since the financial crisis of 2008. As long as the Province of Utrecht only supports their municipalities, they will have a hard time finding suitable projects for applying the MKP-MapTable in practice.

Currently the Province of Utrecht is looking to additional indicators to increase the attractiveness of the MapTable to use the tool in practice, but additional indicators will also increase the demand for data, leading to extra preparation time. Also, additional indicators will make the tool more complex and therefore less user-friendly. Furthermore, it will increase the calculation time and might even increase the risk on technical failures. Therefore, I recommend to first make sure that data sources are well organised and maintained; that calculation times are reduced, while improving the technical performance of the Environmental Quality Profile; and that the flexibility of the tool will be improved by adding possibilities in creating environmental measures. Furthermore, the tool can also be actively promoted in other domains like infrastructure planning and landscape planning. Subsequently it can be helpful to incorporate an indication of the financial feasibility of the plan into the Environmental Quality Profiles. Based upon the two case studies a SWOT analysis of the tool is made, as shown in table 10.

Table 10 *SWOT analysis of the MapTable (Own ill.)*

STRENGTHS • User-friendliness: interactive setting; • Design possibilities; • Tool draws positive attention.	**WEAKNESSES** • Calculation speed; • Compactness: size & weight; • Preparation time.
OPPORTUNITIES • Flexibility; • Streamlining different programs and data sources; • Portability: lighter and thinner; • Greater role citizen participation; • Incorporating financial feasibility.	**THREATS** • Risk of technical failure; • Power relations: fear for decreased negotiation position.

CASES TYGRON AND PLANMAAT

Unfortunately, no users of the serious games of Tygron consented to contribute to this research. Therefore, this case study was executed on the basis of semi-structured interviews with developers of Tygron and a secondary data analysis. This was further complemented by a semi-structured interview with Planmaat and Play the City. Planmaat was incorporated in this research as the interviewed developer has a great understanding of the use of different planning support systems in the Netherlands. This interview contributed to this research with respect to the use of planning support systems in urban development in general. The decision to involve Play the City was made at a later stage of the research, as it appears during researching the urban redevelopment in Buiksloterham that Play the City was planning a game workshop for the stakeholders of Buiksloterham.

INTRODUCTION TYGRON

Serious games simulate a simplified reality to support learning between stakeholders. Tygron and Play the City are examples of multiplayer serious games. Multiplayer games involve multiple stakeholders playing simultaneously, in which the actions of one influence the situation for everyone (Bekebrede et al., 2012). Accordingly, as outlined by Mayer et al. (2009), within the simulated reality, participants can learn from each other about the specific area with its interrelated processes; the possible developments, for instance by executing scenario analysis; and the behaviour and strategies of other stakeholders. Tygron is an example of a serious game that enables stakeholders to experiment with strategies and interventions to examine the reactions of other stakeholders. The games can be easily adapted to the needs of the users through the game engine. This can be done by Tygron, or even by the users themselves.
In March 2015, the game engine was integrated with ESRI ArcGIS Online, by which a wide variety of map overlays, like Top10NL and AHN2, could be loaded into the game (Tygron, 2015). As the game is connected to ArcGIS and specific project data, the game will present reliable information. The connection with ArcGIS Online also enabled the setup of the Buurtvisie (www.buurtvisie.nl). This is an online platform in which citizens can create or improve a design for their neighbourhood. Subsequently, the design can be shared with neighbours, the project developers or with civil servants of the municipality. According to Tygron, the serious games of Tygron are very flexible in use and are thoroughly imbedded in the planning process of each client by using different phases as illustrated in figure 35.

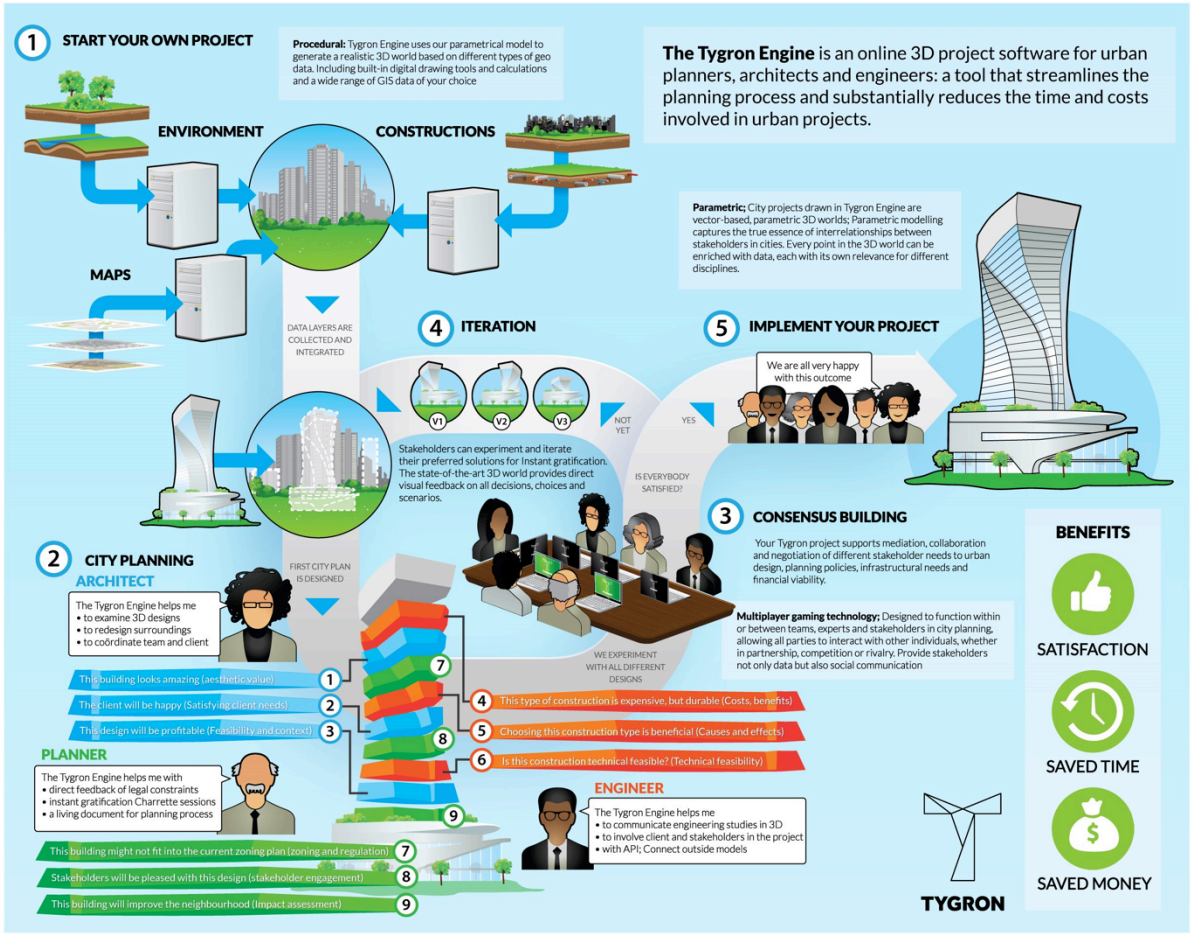


Figure 35 *Incorporation of Tygron into the planning process (Tygron, 2015)*

INTRODUCTION PLANMAAT

Planmaat supports decision-making processes in urban development by, amongst others, the development of ground exploitation models, risk analysis and feasibility studies. To develop new models according to the clients' needs, they generally use existing software like Excel, ArcGIS or DGdialog or their own adaptive tool Plex. Depending on the needs of the client, these systems can be supplemented with additional models. In order to study the feasibility of a plan, they use optimisation through linear programming, as mentioned in the theoretical framework, or computation-and-design tools.

Patrick Nan is one of the owners of Planmaat. He started the company in 2004 with Ellen Mettes. Before starting up Planmaat, both had been working at Adecs, advanced decision systems, which was closely related to Delft University of Technology. However, at that time, the role of the tool was central in solving (spatial) problems. Ellen Mettes and Patrick Nan agreed that the process instead of the tool should be central in urban development and planning projects. Consequently, they have started-up Planmaat in order to guide the development and planning process.

RESULTS SEMI-STRUCTURED INTERVIEW DEVELOPERS

In this section the interview results of the developers of Tygron and Planmaat are outlined.

Tygron

According to one of the developers of Tygron, Tygron is especially suitable for complex development processes (Interview #8, Serious Game Developer, Tygron). She explains that, after the area and relevant information is loaded into the game, the spatial issue is analysed. Subsequently Tygron will visualise the spatial problem in a simplified way. Playing the serious game provides the stakeholders a direction in the process and a starting point for further development of their ideas. While stakeholders tend to desire to incorporate much information into the game, Tygron tries to limit and adapt the game to the key points of the project. The developer emphasises, "as various stakeholders are participating in diverse projects, every gaming session is different" (Interview #8, Serious Game Developer, Tygron).

The developer explained that it is important to find a balance in consultation with the stakeholders between covering the reality of the spatial issue, while creating focus in the game: "when stakeholders do not recognise the project in the game, they do not tend to take the game seriously" (Interview #8, Serious Game Developer, Tygron). However, she also mentions that it depends per stakeholder background whether they tend to accept the results of the game, or not: "Civil servants of the municipalities tend to better accept the results of the game than technical experts, as they are able to see the bigger picture. This is in contrary to the technical experts that prefer to see more detailed calculations in the model. People who are able to think conceptually, can better accept the results as they see it as a starting point for further development." (Interview #8, Serious Game Developer, Tygron) The developer furthermore mentions that, sometimes, stakeholders fear to contribute to playing the game, as they might be afraid for losing their status (Interview #8, Serious Game Developer, Tygron). Moreover, the developer highlights that stakeholders generally find it difficult to openly discuss the project and to share their financial interests in the project with the other stakeholders, as they are used to negotiate in a closed decision-making culture. However, Tygron experiences that when the project team agrees to conduct the open decision-making approach, the end result from a group perspective is commonly positively influenced. However, this does not necessarily mean that also the individual interests of stakeholders benefits an open-decision making approach.

It depends per project how Tygron translates the goal and objectives of the project into a serious game. Tygron believes that a close involvement of stakeholders in the development of the game, makes a great difference in the process. As stakeholders own much information and knowledge relevant to the project, Tygron tries to incorporate that knowledge into the game (Interview #8, Serious Game Developer, Tygron). The developer states that, when stakeholders are familiar with each other's interests and understand why they act a certain way, it creates opportunities for negotiation.

Every stakeholder plays the game from their own computer in a single room. The computers are online connected to each other, whereby actions of one player affects the game of the other players. The developer of Tygron explains that as stakeholders are playing the game from their own computer, the role of each stakeholder and the differences in interests remains clear. According to the developer, this is in line with the reality whereby stakeholders tend to look at the spatial problem after their own interests as well. The developer highlights that, "The greatest learning effect is created when stakeholders are making mistakes in the virtual environment" (Interview #8, Serious Game Developer, Tygron).

After a game session, stakeholders share their experiences and results are discussed jointly. The developer highlights that this discussion is especially relevant to reach a consensus.

According to Tygron, the organisation of multiple gaming sessions for one project is desired, as this enables stakeholders to apply the things that they have learnt in the previous session during the next session, until a consensus is reached. A greater insight into the development project is generated by the stakeholders after a single gaming session, but this will not lead to a solution to the spatial issue. It depends on the complexity of the project, how many gaming sessions are desired. According to the developer, "it is not the case that the result of a gaming session will be implemented directly in practice, but that it provides the opportunity to discuss with each other to see what could be the right solution" (Interview #8, Serious Game Developer, Tygron).

The developer further outlines that the main issues that are reflected in the evaluations by users of Tygron are the desire of users to connect the game to their own data, that people have gained insight into each other's interests, and that by playing the game opportunities were created to find together a solution. However, playing serious games in urban development processes is not yet a common way of working. Sometimes it occurs that the management level of an organsiation wants to play serious games to enhance the process, while the operational level does not want to cooperate or the other way around. Tygron experiences that especially innovative projects are open to apply new methods like serious gaming in practice.

The Urban Planner of Woudenberg-Oost also shared his experience with serious games during the semi-structured interview. Similar to the developer of Tygron, he mentions that, "stakeholders tend to act in their own interests during the development process. Therefore, it can be hard to reach a consensus. A serious game can support the planning process, when the game is played for fun with the stakeholders and when the result does not matter. This way, it might turn out that the result of the game inspires the stakeholders when they recognise their own interests in the plan, while the interests of other stakeholders are also covered" (Interview #23, Urban Designer, Atelier Dutch).

Planmaat
In contrary to the earlier discussed planning support systems, Planmaat translates spatial quality and land-uses into money: costs and benefits. According to Patrick Nan, a tension exists in urban development projects between the allocation of resources within the limited spatial space, and how much these resources costs and yields. "We often do not have the luxury to also create an environmentally optimal plan" (Interview #12, Planmaat). Therefore, ground exploitation models play an important role in the development process in order to create a feasible plan (Interview #12, Planmaat). Patrick Nan also highlighted that, "as we are designing and calculating in the tool at the same time, the tool should be flexible and easily adaptable" (Interview #12, Planmaat).

Planmaat regularly uses linear programming in Excel with the add-in 'What's Best' to solve the financial feasibility of spatial issues. This is a kind of optimisation method in multi-criteria analysis as explained in the theoretical framework on page 21. This technique can be used by everyone, although you need to be able to apply the optimisation method to the specific spatial issue. According to Patrick Nan, this type of planning support has more freedom to change the calculations and indicators to the specific situation, for instance, in comparison to the MKP-MapTable (Interview #12, Planmaat): "however, it can be a challenge to translate the spatial issue into an optimisation model" (Interview #12, Planmaat).

Furthermore, Patrick Nan explained that you can consider the optimisation model as a disposable product as you need to create a new model for every project. According to him, it is better to quickly develop such an optimisation model specifically created to answer the spatial question at that moment in the development process, than using fixed software that requires large preparation times: "fixed software looks at how they can solve the spatial issue with the tool, while we think about what is the spatial issue and what kind of support or information do I need in order to solve that issue?" (Interview #12, Planmaat). He adds to this that fixed software can be useful to evaluate plans, but it is questionable how usefull they are to design development plans.

Moreover, Patrick Nan emphasised that it is important to have an independent role in the development process in order to enhance the process with an optimisation tool: "When there is disrust towards the expertise of a stakeholder, or when a particular expertise is missing the project team, it is better to ask for advise from a third party than joining the discussion" (Interview #12, Planmaat).
Besides being independent, Planmaat also values the transparency of their calculation models. Stakeholders have therefore the opportunity to inspect all the results and the calculations of Planmaat.

Patrick Nan also experienced that some stakeholders are not willing to have an open decision-making process or prefer to execute plan optimisation at a later stage of the process, for instance, when the land is purchased and agreements for urban development are made with the municipality. This way, the stakeholder tries to protect their negotiation space and tries to increase their own profit margin.

ANALYSIS AND DISCUSSION

Although the examples of Tygron prove that serious gaming can enhance the decision-making process in urban development projects, it remains a major investment, both in knowledge and in time and money, despite the adaptation of computer games are becoming easier. Therefore, it is important to think well in advance about the added values of incorporating serious games into the planning process, and the aim of playing the game.

Usually, serious games are not part of the decision-making process, but are organised in addition to the planning processes, hoping that the planning process has indirectly benefited by the game (Bekebrede et al., 2012). However, this is not the case at Tygron. Tygron embeds the game in the decision-making context on the basis of the objectives and needs of stakeholders through different phases.

As the developer of Tygron illustrated, the effectiveness of serious games is not always acknowledged and is sometimes experienced as disturbing. For instance, As stakeholders do not know beforehand what the influence of the game will be for their position, they might fear that their position is weakened by playing the serious game. Another limitation of serious games, is that a serious game can distract its users from the content: Some users like to explore the functionalities and possibilities of the game instead of exploring the reactions of other users on their actions and vice versa.

In order to enable learning, the possibility to think freely is important. Therefore, serious games aim to release the stakeholders from the formal decision-making process by stimulating an open and transparent collaboration between stakeholders.
Planmaat also tries to encourage an open and transparent approach to decision-making in order to jointly achieve a feasible programme of requirements.

The case of Tygron shows an example of a digital serious game, although, also low-tech physical serious games exist like 'Play the City', as discussed in chapter 7. These low-tech physical serious games can also be beneficial to enhance the development process, as not everyone enjoys working with a computer or is able to understand the operation of digital tools easily. Furthermore, technology based tools are vulnerable; for instance, the power can be cut off, tools can crash or the used internet connections might be weak.

GENERAL CONCLUSION TYGRON AND PLANMAAT

As the examples of Planmaat and Tygron show, a wide variety in planning support systems exists. The case of Tygron illustrates that positive effects of applying serious games in the planning process are caused by renewed insights of stakeholders in the (long-term) effects of possible solutions and by the stimulation of creativity to explore new possibilities. However, the effectiveness of serious games is not always acknowledged and is sometimes experienced as disturbing.

The implementation of Tygron or Planmaat in development processes can be beneficial, when complex situations or problems occur, as serious gaming and optimisation methods can contribute in understanding these complex situations. A mutual understanding is crucial in order to collaboratively create an urban design or a feasible programme of requirements. An open and transparent decision-making process enhances learning and therefore the creation of a mutual understanding.

Since the development of a serious game that fits the specific situation is time-consuming and costly, it is important to realise that the variety of serious games is large and that high tech 3D-virtual worlds are not always necessary to achieve the objectives of a project.

6. COMPARATIVE CASE STUDY ANALYSIS

INTRODUCTION

In this chapter the cases outlined in the previous chapter are compared to each other to answer the research question: "In which cases is the application of PSS perceived as useful by its users and developers?" This is validated by semi-structured interviews with experts. An overview of the different cases outlined in the previous chapter is illustrated in table 11.

Table 11 *Comparison of the different PSS (own ill.)*

Name tool:	MKP-MapTable	Urban Strategy	Tygron
Developed by:	IVAM, Province of Utrecht, Mapsup	TNO	Tygron
Exists since:	2006	2005	2005
Based on type of software:	ArcGIS + Community Viz Scenario 360 + Phoenix	ArcGIS + connected to various existing models like OPS, Lotos EUROS, Swung, SRM.	ArcGIS Online + Tygron Game Engine
Type of tool:	Computer-based	Both (light web-based version on request)	Web-based
Purposes:	Descriptive; prescriptive; exploration; selection; negotiation	Descriptive; prescriptive; predictive	Descriptive; prescriptive
	Analysis; validation; exploration; design; evaluation; negotiation	Analysis; validation; exploration; design; evaluation	Exploration; evaluation; negotiation
Indicators related to the following themes:	Energy; materials, water; soil, ecology; noise; air; external safety; odour; light; mobility.	Traffic; noise; air quality; external safety; costs; groundwater; liveability; sustainability (energy).	Budget; building; water storage; water system; liveability; heat stress; green; parking; climate.
Related sources (scientific):	(Arciniegas, 2012; Arciniegas & Janssen, 2009; Arciniegas & Janssen, 2012; Arciniegas et al., 2011; Arciniegas et al., 2013; Pelzer, 2015; Pelzer et al., 2013; Pelzer et al., 2015; Pelzer & Geertman, 2014; Pelzer et al., 2014a; Schatz et al., 2013; Vonk & Ligtenberg, 2010)	(Beurden et al., 2013; Borst, 2010; Dias et al., 2013; Pelzer, 2015; Pelzer & Geertman, 2014; Pelzer et al., 2014b; A Schelling et al., 2010; Te Brömmelstroet, 2014; Te Brömmelstroet et al., 2013)	-
(Popular)	(Mapsup, 2008, 2013, 2015; Mouter & Pelzer, 2013b; Provincie Utrecht, 2015a, 2015b, 2015c; Puylaert & Werksma, 2011, pp. 30-31; Van Helden & De Jong, 2015)	(Mouter & Pelzer, 2013a, 2013b; Ab Schelling et al., 2012; Te Brömmelstroet & Borst, 2012; TNO, 2015a, 2015b)	(Bekebrede et al., 2012; Tygron, 2015)

COMPARISON OF THE DIFFERENT CASES

It has become clear that Urban Strategy is more often used in practice in comparison to the MKP-MapTable. Additionally, the software of Urban Strategy is older, and therefore more mature. This reveals when you are looking at the stability and speed of the software. TNO is also able to organise the data in the tool faster than the Province of Utrecht by using automatic connections between data sources and indicators. Although the software of Urban Strategy is more stabile, faster and accurate in comparison to the MKP-MapTable, the MKP-MapTable has also advantages above Urban Strategy. Although Urban Strategy can visualise more indicators, the MKP-MapTable has a greater diversity of themes. Additionally, the software is easier to understand, which increases the interactivity of the workshops and user-friendliness of the tool. As the MKP-MapTable has a higher level of abstraction, the tool is more suitable to be used in the beginning of the process in comparison to Urban Strategy. Furthermore, the MKP-MapTable has greater drawing possibilities, which makes the tool also suitable for the diverging phase of the design process. The application of Urban Strategy is especially relevant for evaluating design variants during the converging phase of the design process.

Table 12 *Comparison of the different cases (own ill.)*

	Case 1	Case 2	Case 3	Case 4
Tool:	Urban Strategy	Urban Strategy	MKP-MapTable	MKP-MapTable
City:	Tilburg	Utrecht	Woudenberg	Maarssenbroek
Project:	SUMP Tilburg	Gezonde Verstedelijking Utrecht	Woudenberg-Oost	Het Kwadrant
Client:	Municipality Tilburg	Rijkswaterstaat o/b/o IenM	Municipality Woudenberg	Municipality Stichtse Vecht
Type of development:	Inner-city	Inner-city	Greenfield	Infill area
Scale (ha):	-	-	35 ha	3 ha
Development task:	Development of mobility policy	Development of urban health policy	Development of +- 875 dwellings	Development of 140 dwellings
Funding sources:	Government	Government	Government	Developer Kwadrant B.V. & municipality
Process				
Timeframe:	2015	2014-2015	2014-2015	2014-2015
Phase:	Initiation	Initiation	Initiation	Design
Sequence:	-	Sequential	Integral sequential	Integral sequential
Decision-making culture:	-	Closed	Open	Closed
Orientation:	Indicative	Indicative	Indicative	Blueprint
Stakeholders:	Municipality Tilburg.	Rijkswaterstaat; Municipality Utrecht; POSAD; KC HUL.	Municipality Woudenberg; Atelier Dutch.	Municipality Stichtse Vecht; Bon Groep B.V.
The application of PSS				
Reason for using the PSS:	External advise: fast & shifting responsibility	Exploration of possibilities	Exploration of possibilities	Convincing the council of feasibility
Aim:	Prescriptive	Prescriptive	Prescriptive	Prescriptive
Workshops:	(1) Evaluation	(1) Evaluation	(1) Evaluation (2) Drawing, simulation	(1) Evaluation (2) Drawing, simulation
Main themes addressed:	Air & noise quality	Air & noise quality	Odour & external safety & noise	Noise quality
Main data sources used:	Municipality	Municipality	Municipality	Municipality
Result:	Ambition plan	Problem description	Programme of requirements	Feasible design
Main benefits:				
Main drawbacks:				

COMPARISON OF THE CASE STUDY RESULTS TO THE LITERATURE REVIEW

Bekebrede et al. (2012) hightlights that, despite the increasing sophistication, speed and visualisation possibilities of urban models, the high expectations on these models have only partially come true to date. Although planners and decision-makers do recognise the possibilities of these models, they are not widely embraced. This is illustrated by the case studies as well: the developers of Urban Strategy, the MapTable and Tygron all agreed that people are usually interested in PSS, but the actual implementation of PSS often fail to be realised in practice.

As already mentioned in the literature review, this can be explained by the lack of transparency, flexibility and user-friendliness of these tools (Te Brömmelstroet, 2010a). These aspects are also mentioned in the case studies. Especially the flexibility of the tools appears to be limited, while there is a high demand for flexible tools in the dynamic process of urban development projects. As explained in the theoretical framework, new insights of stakeholders lead to feedback on the plan. The PSS need to be able to deal with this feedback in order to be suitable to use repeatedly during the development process. Moreover, when the perception of stakeholders about the plan changes, due to new knowledge, the PSS need to be able to quickly adapt the indicators accordingly to these new insights. In this respect also McNie (McNie, 2007) states that PSS are often too static and time-consuming to develop, and are at a risk to be out-dated at the time the tool is available for the users, as the need for information and knowledge of the users is changing continuously. This causes tools offering solutions that are too expensive, too late and irrelevant. Therefore, the preparation time and unavailability of correct data or suitable indicators were seen as a major barrier to the widespread use of PSS by the users of the case studies.

Addtionally, the case studies have clarified that an open and transparent approach to decision-making is far from common place in practice. Consequently, stakeholders might oppose the use of PSS, as in general these systems stimulate an open and integral decision-making process. Another point that was clarified by the case studies, was that both Urban Strategy and the MKP-MapTable do not cover a holistic approach to urban development. As these tools have a focus on environmental themes, some stakeholders benefit from the application of these PSS more than others. Furthermore, Urban Strategy and the MKP-MapTable are only accessible via TNO and the Province of Utrecht, which generates another limitation to the widespread use of PSS.

The literature review also mentioned that developers of support tools are usually excluded from the decision-making context that they aim to support. However, this is not the case with Urban Strategy, the MKP-MapTable, Tygron and Planmaat. In these cases the developers of the tool are also involved as facilitators during the workshops with the users of the tool.
Both the MapTable and Urban Strategy focus on grey environmental themes. The developers argue that these themes are often bottlenecks to get permission to adopt the zoning-plan or to realise an urban design. Especially when you want to redevelop former industrial areas, like in Buiksloterham, it is important to first make sure that a clean and safe area can be realised, before a zoning-plan can be adopted.

As mentioned in the literature review, PSS are based on heuristic methods. However, as also outlined by Roozenburg and Eekels (1991), the difference between algorithmic and heuristic methods is not always clear, as a method can be algorithmic with regards to the sub-goal, but heuristic with regards to the main objective of the method. Urban Strategy, the MKP-MapTable and Tygron serious games are algorithmic methods with regards to the sub-goal of determining the quality of a design, but they are heuristic in relation to the main objective of these systems: choosing the best design alternative for a geographic area.

The results of the case studies are to a great extent similar to the results of Peter Pelzer: Also in this study, users and developers highlight the importance of a good process above the importance of a good PSS. Furthermore, we have seen that in general, the financial dimensions are less strongly reflected in the tools, whereas it is a vital aspect in the decision-making in practice.

Additionally, the cases have illustrated that the tool is perceived differently per discipline: architects and policy makers are looking to the plan on a more abstract level, while engineers prefer to exactly understand every detail of the software, and economist prefer to have an overview of the results in a spread sheet. Also people with affection for IT will be more open to use a PSS, than people without affection for IT. The acceptance of PSS by potential users is affected by the work culture of people and people's habits. This corresponds to the work of Vonk (2006) in relation to his Technology Acceptance Model. To deal with these barriers, all developers mention that they are looking for early adopters.

The influence of power relations and political interests was evident in all case studies. But also the background of the supplier of the PSS appears to be important in the decision whether to use PSS in the development process or not. The PSS developers therefore aim to have an independent role in the process in order to be able to represent the interests of all actors that are involved. Also Te Brömmelstroet (2010b) has emphasized the importance of a facilitator who can act neutrally. However, the users seem to prefer to be able to operate the tool by themselves without the need for a third party.

The use of PSS is especially appropriate for complex processes with a certain scale and amount of involved stakeholders. Furthermore, an open approach to decision-making is a precondition for using a planning support system. In general, actors are hiring PSS, when they have seen the PSS before, but the way of working with PSS is often new to the stakeholders.
It is hard to make the effectiveness of planning support tools explicit. And it is impossible to determine the effect of planning support systems for a specific project before hand, as every project is different. Additionally, the results of PSS related to the soft systems approach are not clearly defined.

CONCLUSION

It has become clear that PSS is still a niche: PSS are not regularly applied in practice, although developments in real-time data and GIS create an opportunity for PSS to gather and process data more automatically. By decreasing the preparation times of the tool and therefore also the costs, PSS can be used by a wider audience.PSS also need to become more flexible in order to deal with the new insights of stakeholders during the planning process.

Hard systems approach in contrast to soft systems approach

Planning support systems can be seen as deterministic systems in a social system of urban development. The social system of urban development contains also other social subsystems, as many different parties are involved in the decision making process for adapting a geographical area. These social subsystems contain animated systems (people) with their deterministic systems (like computers). As planning support systems are closely related to the planning tasks of urban development projects, these systems have developed parallel to new approaches to spatial planning and urban development. Planning support systems have experienced a shift from technocratic models towards sociocratic models. This is illustrated in figure 36.

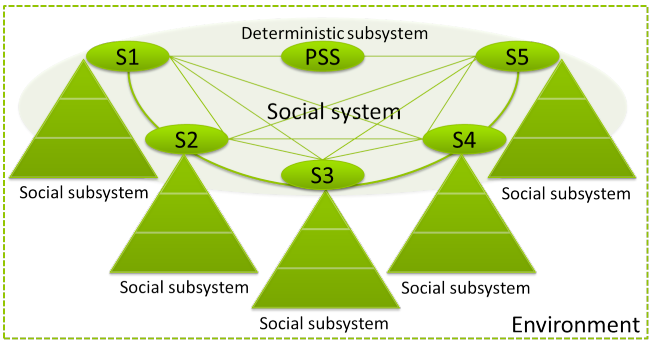


Figure 36 *PSS in relation to systems theory (own ill.)*

Explicit knowledge in contrast to tacit knowledge.

PSS are not able to visualise all the effects of urban development plans, due to the complex relationships between the different elements of urban development. Therefore, PSS advise stakeholders, but stakeholders do not have to abide by the result. PSS only covers explicit knowledge, though explicit knowledge is the tip of the iceberg of all knowledge that is available. PSS can determine the feasibility of a plan by processing explicit knowledge, while tacit knowledge can be shared during the workshop in order to determine the desirability of a plan.

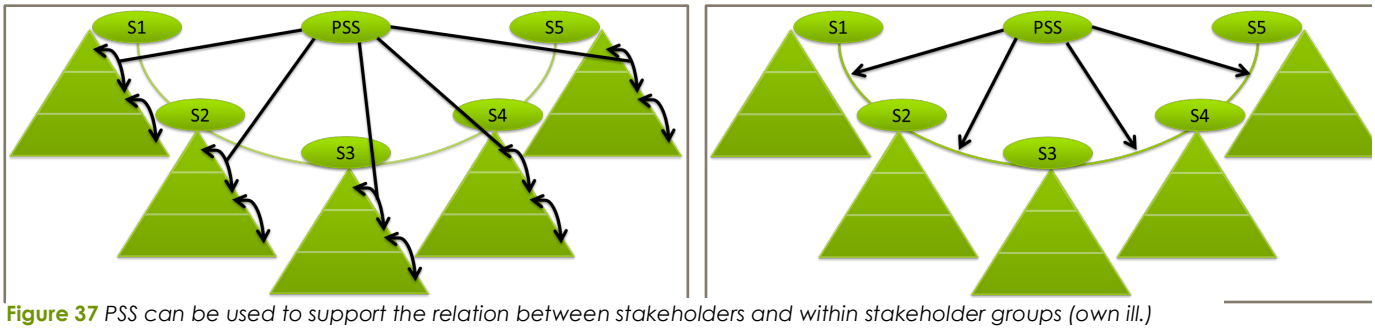


Figure 37 *PSS can be used to support the relation between stakeholders and within stakeholder groups (own ill.)*

Group objectives in contrast to individual objectives
The stakeholders have different backgrounds and vary from citizens with limited knowledge about redevelopment processes to developers and planners. PSS can play an important role in sharing information and knowledge between the different stakeholders, by which they gain a mutual understanding of the complexity of the project. A mutual understanding between the stakeholders supports collaboration between the stakeholders to develop the area in an integral way. However, PSS can also be used within organisation in order to better align different departments with each other. This is visualised in figure 37.

The moment in the development process
Planning support systems can be divided in drawing, simulation and evaluation tools as mentioned in the evaluation framework based on Eikelboom (2015). However, Urban Strategy, MKP-MapTable and Tygron appear to cover all three functions. One can therefore wonder if this distinction is useful in order to classify planning support systems. I think however, that the level of support in these three functions differ per PSS. Also, earlier developed PSS did not always cover all three PSS functions.

As the PSS analysed in this research cover different functions, they can be used at different moments in the development process. By applying PSS repeatedly during the process, stakeholders are getting used with the tool. This way, the tool becomes more intertwined into the process, resulting in a greater impact of the tool in the process.

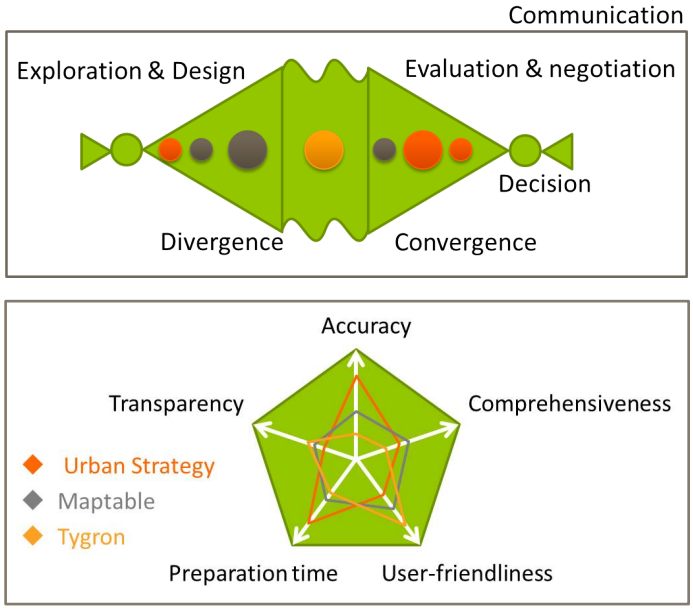


Figure 38 *Comparison of the different PSS (own ill.)*

Although Urban Strategy can visualise more indicators, the MKP-MapTable has a greater diversity of themes. Additionally, the software is easier to understand, which increases the interactivity of the workshops and user-friendliness of the tool. As the MKP-MapTable has a higher level of abstraction, the tool is more suitable to be used in the beginning of the process in comparison to Urban Strategy. Furthermore, the MKP-MapTable has greater drawing possibilities, which makes the tool also suitable for the diverging phase of the design process. The application of Urban Strategy is especially relevant for evaluating design variants during the converging phase of the design process. This is visualised in figure 38.

7. BUIKSLOTERHAM

INTRODUCTION

Circular Buiksloterham is an organic transformation project in Amsterdam Noord and part of the wider restructuring of the Northern IJ-Banks in Amsterdam. The industrial area of 100 ha (net plan area consist of 52 ha) will be translated into a mixed-use urban area with a timeline running from 2005 to 2030. The Municipality of Amsterdam owns 35 ha, of which 4.6 ha consists of green space and 3.3 ha consists of public space. The total number of residents is projected to increase from 252 in 2013 to 6.429 in 2030. The total amount of usable building space will increase from 300.000 m^2 to 1.000.000 m^2. The zoning plan is shown in figure 37.

The project has high ambitions regarding circular economy. These ambitions were recorded in the ambition and vision document and signed by 24 parties in the Manifest. The bottom-up approach and the high sustainable ambitions have led to much attention for this development in and outside the Netherlands.

Figure 39 *Plan area Buiksloterham (Zondaa CS Architecten, 2015)*

A TIMELINE OF EVENTS AND DECISIONS

In 2006, the municipal council accepted the investment plan ("Investeringsbesluit Buiksloterham. Transformatie naar stedelijk wonen en werken") for Buiksloterham's development. Total projected investments were €157 million, while the total projected income from ground lease was €141 million (NPV 2006), leaving a gap of €16.3 million. The first draft of the land-use plan has been sent for consultation to public authorities already in October 2007, but it took until 2009 to adopt the new land-use plan. An overview of the different policies made for Buiksloterham is presented in table 16.

Table 13 *Urban policies created for Buiksloterham (own ill.)*

Date	Urban policies for Buiksloterham
1995	Masterplan voor het Noordzee kanaal gebied (NZKG)
10-1998	Plan van Aanpak Buiksloterham/Papaverhoek
01-2001	Toekomstvisie Panorama Noord
11-2002	Concept Masterplan: Noord aan het IJ
02-2003	Streekplan Noord-Holland Zuid
04-2003	Structuurplan Amsterdam tot 2030: Kiezen voor stedelijkheid
10-2003	Masterplan Noordelijke IJ-oever: Noord aan het IJ
04-2004 / 02-2006	Nota Ruimte
06-2004	Projectbesluit Shellterrein
09-2004	Stedebouwkundig Plan Shellterrein
07-2005	Projectbesluit Buiksloterham
12-2006	Investeringsbesluit Buiksloterham, transformatie naar stedelijk wonen en werken' together with the 'Welstandsnota'
2007	Concept bestemmingsplan Buiksloterham
12-2009	Bestemmingsplan Buiksloterham
10-2010	Structuurplan Amsterdam tot 2040: Economisch sterk en duurzaam

Due to the financial crisis the development plans for Buiksloterham were delayed, waiting for better times for investments. It also costs extra time to find a suitable location to relocate Air Products and deal with the objections of existing companies like Greif Tri-sure, CPM Europe B.V. and Wegter & Zn. B.V. These companies are producing noise and odour nuisance and are therefore limited by the new zoning plan. At first sight, no housing would be possible close to these companies, but by measuring the actual environmental load, realisation of dwellings was made possible in their neighbourhood.
A consequence of this measurement method was that these companies cannot expand their business any further. VEBAM, an organisation representing the existing companies, supported the zoning-plan and therefore enhanced the agreement between Air Products, the Municipality of Amsterdam and De Alliantie, to move Air Products towards business area PolanenPark close to Schiphol airport. This way Air products could continue their business in the neighbourhood of their former location, the Municipality of Amsterdam could continue the development plans of Buiksloterham, and housing cooperation De Alliantie was able to acquire the land for the development of 700 dwellings.

For the development on the area a subsidy was obtained via 'Nota Ruimte', which was mainly used for the construction and renovation of bridges between Buiksloterham and Amsterdam Noord. The first self-build plots were sold in 2010 and after two adaptations of the zoning-plan, it was declared to be irrevocable in 2011. Soon after, the first development projects started, resulting in the construction site of Buiksloterham today. The entire timeline of the different developments in Buiksloterham is presented in appendix L.

The stakeholders can be divided into three groups: governmental organisations, civil organisations and private organisations. Governmental organisations include the national, regional and local governmental bodies: the state, the Province of Noord-Holland and the Municipality of Amsterdam. The project is coordinated by Project Management Agency Noordwaarts. Additionally, the building aesthetics committee and the Amsterdam Council for Urban Development were involved in the creation and adoption of the land-use plan. Civil organisations include ANGSAW, SPINN, Platform van der Pek en Distelbuurt, houseboat owners, and klankbordgroep Shellterein. Later on, also Beleef Buiksloterham, Citylab Buiksloterham, and collective private commission groups emerged as civil organisations. The private organisations consist of the existing companies who are represented by VEBAN. Developers like Hurks and Amvest also became active in the area and housing cooperations like Eigen Haard, De Alliantie and Ymere.

The sustainable ambitions of the Municipality of Amsterdam for Buiksloterham have been published in notes since 2007. During a meeting organised by Waternet (Buiksloterham 'Achter de voordeur') in Pakhuis de Zwijger on April 15, 2014, the basis was laid down for the circular ambitions of Buiksloterham. 20 participants of different organisations signed the manifesto to contribute to the establishment of livinglab Buiksloterham. This has led to an in-depth analysis of the area, resulting in the Vision of Buiksloterham, published by Metabolic, Studioninedots, and Delva Landscape in March 2015. During this publication, the manifesto to develop Buiksloterham in a circular manner was signed by 21 different parties, and an additional three parties signed later on: Waternet, Alliander Duurzame Gebiedsontwikkeling, De Alliantie, Amsterdam Rainproof, Eigen Haard, Metabolic, DELVA Landscape Architects, Studioninedots, Amsterdam Institute for Advanced Metropolitan Solutions (AMS), Stichting Schoonschip, Vereniging de Ceuvel, Beleef Buiksloterham, Afval Energie Bedrijf Amsterdam, Amsterdam Economic Board, Westpoort Warmte, Zelfbouwers Buiksloterham, Waterschap Amstel, Gooi en Vecht, Pakhuis de Zwijger, Municipality Amsterdam, NUON, and New Energy Docks.

Frank Alsema, Peter Dortwegt and Saskia Müller were signatories and joint forces in Citylab Buiksloterham in order to stimulate the sustainable development of the area. They spend a lot of time voluntarily, stimulating the sustainable developments in Buiksloterham. Saskia Müller explains that it is difficult to implement PSS in Buiksloterham, as Buiksloterham is an organic development without one leading party that can finance the application of PSS. Although they welcome new initiatives, they need to be selective as they have limited means, time, money and capabilities, to implement them in practice. First, the stakeholders must have a clear demand for it and should be willing to co-finance it. According to Saskia Müller, although Buiksloterham involves many small projects and innovations, the communication between these projects is good. Citylab Buiksloterham tries to enhance the communication between different parties by organising table sessions related to different themes, like energy, water and waste. As soon as these table sessions can be organised independent of Citylab Buiksloterham, one of the leading stakeholders will take over the organisation of these sessions. This enables Citylab Buiksloterham to start-up a table session on a new theme. Additionally, Citylab Buiksloterham organises a meet-up for all interested and involved parties once every six weeks to share information and give an update about the state of affairs. Furthermore, they organise several events to attract new people to the area, to raise awareness about the circular ambitions of Buiksloterham, and to stimulate interaction between the involved actors (Interview #27a, Circulair Buiksloterham Team).

Although it seemed difficult for Buiksloterham to apply a planning support system in practice due to limited funds, it was possible to organise a serious game session with Play the City. Saskia Müller explains that this was viable as Play the City has taken initiative to develop the game and as Pakhuis de Zwijger was willing to co-finance the gaming session (Interview #27a, Circulair Buiksloterham Team).

CITY INNOVATION GAME BUIKSLOTERHAM

INTRODUCTION CITY INNOVATION GAME BUIKSLOTERHAM

According to Ekim Tan, "Play the City uses gaming to engage multiple stakeholders in resolving complex urban challenges. Play the City designs physical games as a method for collaborative decision-making and conflict resolution. They tailor their games according to the questions of our clients. These can relate to large urban projects, refugee camps, violence prevention and other multi-stakeholder challenges societies face. They use gaming as a problem-solving method bringing top-down decision makers together with bottom-up stakeholders. In the accessible environment of games, freed from the jargons, various ideas, plans and projects meet, conflict and collaborate towards negotiated outcomes." (Tan, 2015)

Ekim Tan has founded Play the City in 2008. Play the City was first applied to real urban questions in the Netherlands, later expanding to Istanbul, Tirana, Brussels, and Cape Town. She has developed the game during her doctoral research at the TU Delft, resulting in a PhD degree with her thesis "Negotiation and Design for the Self-Organising City: Gaming as a method for Urban Design" in 2014. Tan's thesis proposes Generative City Gaming as an innovative urban planning and design method based on serious gaming. Going beyond the educational scope of other serious games, the ultimate aim of city gaming is to become operational in urban processes in practice.

After playing Amsterdam Noord, Ekim Tan also recognised the need for a serious game in the adjacent Buiksloterham. This City Innovation Game especially aims to translate themes related to circularity, citizen participation and 'do it yourself' (DIY) into concrete urban interventions and business cases. After prototyping the game with some stakeholders, like Eigen Haard, Citylab Buiksloterham, and Clean Tech, in August 2015, the game is launched during the international planning conference Isocarp in October 2015.

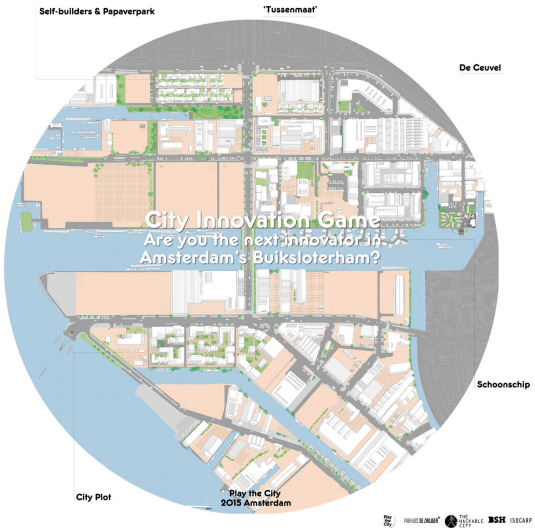


Figure 40 *The City Innovation Game (Play the City, 2015)*

Figure 41 *The game session (own photo)*

GAME SESSION CITY INNOVATION GAME

On 26 November the first real City Innovation Game session was held with stakeholders of Buiksloterham in Pakhuis de Zwijger in Amsterdam. 80 people from different parties and disciplines were invited to participate in the game and 30 people showed up. Amongst the participants were self-builders, architects, developers, a housing cooperation, the municipality, entrepreneurs, water en energy related companies like Alliander Duurzame Gebiedsontwikkeling and Waternet, Citylab Buiksloterham, researchers, and local residents. Citylab Buiksloterham, De Alliantie, Research Group Play & Civic Media of Amsterdam University of Applied Sciences, Pakhuis de Zwijger, and Beleef Buiksloterham made the game possible.

The game allows participants to represent their point of view, to test new ideas and to gain an understanding of the desirable but complex interaction of the circular systems and disciplines. The aim of the game is to test whether Circular Buiksloterham can maintain and realise their innovative character and is able to share the gained knowledge of the development process so far.

The content of the game
The different players received a card with their name and their role in the game when they arrived at the game simulation room in Pakhuis de Zwijger. Before the game started, there was an opportunity for the stakeholders to meet each other and to talk about their projects in an informal way.

Ekim Tan and Khashayar Ghiabi of Pakhuis de Zwijger were the Game Masters. They facilitated the game session and structured the different game rounds. Frank Alsema of Citylab Buiksloterham was also actively involved in the discussions and tried to summarise and connect the things input of the players. Three researchers of The Hackable City reported the comments and actions of players.

Ekim Tan started with a brief presentation about the game and the content of the game. The game table was a printed map of Buiksloterham glued on large tables providing a 10x10m grid, upon which different buildings and land uses could be placed. The buildings were colour coded according to different land-use categories: hospitality, public, business, services, housing, agricultural, culture and retail. Additionally, different land-uses could be placed on the game table: greenhouses, renewables, agriculture, canals, recreational green, water, and infrastructure. These land uses and buildings had a fixed price per square meter for each category.

Innovation cards represented the sustainable projects or ambitions of stakeholders. The innovations were related to energy, water and waste. The innovation cards indicated the price of the innovation per household, 50 households or 250 households and the effect of the innovation with respect to people, planet and profit. Ekim explained that the amount of money per stakeholder was based on their investment in Buiksloterham so far. However, the money and prices of the buildings, plots, land-uses and innovations were not used during the game.
Although, the building rules and playing rules were meant to be determined by the players during the game, no building rules or playing rules were introduced by the players or facilitators of the game.

After an introduction of the game, participants introduced themselves and their connection to Buiksloterham, and explained their ambitions. Everyone who owns or works on a plot placed his/her sticker on it. This round was named 'Buiksloterham Now'. After the introduction, the participants placed their buildings and innovation cards on the game table illustrating the current (planned) situation of Buiksloterham.

After this first round, the second round was named 'Buiksloterham Now or Never'. All the players discussed what they had been building; their biggest challenge in realising their project; what they want to know from other players; and how they want to realise their project. After the current status of developments in Buiksloterham was discussed, players were allowed to hack plots and projects of others the way they desired it to be, and to form collaborations with other players to realise common ambitions.
The third round discussed the possible future state of Buiksloterham: 'Buiksloterham Soon'. Every player got two minutes to explain his/her actions: why they want to develop Buiksloterham that way and how they are planning to realise it.
The gaming session ended with an evaluation of the afternoon which took 5 hours in total. The second round, 'Buiksloterham Now or Never', took the longest, compared to the first and third gaming round.

Reactions of players
Many participants attended the gaming session to meet other stakeholders, to get insights about their plans and ambitions and to stay up to date about the developments going on in Buiksloterham. As one of the developers mentions: *"I especially met new people, gained ideas and got new insights into the developments in Buiksloterham."* Additionally, different players mentioned the importance of transferring knowledge to (new) stakeholders in the area and to similar projects in the Netherlands. *"With the knowledge of everyone, we can reach great heights."*

By discussing the plans and ambitions of each stakeholder, many discussions were related to building regulations and to specific topics concerning wastewater treatment and energy and heat generation. One of the reactions was: "Can we solve this problem without the involvement of the municipality?" Upon which many agreed that they need to make Buiksloterham circular together, by collaborating. *"But saying, there are no rules is quite optimistic."* As living lab you might be able to get an exception on a rule, but to which extent is unsure at this moment.
Not only building regulations can impede circular developments, large organisations like housing cooperations can do the same: Alliander, district heating and Waternet, does not always want to cooperate with small bottom-up initiatives.

Furthermore, the Municipality of Amsterdam stimulates citizens and businesses to collaborate: *"Mass is impact".* "For us, it is difficult to support every single self-builder, but together you are much stronger." Some players generated joint ideas, like a wastewater biorefinary and collective generation of energy via solar panels.

The buildings on the game table were no realistic representation of the plans and ambitions of the players. Like the housing cooperation explains: *"It is a bit messy, and it is not exactly what it is going to be, it only indicates what we are planning to realise."* Others also clarify that *" it is definitely not a final plan."*

Although it was interesting that many different players were attending the gaming session, the players agreed that it was a pity that large players like Eigen Haard and Ymere were absent: *"Eigen Haard and Ymere are not present, but these parties have land ownership. Many plans of the players cannot be realised without their cooperation."* Others note that also the municipality and (future) inhabitants were not well represented. A player comments on this that many people would like to participate, but do not know how. Frank Alsema replies that the website is therefore an important medium to communicate and inform each other. Not only about the events going on in Buiksloterham, but also about information you need or want to share with others, for instance in relation to building regulations or innovative ideas that might also be suitable to implement in Buiksloterham. The Municipality of Amsterdam is working to enhance citizen participation and involvement in the entire city by setting up an online platform.

The general feeling that exists amongst the participants of the game is that people, companies and governments need to act now in order to realise a Circular Buiksloterham. For instance, self-builders and real estate developers will not adapt their buildings to a sustainable wastewater biorefinary, when it is not sure whether this biorefinary will be built in the area.

Observations of the gaming session

The serious game encouraged the participants to think about concrete solutions in order to fulfil their ambitions. The great variety of different disciplines and parties has led to balanced discussions. However, it seemed that players who do have a large stake in the project, like the developers and the housing cooperation, were not entirely tranparent about their interests and ambitions. The absence of Ymere and Eigen Haard also had a large influence on the game.

During the afternoon a lot of discussions took place between the players and little time was spent on building and changing the development plan. Despite that, during the discussion a lot of information was shared and the physical game made the topics tangible. In the beginning of the afternoon, stakeholders approached the problem primarily from their own perspective. The topics were very specific and were therefore less interesting to other players. At the end of the afternoon the stakeholders generated more joint ideas.

The level of knowledge of the participants was quite high. Also,the residents and self-builders were highly involved in the project, although the residents were not strongly represented. Besides the communication about the event, this might be caused by the fact that the game session was held during office hours.

At the beginning a group of 30 players seemed quite large, resulting in time-consuming game rounds, but the stakeholders listened well to each other during the entire afternoon. Although it takes a lot of time to discuss the developments in Buiksloterham due to its large scale and complexity of the projects. Therefore, more session on specific topics would be desirable. The game encouraged informal communication and stakeholders were acting on an equivalent level. Especially the breaks between the rounds to build and change the plan were valuable for the stakeholders to continue conversations in more detail and to find common interests. During the breaks, stakeholder groups emerged and information was shared. The physical game, whereby everyone was working in one room, enhanced the team spirit. It was in addition easily understandable to all players.

As Frank Alsema mentioned at the beginning of the game session, circularity cannot be accomplished without cooperation, nor without innovation. The game table was the focal point for discussions as the game table provided the visualisation of ideas.
The structure of the game discussing the current situation, planned situation and desired situation enhances an organised way of thinking and acting. The role of the game masters to manage the time spent during every round was important, as the game would otherwise take too long.

RESULTS CITY INNOVATION GAME SESSION

The objectives of the manifest were made tangible by playing the game. The game encouraged an informal and informative way of communication, stimulating participants to collaborate. A kind of marketplace emerged, where demand and supply of information and capabilities met each other. Although stakeholders generated joint ideas, it is questionable how feasible these ideas are, since there were no limitations and funds were not taken into consideration.

Due to the large amount of participants and the complexity of the project, the majority of time was spent discussing the plans around the game table, while little time was spent building or changing the plan. Nevertheless, the game provided a good medium to connect the different projects and parties to each other. the stakeholders can achieve more when they cooperate, 'the whole is greater than the sum of its parts'. However, it still stands to question how collaboration becomes attractive for all parties involved. *"Brainpower should be mobilised: the technique is in place, but the way of organisation and funding should be devised."*Often no business case was conceived yet for the ideas and plans of players. Many ideas need large investments and only create value in the future. If these values are considerable, one should also be able to find investors for it. Input during the evaluation was that it would be a good idea to play 'Pay the City', involving the finances of the project. Additionally, Frank Alsema admits that *"Financial advisors are often missing in the discussions around Buiksloterham"*. Some players came up with creating a cooperation like Amsterdam Noord trust. Amsterdam Noord trust is a cooperation that enables inhabitants to exchange goods, knowledge, work and money. When one player suggested that it would be interesting to also involve the inhabitants of Noord in these cooperations, another player warned that when the cooperation gets too large, it loses its dynamics. Self-builders are also concerned with this tension: to which extent do they want to collaborate to get more things done? Because a disadvantage of collaboration is that they are less able to execute their ideas exactly as they want it to be. Another player adds tot this that *"we shouldn't use old concepts in a new way: new roles and a new interpretation of roles is needed to make a difference."*

The session concluded that it was a pity that players like Ymere, Eigen Haard, residents, business owners, and the alderman were missing and that so little civil servants attended. The one civil servant that attended admits that the municipality might be afraid to share their visions, as there are many civil servants involved, they might not all share the same point of view about the developments in Buiksloterham. The players agreed that it would be desirable to play the game more often with other players, and in relation to specific topics like public space, energy, waste and finance.

RESULTS SEMI-STRUCTURED INTERVIEWS

The Citylab Buiksloterham team is financed by the signatories of the manifesto and by subsidies. Furthermore, a lot of time is spent voluntarily, stimulating the circular development of Buiksloterham. According to Saskia Müller, the challenge is to go against the flow with limited resources. Organisations need to adapt their way of working and thinking in order to realise a circular area. They need to regard their interests from another perspective, taking interests of other parties into account and sometimes they need to be able to set aside their individual interests, in the interest of the greater good, not only on managerial or strategic level, but also on operational level. Especially on operational level resistance exists to change the way of working. Since Citylab Buiksloterham does not have the authority to change these operational approaches in other organisations, it takes a lot of energy and time to achieve this change via the board and strategic level of that organisation, and by networking within the organisation. *"The mechanics of Liander, Waternet; the inspectors of Building and Housing Inspection of the municipality; the environment department: they have nothing to do with a signature of an alderman or director."..."This is a very tough process, but if you do not keep trying, nothing will change."* (Interview #27b, Circulair Buiksloterham Team)

Saskia Muller recognises that change is never achieved fully at once: when actors are leave the meeting and go back to their office, they move back to business as usual and old habits. It is therefore important to communicate thoroughly and remind people about what is going well in the project. To also involve visitors of Buiksloterham and potential or future residents, Citylab Buiksloterham communicates the developments of Buiksloterham in several ways. Their approach is not only one-way communication, but also organising events in the area, like an art exhibition focusing on circularity. Additionally, Saskia Müller notes that you need to set high ambitions to develop a sustainable area and that it is important to share the obtained knowledge with similar projects like the Floriade in Almere: "When it does not work out in Buiksloterham, it might work out in a different way in Almere."

Upcoming year the developments in Buiksloterham will be genually given shape by the arrival of 1000 new inhabitants. As Saskia Müller explains, you need these inhabitants to further develop Buiksloterham in a circular way and to execute circular projects. Part of the circular approach is to also enhance citizen participation: *"inhabitants should get control over their living and working environment as much as possible."* (Interview #27b, Circulair Buiksloterham Team)

The organisation of space in the urban plan for circular solutions to store, process, and divide circular flows is a great challenge they are dealing with at the moment. They did not take the space needed for these solutions into account in the current urban design. Furthermore, new standards and norms need to be developed in order to be able to implement new solutions.

A great threat to the developments in Buiksloterham is the increasing attention of large players to invest in the area. *"In the end 80% of the discussions are about money. Amsterdam has increasing international interests of foreign investors. Their shareholders horizon is running until the next shareholder meeting in a half year and their financial horizon is running up to three years ahead for most companies, while we are thinking in 10 of 20 years from now."* When you are talking in different time scales, it is difficult to reach an agreement (Interview #27b, Circulair Buiksloterham Team).

Also Ekim Tan recognises that big players are involved that cannot be influenced easily: "Big guys are building and project managers are happy to talk to them. For instance, Ymere has sold their building rights to Amvest and they have come up with a very traditional outcome. They are building on one of the nice pieces at the waterfront and it is business as usual: It has nothing to do with circularity. I do not think that is really relying on us. I mean, we can help and try to positively influence the activities, but there is big money and power involved at the same time." (Interview #28, Play the City)

"I think it will be really exciting if the signatories of the manifesto will stick to their own ambitions." (Interview #26, Researcher, ACC)

According to the researcher, as a result the municipality needs to execute a strong vision, otherwise the circular ambitions will only be used as advertisement and nothing will truly be achieved. Buiksloterham will be developed in one way or another, because the area is situated in an attractive location close to the city centre. Because large players are discovering Buiksloterham, those circularity ambitions come under severe pressure, and as a result the role of the municipality will be crucial in achieving the sustainable ambitions.

The researcher is involved in the Adaptive Circular Cities project since October 2014. Their research project investigates tools to support city officials and civil servants in taking investment decisions related to circularity and adaptivity of cities. Buiksloterham is one of the case studies of their project. The aim is to provide stakeholders insight into the economic effects of aligning different urban flows to each other in a circular development project like Buiksloterham. The researcher admits that little tools are available that are able to create insight into the economic effects of a development. Therefore, they are looking into the possibility to combine different existing tools.

During the project, the researcher has been in touch with the different stakeholders of Buiksloterham and has some critical notes about the developments going on there at the moment:
You can question whether the manifest makes sense, as many parties have signed the document, but until now not many circular projects have been realised. For instance, De Alliantie was called back by the municipality to realise circular measures, like constructing the housing all-electric, as the municipality has a major stake in district heating. Such issues illustrate how difficult it is to realise smart circular measures. Another example is that the housing cooperation was planning to use sustainable materials, but the building code by the Municipality of Amsterdam did not allow this, forcing the housing cooperation to choose for a less sustainable alternative. This illustrates the large difference between what the policy department aims for and what the operating department decides upon. Therefore, it is especially important to support interaction within the whole chain of decision-making, engaging the operations department in the thoughts behind technological innovations or changes in policies. So the planning support system should support the collaboration and alignment between different departments.

These departments have different kind of relationships with each other. And the example above illustrates that the policymaking department, and the formation of ambitions on the one hand and the implementation and enforcement department on the other hand speak different languages.
Saskia Müller also mentions this: "different parties of the municipality think about sustainability in different ways" and "if the enforcement officers do not cooperate in issuing permits, then that is a game changer for the developments in Buiksloterham."

According to the researcher, traditionally one assumes that the ideas of the alderman are supported by the policy department. He/she proposes the idea to the city council and needs to convince them in order to implement the idea. When the city council is positive about the idea, the operations department is responsible for the execution. However, such decision-making chain is rarely linear. Therefore, it is better to look into the tensions between different departments or parties that have a shared responsibility in developing an area. A PSS could support the interaction between the alderman and the city council by providing information in order to convince them. Thereby, it is important to consider whether the PSS supports the alderman to have a conversation with the city council to take that decision. Or in case of the enforcement officers at the operations department: Whether the PSS can support the working culture on both operational and strategic level within organisation. The enforcement officers need to understand the background of a rule in order to be able to apply the rules in the philosophy of that rule to serve a certain purpose. This way, it becomes clear to the enforcement officer what the decision-making space is around a certain rule or building law. According to the researcher, in general the policy department can generate new ideas faster than the implementation and enforcement departments can operate them. Therefore, platforms of interaction between different parties and different departments within organisations are needed. A PSS could support this interaction not only by providing information, but also by supporting the communication and collaboration between different people.
Saskia Müller also recognises the issue of different departments that are working in a different way: *"It depends on which enforcement officer inspects the plan and at which department he/she works whether permission is given."*

Saskia Müller also explains that she graduated in the automation of policy evaluation methods. "My conclusion was that it does not make sense, as there is so much discretion in the development of evaluation of policies, that you cannot incorporate that in tools. You can develop a method to incorporate that in the process, but as it is a dynamic process, it is not sure in which way it will affect the result. Buiksloterham experiences quite a chaotic development: there is no control on the amount of players involved and there is no single leader. Additionally, the organisation of the Municipality of Amsterdam is administratively complicated at the moment due to a transition of power and money of the districts towards the central city of Amsterdam. Many civil servants that were involved in the project from district Amsterdam Noord have moved towards the central city. When you implement a PSS that does not have a clear result in a complex and chaotic process, it might become even more complicated." (Interview #27b, Circulair Buiksloterham Team)
According to Saskia Müller, also the more exact planning support systems like Urban Strategy might not be suitable for Buiksloterham yet as the process is too chaotic without one clear final plan to evaluate.

Nevertheless, Saskia Müller thinks playing serious games is an attractive way to involve people in the process and share information with each other. Furthermore, it creates awareness amongst actors that an integral approach is needed to develop Buiksloterham to deal with the overall complexity of the project. *"In a serious game you can better experience the consequences of your activities for another party."* (Interview #27b, Circulair Buiksloterham Team). She further explains that with an example about playing Monopoly: *"If you play Monopoly without investing in the first five rounds, you'll never win. It is possible to learn that in the lecture halls, but by playing Monopoly, you really experience that you need to invest: otherwise all streets are already taken by other players."* (Interview #27b, Circulair Buiksloterham Team)

Additionally, Ekim Tan explains during a seminar at the TU Delft, Faculty of Architecture that: *"Games can translate big data to a bigger audience."* Ekim Tan has developed a new serious game, although several serious games already existed, because she believes that every spatial issue needs a different game: *"All of our games are different, we are not playing one game 2000 times to solve a generic question."* Each time you need to tailor the game to its specific situation. "And I do not think there is one game, or there are ten games that can solve all the urban questions we have. Rather every urban design, or urban development by itself is a game. And certain questions are more worthy than others to make a game for."(Interview #28, Play the City)

According to Ekim Tan: "The tension in Buiksloterham is that during the crisis a lot of knowledge was collected from the bottom-up players. These players do not only know about the available innovative technologies, but also how they can implement it in architecture: what it implies for public space and what it implies for collective housing. That knowledge is very interesting, because Eigen Haard or other bigger parties, who also have the right to build there, do not have that knowledge yet. Therefore, I think a game is interesting for information exchange." (Interview #28, Play the City)
Ekim Tan thinks that experience-based knowledge is shared during the game from individual to individual. Additionally, they are trying to incorporate explicit knowledge into an app that can be consulted by players as well, before and after the game. However, this was not realised during the City Innovation Game session yet.

"If you do it in a smart way, you can use the game as a platform to collect all this data and share it with different groups, with bigger groups who are planning to build in Buiksloterham, but also with new people who come and live in Buiksloterham. To make sure that they actually understand the principles. It is more a learning and knowledge exchange game, rather than a building game. Because I think in Buiksloterham basically all positions are already taken. It is not about who is going to build it, it is about how are we going to build it." (Interview #28, Play the City)
Additionally, a serious game is well suitable for Buiksloterham as the inhabitants are in general well educated and actively involved in the developments (Interview #28, Play the City).

To finance the development of the game, Play the City has created a new business model, whereby different interested parties sponsor the development of the game. This kind of fundraising has some benefits, as the sponsors of the game will take the game and its consequences more serious as they are actually paid for it, "rather than you just get advice from a game someone else paid for and you enjoyed your day" (Interview #28, Play the City).

Ekim Tan thinks that the creative environment of playing the game will convince people to share information and to have an open attitude towards new ideas and decision-making. However, she cannot assure that people will not hide their agendas. But according to Ekim Tan, you can play the game smarter when you also know more about the other players. *"It is not about the knowledge you own, it is about with whom you collaborate."*
Additionally, Ekim experienced that although players might have completely conflicting agendas, by playing the game they can come up with a solution that you would not expect beforehand and can help both in a way.

The main threat for serious games is, according to Ekim Tan, the perception disadvantages that exist: "People have to get used to it." Additionally, she mentions the importance of not going into details at the beginning of the project, but rather to come up with more general ideas and a collaborative vision. However, this is dependent on the phase in which the game starts: *"you obviously have different priorities each time"* (Interview #28, Play the City).
Projects that are determined by an open decision-making culture are suitable for playing serious games. Additionally, it is crucial that the people who have the decision-making powers participate in the game as well.

DISCUSSION AND ANALYSIS

The process of Buiksloterham is often called a bottom-up initiative, but the extent to which the developments are realised bottom-up is limited. This might be explained by the limited amount of inhabitants in Buiksloterham at the start of the redevelopment, but also by the changing market conditions after the peak of the financial crisis. Although Citylab Buiksloterham plays a crucial role in enhancing the bottom-up character of the development, many large players have entered the field of decision-making in Buiksloterham over the past few years. These players can make the project feasible, but good communication between the various parties is necessary in order to develop Buiksloterham in a circular way.

Many large companies have also signed the manifesto, but it will become clear in the coming years to which extent they will achieve their ambitions. When ambitions are not achieved this has to do with many aspects influencing the plan. It might become clear that some ambitions are not legally or financially feasible. Or it might only be sustainable when a certain project is organised on a particular scale. These insights will change the way stakeholders perceive sustainability and circularity, which may also result in changed ambitions.

The relevance of playing a serious game in Buiksloterham is especially related to the soft systems approach. The game aimed to encourage players to collaborate and to share information. As many stakeholders are involved in the project, and as the level of knowledge between players differs largely, playing a serious game can support the circular development in Buiksloterham by creating new insights. It is not the question if decisions will be made, but what decisions will be made. Either way, Buiksloterham will be developed, but the game raised awareness between players that an integral and collaborative approach is needed. It is important to align the different projects in Buiksloterham to each other and to the surrounding neighbourhoods in Amsterdam Noord to create a greater impact. Moreover, the communication between the different departments within an organisation needs to be aligned as well. The overall transformation project seemed to be too large to deal with in one serious game. Since the participants were positive about playing the City Innovation Game, additional gaming sessions could focus on certain themes, or certain organisations. This way the game cannot only improve the relationships between stakeholders, but also within organisations.

However, the game did not provide any tangible results yet. Therefore, it is understandable that PSS like serious games are not regularly applied in practice. It takes a lot of time and effort to build the game and to gather necessary information in order to adapt the game to the situation under consideration. Since no building regulations or money were involved in the game session, the game was more a platform for discussion than a serious game. It is easy for players to say that they want to collaborate if no money is involved. The game should be based on building plans, calculating the effects, and signing for collaborations in order to make a true difference in the project. Therefore the players with decision-making powers should also attend the game. Although, they may not be interested in playing the game, when they do not want to be open about their interests for instance.

Money should also be involved in playing the game to incorporate the creation of business models and in order to generate financially feasible ideas. But the involvement of money can also lead to objections of parties to participate in the game when they are afraid that their negotiation position will be compromised by playing the game. They might prefer to keep leverage in their calculations in order to optimise their plans, resulting in greater individual profits.
In order to create an open financial model, each party must benefit from the group interests. Some parties have individual interests that do not match the group interests or the group interests do not outweigh their individual interests. In that respect, it is understandable why such parties do not want to cooperate in an open decision-making process.
Furthermore, an open decision-making process only works with a high level of trust between the stakeholders. The parties must have confidence that they are honest to each other. Additionally, they need to acknowledge that risk and reward should be in proportion, just as they need to acknowledge that prices are determined by supply and demand.
Since many parties are involved in the redevelopment of Buiksloterham and as new parties continuously enter the decision-making space, while others are leaving, an open decision-making process will be hard to realise in such a project.

Although the moment of playing the game was not deliberately chosen, it was a good moment as many players indicated that stakeholders need to act now in order to develop Buiksloterham in a circular way. Otherwise it will be too late to develop the area in an integral way, because some parties have already developed their plans and designs further than others. It was also a good moment for Play the City to organise the gaming session, just after the launch of the game at the Iscocarop conference. As soon as Play the City got sponsors, they started to prepare the gaming session.

CONCLUSION

Circular Buiksloterham is a bottom-up, organic, transformation project in Amsterdam Noord and part of the wider restructuring of the Northern IJ-Banks in Amsterdam. The industrial area of 100 ha will be translated into a mixed-use urban area with a timeline running from 2005 to 2030. This means that the project is in its initiation phase whereby decision-making still plays a major role in the process. The contaminated soil and the environmental impact of residual industry together with the high sustainable ambitions increases the complexity of the project, enlarging the need for decision support tools.
Also, the bottom-up approach of the redevelopment, in which many stakeholders are involved, increases the relevance for a PSS in structuring the ambitious redevelopment process.

The stakeholders have different backgrounds and vary from citizens with limited knowledge about redevelopment processes to developers and planners. PSS can play an important role in sharing information and knowledge between the different stakeholders, by which they gain a mutual understanding of the complexity of the project. A mutual understanding between the stakeholders supports collaboration between the stakeholders to develop the area in an integral way.

Therefore, especially planning support systems that improve the communication between different stakeholders and within organisations seem relevant for Buiksloterham. As decision-making powers need to decide soon how to develop Buiksloterham in a circular way, the PSS should provide the stakeholders with relevant information to make these decisions. However, a tension exists between the extensiveness of a tool, and the preparation time and costs to organise workshops with this tool. A higher complexity of the tool negatively influences the transparency of the data and calculation methods.

The serious game applied in Buiksloterham was very user-friendly, simple and interactive. It supported the information exchange between the participants, but as no building regulations or money were involved in the game, the results of a game session are quite vague. Additional gaming sessions could focus on certain themes, or certain organisations. This way, the game cannot only improve the relationship between stakeholders, but potentially also improve the alignment of different departments within organisations.
By playing the game, the objectives of the manifest were made tangible. Additionally, the game encouraged an informal and informative way of communication, stimulating participants to collaborate. A kind of marketplace emerged, where demand and supply of information and capabilities met each other.
Although stakeholders were formed joint ideas, it is questionable how serious these ideas are as no conditions were set and as no money was involved. Because no money was involved, it was easy for the stakeholders to say that they want to collaborate. The actors should keep working together and think about a feasible business plan in order to make realisation of their ideas possible. Hence, it is crucial that decision-making powers are also involved in these collaborations.

8. CONCLUSION

THE ATTAINMENT OF RESEARCH - AIMS

The embedding of planning support systems into the planning process of urban development is examined through the execution of various case studies, semi-structured interviews and an extensive literature review.

ANSWERING THE MAIN RESEARCH QUESTION

8.1.1. RESEARCH QUESTION 1

- **What are the characteristics of the decision-making process in urban development in the Netherlands?**

Urban development is seen as a complex task often related to ill-defined problems in a dynamic context. It requires an integral approach (Bruil et al., 2004, p. 397), as different spatial scales, development phases, policy domains, spatial scales and disciplines need to be aligned with each other. This alignment takes place within complex decision-making processes in inter-organisational networks (Bruil et al., 2004, pp. 19-20). Hence, it is characterised by complex relationships between societal, economic-financial, technical, political, environmental, legal, and spatial factors.

Urban development is based on a soft systems approach, whereby design thinking and decision-making play an important role. Design thinking can be perceived as a way of decision-making, whereby experiential learning and creativity plays an important role. New insights, feedback on the plan, will determine the next steps in the design process. These feedback loops cause the iterative and circular character of the design process. Furthermore, the objectives of stakeholders might change during the design process because of new insights. This is indicated by Argyris and Schön (1974) as double-loop learning. Important aspects of design thinking are next to the iterative learning process, the human-centred approach and the diverging and converging phases within the process.

8.1.2. RESEARCH QUESTION 2

- **What are PSS and how do they work?**

Planning support systems (PSS) are a category of information systems composed of a database, GIS software, models, and a so-called knowledge engine, which allow users to deal specifically with locational problems.

Planning support systems are "geo information technology-based instruments that incorporate a suite of components that collectively support some specific parts of a unique professional planning task" (Geertman, 2008, p. 217). The planning tasks can be classified according to Carton and Thissen (2009) and De Bruin et al. (2009). As planning tasks are central in the use of planning support systems, these tasks are incorporated into the evaluation framework as mentioned on page 37. Furthermore, it has been clarified that PSS have experienced a shift from top-down, technocratic spatial decision support systems and GIS tools from the 1960s, towards bottom-up, sociocratic, participatory planning support systems from 1989 onwards. Planning support systems seek to interact between quantitative object knowledge and qualitative process methods.

Planning support systems can be perceived as deterministic systems as they do not have a purpose without people controlling them. They serve the purpose of its users. Urban development processes are examples of social systems, whereby the project team has the goal to physically adapt a specific area to social- economic and spatial needs. The individual stakeholders also have individual goals, as different stakeholders from different companies belong to different social subsystems. The spatial problem is an undesired difference between the existing and aspired situation. It is the reason to pursue improvement or renewal. However, if there are more decision makers, one cannot assume that they agree with each other. As De Leeuw (2002) outlines, problems arise because judgments (normative statements) are spoken about aspects of reality. It is therefore essential that the role of these objectives is clear.

8.1.3. RESEARCH QUESTION 3

- **How are PSS applied in urban development?**

Planning support systems can be seen as deterministic systems in a social system of urban development. The social system of urban development contains also other social subsystems, as many different parties are involved in the decision making process for adapting a geographical area. These social subsystems contain animated systems (people) with their deterministic systems (like computers).
As planning support systems are closely related to the planning tasks of urban development projects, these systems have developed parallel to new approaches to spatial planning and urban development. Planning support systems have experienced a shift from technocratic models towards sociocratic models,

while urban development has evolved from top-down centralised approaches to bottom-up holistic and integral approaches. These shifts can be related to systems theory as well. Whereas initial planning support systems where developed form a hard systems approach, currently it is widely recognised that a soft system approach is more suitable for these systems
Based on the literature review, I can conclude that a wide variety of planning support systems exists, which is used in various fields. The models often focus on a particular aspect of urban development by including a limited number of indicators. As a consequence, they do not present the complex and dynamic nature of decision-making in urban development. Additionally, they usually do not support the participation of different stakeholders. Furthermore, it appears that these models are often not used in practice: they are only used to validate theories or simulate urban processes. Therefore it is difficult to conclude what impact such models have on urban development in practice. Research that include case studies in the Netherlands are primary related to doctoral dissertations of Peter Pelzer (2015), Tessa Eikelboom (2015), Gustavo Arciniegas (2012), Marco te Brömmelstroet (2010b), and Guido Vonk (2006). These studies suggest that different tools can be used for different purposes, and are suitable for different phases in the overall urban development process. They also mention that PSS are still not widely applied in practice. The researchers studied different aspects of the PSS in different ways, but they do have some overlap:

- Task-technology fit: researching the extent to which the technology fits the tasks of the stakeholders;
- Relations with decision-making theory and knowledge management.

Based on these studies an evaluation framework is determined, which makes use of the adaptation framework of Willows and Connell (2003) in combination with the real estate development cycle, and in relation to the matrix of Eikelboom (2015), based on Carton (2007) that couples tasks, tools and the stages in the adaptation framework for spatial adaptation.

8.1.4. RESEARCH QUESTION 4

- **What is the role of PSS in urban development projects in the Netherlands in relation to Urban Strategy and the MapTable?**

Urban Strategy
Urban Strategy is a planning support tool developed by TNO since 2005 that focuses on visualising environmental effects of different spatial measures. A SWOT analysis of the tool based upon the two case studies is mentioned below.

Urban Strategy is particular suitable for difficult processes with many stakeholders as it provides insight into the fact that the overall problem is bigger than their individual interest. Whereas normally people are against or in favour of a plan, the application of Urban Strategy stimulates a discussion between stakeholders about the effects of a plan upon their interests, which creates a mutual understanding of the problem. The mutual understanding enhances a collaborative and integral approach to solving the spatial issue.

However, the two case studies illustrate that it takes much preparation time to load all the needed data correctly into the system, and to eventually adapt indicators to the specific situation. It is therefore remarkable that, beforehand, it is not really clear what the stakeholders want to do with the advice and if the support of Urban Strategy is crucial for the progress of the process. Furthermore, the interactivity of the workshops still appeared to be limited, as a facilitator and operator of TNO are needed to use the software due to its complexity.

Often users prefer to be able to use the tool independently. Therefore TNO can offer a web-based version of Urban Strategy. However, it is not possible to use the tool entirely independent of TNO: during the Urban Strategy workshop a facilitator and operator is needed to operate the tool and structure the workshop.

Urban Strategy can be used at different phases of the process: during the exploration of the spatial issue; during the initiation phase in determining relevant indicators and the necessary data; during the design phase by evaluating different designs and executing scenario analysis; and during the construction phase in planning and monitoring the building process and informing the involved actors about the progress of the project. TNO would like to apply Urban Strategy as early as possible in the development process. This way the tool can be more extensively used, enabling TNO to generate a greater business result.

However, during the exploration phase a tension exists between the application of the tool whereby much data is needed and the unavailability of this data as not much is known yet at the beginning of the project. The availability of data is a precondition to work with Urban Strategy. Sometimes, it is better to provide quick insights that are less accurate, than accurate results that take too much time. An accurate analysis can be conducted later on in the process when more things are known and when more data is available. Nevertheless it is valuable to introduce Urban Strategy at the beginning of the process, enabling stakeholders to keep the possibilities of Urban Strategy in mind and to have a greater insight into the current situation, as Urban Strategy is able to clarify the constraints and possibilities of the area.

By applying Urban Strategy repeatedly during the process, stakeholders are getting used with the tool. This way the tool becomes more intertwined into the process, potentially resulting in a greater impact of the tool in the process.

Table 14 *SWOT analysis of Urban Strategy (Own ill.)*

STRENGTHS	WEAKNESSES
• Calculation model: – Reliable statutory calculation methods; • Speed; • Visualising relation between different themes.	• Focus on 'grey' environmental themes; • Accessibility: available via TNO; • Data intensive: large preparation time needed; • Level of interactivity: – Limited user-friendliness: operator is needed.
OPPORTUNITIES	**THREATS**
• Rule-of-thumb indicators; • Online availability; • Internationalisation; • Maturing of the software.	• Competitive tools; • Awareness of the tool of potential users; • Accustomed to traditional workflow or seen as threat to their job; • Fear for differences in results and rejection of the results; • Seen as a limitation of the design freedom.

The MKP-MapTable

Through the combination of environmental quality profiles, the software and hardware of the MapTable, and location specific information, stakeholders can gain insight into the environmental quality and sustainability aspects of a plan, which allows them to optimise different design alternatives.

The MKP-MapTable is a combination of an aspect system and component system, therefore indicated as an aspect-component system (De Leeuw, 2002, p. 104). Attention is firstly paid to the overall system of the urban development; subsequently attention is paid to the subsystems of the urban development (the 11 themes); whereupon aspects of these themes, the 20 indicators, are considered.
The soft systems approach is recognizable in enabling the stakeholders to determine the aimed performance of the environmental quality profiles.

During the second workshops all the chosen criteria from the first workshop were recalculated by every adaption to the plan. As this presents the effects of one measure on all the relevant criteria, this approach can be indicated as purpose treatment (doelverwerking) (Micheels, 2014, p. 371).

The use of the MKP-MapTable does not bind stakeholders to choice for the most sustainable plan in relation to the environment. Therefore the influence of using the MapTable on the design outcome is limited. Micheels (2014, p. 371) gives a practical example whereby stakeholders also were not tied to their choices illustrating that decisions can be easier made, when stakeholders know that this can be modified again at a later stage. This is in essence not wrong. Correspondingly to the soft systems approach, in this way new insights can be used to improve the plan.

The MKP-MapTable can be used on different moments during the planning process, preferably in at least two workshops. It can be used during the initiation phase for giving insights into the opportunities and threats in relation to the baseline situation with its environmental quality profiles. It can be used during the programme phase in order to determine feasible ambitions and its related criteria.

Furthermore, some scenario's, or rough draft design principles, can be made as preparation for the design phase. Lastly the MKP-MapTable can be used during the design phase for evaluating (interim) designs or design alternatives in relation to the environmental quality profiles.
A SWOT analysis of the MapTable is shown in table 18.

Table 15 *SWOT analysis of the MapTable (Own ill.)*

STRENGTHS • User-friendliness: interactive setting; • Design possibilities; • Tool draws positive attention.	**WEAKNESSES** • Calculation speed; • Compactness: size & weight; • Preparation time.
OPPORTUNITIES • Flexibility; • Streamlining different programs and data sources; • Portability: lighter and thinner; • Greater role citizen participation.	**THREATS** • Risk of technical failure; • Power relations: fear for decreased negotiation position.

Tygron and Planmaat
Despite the development of computer games is becoming easier, it remains a major investment, both in knowledge, as in time and money. Therefore it is important to think well in advance about the added values of incorporating serious games into the planning process, and the aim of playing the game.

Usually serious games are not part of the decision-making process, but are organised in addition to the planning processes, hoping that the planning process has indirectly benefited by the game (Bekebrede et al., 2012). However, this is not the case at Tygron. Tygron embeds the game in the decision-making context on the basis of the objectives and needs of stakeholders through different phases.

For all planners willing to do something with serious gaming, it is good to know that serious gaming can contribute to planning processes when complex situations or problems occur, as serious gaming can contribute in understanding these complex situations. A step ahead is experimenting with effects of several alternatives or the creation of different alternatives. Since the development of a serious game that fits the specific situation is time-consuming and costly, it is good to realise that the variety of serious games is large and that high tech 3D-virtual worlds are not always necessarily to reach the objectives of a project.

8.1.5. RESEARCH QUESTION 5

- **In which cases is the application of PSS perceived as useful by its users and developers?**

It has become clear that PSS is still a niche: PSS are not regularly applied in practice, although developments in real-time data and GIS create an opportunity for PSS to gather and process data more automatically. By decreasing the preparation times of the tool and therefore also the costs, PSS can be used by a wider audience.PSS also need to become more flexible in order to deal with the new insights of stakeholders during the planning process.

Hard systems approach in contrast to soft systems approach
Planning support systems can be seen as deterministic systems in a social system of urban development. The social system of urban development contains also other social subsystems, as many different parties are involved in the decision making process for adapting a geographical area. These social subsystems contain animated systems (people) with their deterministic systems (like computers). As planning support systems are closely related to the planning tasks of urban development projects, these systems have developed parallel to new approaches to spatial planning and urban development. Planning support systems have experienced a shift from technocratic models towards sociocratic models. This is illustrated in figure 36.

Explicit knowledge in contrast to tacit knowledge.
PSS are not able to visualise all the effects of urban development plans, due to the complex relationships between the different elements of urban development. Therefore, PSS advise stakeholders, but stakeholders do not have to abide by the result. PSS only covers explicit knowledge, though explicit knowledge is the tip of the iceberg of all knowledge that is available. PSS can determine the feasibility of a plan by processing explicit knowledge, while tacit knowledge can be shared during the workshop in order to determine the desirability of a plan.

Group objectives in contrast to individual objectives
The stakeholders have different backgrounds and vary from citizens with limited knowledge about redevelopment processes to developers and planners. PSS can play an important role in sharing information and knowledge between the different stakeholders, by which they gain a mutual understanding of the complexity of the project. A mutual understanding between the stakeholders supports collaboration between the stakeholders to develop the area in an integral way. However, PSS can also be used within organisation in order to better align different departments with each other. This is visualised in figure 37.

The moment in the development process
Planning support systems can be divided in drawing, simulation and evaluation tools as mentioned in the evaluation framework based on Eikelboom (2015). However, Urban Strategy, MKP-MapTable and Tygron appear to cover all three functions. One can therefore wonder if this distinction is useful in order to classify planning support systems. I think however, that the level of support in these three functions differ per PSS. Also, earlier developed PSS did not always cover all three PSS functions.

As the PSS analysed in this research cover different functions, they can be used at different moments in the development process. By applying PSS repeatedly during the process, stakeholders are getting used with the tool. This way, the tool becomes more intertwined into the process, resulting in a greater impact of the tool in the process.

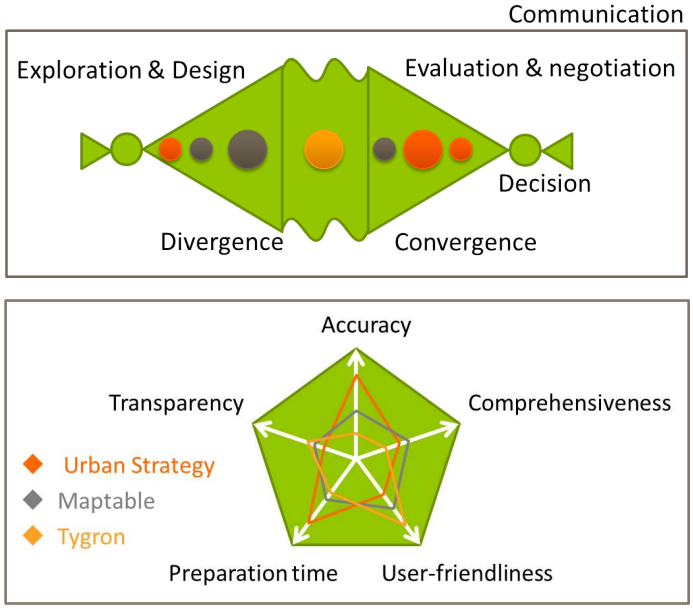


Figure 42 *Comparison of the different PSS (own ill.)*

Although Urban Strategy can visualise more indicators, the MKP-MapTable has a greater diversity of themes. Additionally, the software is easier to understand, which increases the interactivity of the workshops and user-friendliness of the tool. As the MKP-MapTable has a higher level of abstraction, the tool is more suitable to be used in the beginning of the process in comparison to Urban Strategy. Furthermore, the MKP-MapTable has greater drawing possibilities, which makes the tool also suitable for the diverging phase of the design process. The application of Urban Strategy is especially relevant for evaluating design variants during the converging phase of the design process. This is visualised in figure 38.

8.1.6. RESEARCH QUESTION 6

- **How can the development process in Buiksloterham be characterised?**

Circular Buiksloterham is a bottom-up, organic, transformation project in Amsterdam Noord and part of the wider restructuring of the Northern IJ-Banks in Amsterdam. The industrial area of 100 ha will be translated into a mixed-use urban area with a timeline running from 2005 to 2030. This means that the project is in its initiation phase whereby decision-making still plays a major role in the process. The contaminated soil and the environmental impact of residual industry together with the high sustainable ambitions increases the complexity of the project, enlarging the need for decision support tools. Also,the bottom-up approach of the redevelopment, through which many stakeholders are involved, increases the relevance for a PSS.

8.1.7. RESEARCH QUESTION 7

- **How can PSS improve the development process in Buiksloterham?**

In structuring the ambitious redeveloping process. Many stakeholders with vary different backgrounds are involved, from citizens with limited knowledge about redevelopment processes to developers and planners. PSS can play an important role in sharing information and knowledge between the different stakeholders, by which they gain a mutual understanding of the complexity of the project that can support collaboration between stakeholders to develop the area in an integral way.

Especially planning support systems that improve the communications between different stakeholders and within organisations seem therefore relevant for Buiksloterham. As decision-making powers need to decide soon how to develop Buiksloterham in a circular way, the PSS should provide the stakeholders with relevant information to make these decisions. However, a tension exists between the extensiveness of a tool, and the preparation time and costs to organise workshops with this tool. A higher complexity in the tool also influences the transparency of the data and calculation methods.

The serious game applied in Buiksloterham was very user-friendly, simple and interactive. It supported the information exchange between the attendees. However, as no building regulations or money was involved in the game the results of a game session are quite vague. Additional gaming session could focus on certain themes, or certain organisations. Therefore the game cannot only improve the relationships between stakeholders, but potentially also improve the alignment of different departments within organisations.
The objectives of the manifest were made concrete by playing the game. The game encouraged an informal and informative way of communication, stimulating attendees to collaborate. A kind of marketplace emerged, where demand and supply of information and capabilities met each other. Although stakeholders were forming joint ideas, it is questionable how serious that was as no conditions were set and as no money was involved. As there was no money involved, it was easy for the stakeholders to say that they want to collaborate. Therefore the actors should keep working together and think about a feasible business plan in order to make realisation of the ideas possible. It is crucial that decision-making powers are involved in these collaborations.

RECOMMENDATIONS FOR FURTHER RESEARCH

The content of PSS
Currently, the PSS are limited by the amount and variation of indicators that they are able to visualise. However, the incorporation of more themes will also have disadvantages. It will increase the complexity of the tool, the calculation speed and the preparation time to collect the needed data. Furthermore, extra indicators can be a distraction from the key problem of a certain spatial issue. It becomes less clear which indicators are more relevant than others in solving the problem. Therefore a demand has been noted by developers to have a greater insight into the relevance of including extra indicators in their PSS.

Evaluating the financial feasibility
The different PSS case studies also clarified a demand of users to also incorporate financial indicators into PSS. Also, one of the ambitions of TNO was to incorporate more economic indicators into the software. However, next to indicating the costs, it is also important to indicate the benefits of a measure in monetary value. This is very difficult as the costs and benefits are largely dependent on the specific project and the changing market conditions.
Real-time data sources can provide a solution for this, as it can make comparisons between the project and similar projects in the neighbourhood feasible. However, additional research is needed to analyse how the financial feasibility can be effectively evaluated by PSS like Urban Strategy and the MKP-MapTable

The impact of using PSS more regurally during the development process
The PSS developers argue that by applying the PSS repeatedly during the process, stakeholders are getting used to the tool. This way the tool becomes more intertwined into the process, potentially resulting in a greater impact of the tool in the process. However, PSS are usually only applied during two workshops. It is therefore not sure whether it is profitable to use PSS repeatedly during the development process or whether it is more attractive to create a new tool for every new problem. Therefore I would recommend further research in the benefits and constraints of applying PSS repeatedly during the planning process in order to find out if it outweights the preparation time needed to regurally adapt the tool to the specific phases in the process.

RECOMMENDATIONS FOR (POTENTIAL) USERS OF PSS

The application of PSS is interesting in projects with a high level of complexity. When stakeholders are interested in using PSS into their project, they should determine the purpose of using a PSS beforehand. As is clarified in this research, a wide variety of PSS exists, supporting different phases and tasks in the development process. Therefore, it is important to select the PSS that best fits the nature of the spatial issue en the type of development process.
Subsequently, a demonstration can give stakeholders insight into the possibilities with a PSS. This demonstration can already give a first insight into the current situation of the project.

Afterwards, ambitions for the project can be determined and translated into indicators. Before determining whether the PSS is suitable to use in the project, it should be examined whether:

- Those indicators are already available in the PSS;
- The necessary data related to those indicators are already available;
- It is feasible to collect and process the unavailable data.

This checklist allows stakeholders to make a deliberate choice to apply PSS when it suits the spatial issue, the ambitions and indicators, the type of process, and if there is already a large amount of data available. During the development process the PSS can be repeatedly used. The rate of recurrence should depend on the complexity of the project, and the extent to which the outcome of the PSS meets the ambitions of the project. When the PSS is repeatedly used during the process, the tool becomes more intertwined in the development process potentially leading to a greater impact in the project.

9. REFLECTIONS

VALIDATION OF THE RESEARCH TOPIC

PROBLEM STATEMENT

Despite the promising development of planning support systems from technology focused models towards participatory human-centred support, the application of planning support systems in practice is still lagging behind (Brail and Klosterman 2001; Geertman and Stillwell 2003; Uran and Janssen 2003; Couclelis 2005; Vonk 2006). Couclelis (2005, p. 1359) argues that this can be explained by the difference that planning is about policy, while the models are based on science.
Also Uran and Janssen (2003) identify the mismatch between the decision problem of end-users and the answers produced by the system as the main factor for this lack of success. A few years later, Geertman and Stillwell (2009) still confirm that it appears that after decades of development PSS were still not transparent enough, neither flexible nor user friendly and therefore incompatible with the unpredictable and flexible nature of most planning tasks and information needs.
Different authors mention that the major challenge in this area is to better link the decision-support tools to the ways in which stakeholders use these tools. Some reactions focus on improving PSS software by adding new functions to it; for example, PSS that are more integrated (i.e. 'What If' developed by Klosterman (1999)), more interactive (i.e. 'Urban Strategy' developed by TNO (2015a, 2015b)) or more user-friendly (i.e. 'UrbanSim' developed by Waddell (2002, 2011)). Others follow a more hardware-oriented path, such as 'MapTables', 'Sketchtables' and other visual gadgets. Then, there is the process-oriented line that focuses on bridging the human gap between the potential end-users and the PSS developers with more participative, iterative PSS development structures (Te Brömmelstroet & Schrijnen, 2010), like the serious gaming tools. However, not much empirical research is done whether these recent developments have bridged the implementation gap between theory and their use in the practice of urban development.

SCIENTIFIC RELEVANCE

This thesis contributes to the scientific field of the use of planning support systems as:

- Empirical research often focuses on the tool instead of the process in which the tool is applied. Therefore, there has not yet been much empirical research about the performance of planning support systems made;
- Empirical findings are explained and evaluated through the lens of systems theory;
- The study is executed from a Dutch urban development point of view;
- The results of the comparative case analysis are immediately applied in an urban development project in Buiksloterham, Amsterdam-Noord.

PRACTICAL RELEVANCE

This study has a practical relevance, as the context of the application of planning support systems is very dynamic. New tools or improvements in planning support systems are developing rapidly, while the perspective on urban development processes is also continuously changing. This study therefore provides a contribution to the development of knowledge in relation to the current use of planning support systems in practice.
Additionally, the case studies evaluate in detail the planning support systems in its specific context. This supports the facilitators of planning support systems in improving the way their systems are used, and in gaining insights into the strengths and opportunities of their systems. Furthermore, the recommendations for the urban redevelopment in Buiksloterham will support the stakeholders in deciding whether to use or not use particular planning support systems in relation to their specific demands and the development stage of the proces.

RESEARCH OUTCOME UTILISATION RELEVANCE

The redevelopment project of Buiksloterham will be used to apply the findings of this research into the specific Dutch context of urban development, resulting in recommendations about the use of planning support systems in this particular case.

REFLECTION ON THE RESEARCH DESIGN

This research is based on a qualitative approach in order to clarify the complex context of the applications of planning support systems in urban development. The case studies describe this context. As every project is executed in a different context, multiple case studies were executed. By executing a comparative-case study the transferability of the findings is increased from one specific context to several. But most of all, this research design enables to discover patterns between different cases, similarities and differences, by which empirical findings can be further clarified. It is a comparative case study research design whereby different research methods will be used aligned to the different research sub-questions, like literature review, semi-structured interviewing, observations and secondary data analysis. The validation of the research methods is done according to Bryman (2012). Bryman (2012) distinguishes based on Lincoln and Guba (1985) four criteria in order to determine the quality of the research. In relation to qualitative research these criteria are indicated as the internal validity, external validity, reliability and objectivity. Internal validity is concerned with the question of whether a conclusion that incorporates a causal relationship between two or more variables holds water; External validity Is concerned with the question of whether the results of a study can be generalised beyond a specific research context; and reliability concerns with the question whether the results of the study are repeatable. As it is difficult to establish causal directions from resulting data, the internal validity of the comparative analysis of the case studies is typically weak. Therefore this research is related to other empirical studies and broadly accepted theories, like the soft systems approach. Furthermore, the research tasks are outlined in this thesis in order to increase the transparency of this research and thereby the possibility to replicate the study.

REFLECTION ON THE RESEARCH METHODS

REFLECTION ON THE LITERATURE REVIEW

The literature review is executed to generate an understanding of the topic and to be able to link the result findings to already established scientific knowledge. The literature review is, opposed to a systematic review, an example of a narrative review. The criteria for exclusion or inclusion of studies are less explicit in comparison to systematic reviews. However, as this research considers a complex context, which cannot be defined in fixed variables, it is hard to execute a systematic review. The narrative literature review enabled me to consider new literature during the research process, when I gained new insights into the topic. In this way, it supported experiential learning. I have used Excel to structure my sources on topic, relevance, and whether they have been read and summarised.

REFLECTION ON THE CASE STUDIES

Next to semi-structured interviews of developers, users and experts, the cases are supported by secondary data analysis and observation. By executing different research methods triangulation is achieved. Triangulation entails using more than one method or source of data in the study of social phenomena, resulting in greater findings as it enables crosschecking findings deriving from different research methods.

Reflection on the case sampling

Of all planning support systems available, the MapTable, Urban Strategy and Tygron were chosen as subject of study as (i) they are used in different urban development projects, on the scale of a neighbourhood; as (ii) they are comprehensive tools, taking into account a wide variety of indicators; as (iii) the tools involve stakeholder participation; as (iv) the working of the tools are clear allowing to compare different tools with each other; and, as (v) the tools are flexible and adaptable, by which they can be adapted to the specific situation of different development projects.

Due to the financial crisis, a limited amount of cases concerning urban development and using the MapTable, Urban Strategy and Tygron have been executed recently. Furthermore, many projects currently cover a smaller scale in comparison to projects executed before the financial crisis. Planning support systems are primarily used for large scale developments, by which the choice to execute case studies concerning recently used applications of planning support systems in Dutch urban development projects was very limited. Therefore, I also accepted to include projects like SUMP Tilburg, which has its focus on mobility issues instead of urban development. However, the application of planning support systems in mobility related projects are comparable to urban development projects, as in both cases many stakeholders with different backgrounds are involved, and as both types of projects aim to physically adapt a specific area to social-economic and spatial needs. Unfortunately no users of the serious games of Tygron consented to contribute to this research.

Therefore, this case study is executed on the basis of semi-structured interviews with developers of Tygron and a secondary data analysis. This is further complemented by a semi-structured interview with Planmaat and Play the City. Planmaat is incorporated in this research as the interviewed developer has a great understanding of the use of different planning support systems in the Netherlands. This interview contributes to this research with respect to the use of planning support systems in urban development in general. The decision to involve Play the City is made at a later stage of the research, as I discovered that Play the City was planning a game workshop for the stakeholders of Buiksloterham during researching the redevelopment Buiksloterham. Attending the Buiksloterham City Innovation gaming session was of great value to gain a greater insight into the possibilities of applying PSS in Buiksloterham.

Requirements for the case studies were that (i) they have been executed recently applying the last developments of planning support systems; that (ii) the workshops have been completed in order to execute ex post evaluation enabling to evaluate the results and perceived effects of the planning support systems; that (iii) the PSS developers could put me in contact with the project-related users; and (iv) that the PSS has been used in the Dutch context of decision-making and urban development. It turned out that the different cases were very complementary to each other. For both the MKP-MapTable and Urban Strategy, one positive case and one less positive case were conducted.
The cases were conducted on different moments in the planning process enabling to reveal a wide variety of planning tasks supported by the planning support systems in its practical context. The amount of cases are determined by practical considerations in order to be able to validate the assumptions based on a variety of cases, while the amount of cases is limited due to time constraints.

Reflection on the interviews

The semi-structured interviews are used to gain information of the individual, personal experiences and opinions from the developers, users and experts. During the interviews the interviewee is motivated to share their perspectives. The interview formats of the PSS developers and PSS users are shown in appendix B and C. These formats are based on the literature review, whereby attention is paid to the context of the cases accordingly to the soft systems approach. The results therefore need to be interpreted in the context of the case studies. The semi-structured interviews allowed flexibility to explore the different aspects influencing the use of planning support systems in practice and to zoom in on specific issues of relevance. Therefore more precise assumptions regarding to the aspects influencing the use of planning support systems and the perceived effectiveness of its users. The procedures of executing the interviews are outlined to improve the transparency and reliability of this research.

A total of 15 users were being interviewed for the four cases, which is further supported with 8 interviews of PSS experts and developers. An overview of the interviewees is shown in appendix A. The interviews lasted 30 to 75 minutes. The interviews with the users in general lasted shorter than the interviews with the developers, as the interviews with the developers were conducted first. During these first interviews, general information was gained about the cases, which saved time in the other interviews later on. The interviews are transcribed verbatim, and checked and approved by the interviewees. Amongst the PSS users different disciplines participated in this study. For the MapTable case studies civil servants from various domains from the two municipalities were interviewed, like a consultant Infrastructure, consultants Environment, and the municipal project leaders. Furthermore, the urban planner gave interesting insights from his perspective. For the Urban Strategy case the project leaders of TNO were interviewed, civil servants of the Municipality Tilburg, an urban designer for Healthy Urbanisation Utrecht and a representative of Rijkswaterstaat.

Additionally, to the interviews, I have received a demonstration of every tool to experience the possibilities of the tool by myself. As the workshops were not attended and observed by the researcher, because of limited time to execute this research, one can only argue that this research delivers assumptions about the perceived usefulness of planning support systems by its developers and users.

Reflection on primary and secondary data analysis

To further support the results of the case studies a secondary and primary analysis of data is executed. The primary analysis of data concerns the transcriptions of the interviews, while the secondary analysis of data concerns documents of the Province of Utrecht and TNO. These documents cover information about the projects and about technical information about the planning support systems. Some of this data is included in the appendices. The reliability of the data of the Province of Utrecht and TNO is considered to be high as they have expert knowledge about their own tools, direct contact with the end-users and as they facilitate the workshops with the planning support systems. The verbatim-transcribed interviews offer a transparent foundation to analyse the findings.

REFLECTION ON THE COMPARATIVE CASE STUDY ANALYSIS

A drawback of executing case studies is that the researcher cannot manipulate any of the variables influencing the use and perceived effectiveness of planning support systems in practice. Therefore, there exist some ambiguity about the relationships between variables discovered during the analysis of the different case studies. To limit this ambiguity, the comparative case analysis is based upon an evaluation framework resulting from the literature review and theoretical framework. This enabled connecting the empirical findings to other scientific sources to improve the validity of the assumptions. Furthermore, expert interviews were executed to validate and test the findings. The evaluation framework relates six planning tasks that are performed by PSS to three different types of PSS and three phases of the development process. However, Urban Strategy, MKP-MapTable and Tygron appear to cover all three functions. One can therefore wonder if this distinction is useful in order to classify planning support systems. I think however, that the level of support in these three functions differs between different PSS.
Also, earlier developed PSS did not always cover all the different PSS functions. Linear Programming is for instance an evaluation tool, which does not cover drawing and simulation functions. In the end the distinction of different planning tasks appears especially relevant in recognising different types of interaction between the stakeholders, enabling to characterise different types of learning.

REFLECTION ON BUIKSLOTERHAM

The use case was chosen to apply my findings directly into practice to increase the utilisation potential of this research. Buiksloterham was chosen, as it is an innovative sustainable project. These types of projects are typically open towards new innovations like the use of planning support systems. The complexity of this transformation project supported the need for such a PSS: due to the bottom-up, organic approach, many stakeholders are involved in an unstructured way; Furthermore, the contaminated soil and the environmental impact of residual industry together with the high sustainable ambitions increases the complexity of the project as well. Additionally, the large amount of involved actors enabled to research the many different perspectives and demands for information related to those different stakeholders. Also the timing of the case made it suitable to be used to apply the findings: the timespan of the project runs from 2005 to 2030. This means that the project is in its initiation phase whereby decision-making still plays a major role in the process. The practical reason that Buiksloterham is chosen is that it could be executed in collaboration with AMS, Amsterdam Institute for Advanced Metropolitan Solutions. The case study is related to the theoretical framework and literature review, just as the urban development process characteristics of the PSS cases. The case study is validated by semi-structured interviews, observations, and data analysis. The semi-structured interviews covered three persons related to the redevelopment of Buiksloterham. As many actors are involved, one cannot argue that these perspectives correspond to the perspectives of all involved actors. Also, as the redevelopment of Buiksloterham consists of many different subprojects, it might be the case that in some subprojects the application of the PSS would be more suitable than in others. However, the urban redevelopment of Buiksloterham is in this research used to illustrate how the recommendations and assumptions of the case studies can be applied in practice, and aims not to analyse the development into great detail. The observations were based on a game session of the City Innovation Game of Play the City.

EVALUATION OF THE RESEARCH PROCESS

As mentioned in the preface, I started this research by studying smart city developments and the way in which data can be used in the decision-making process in urban development. Soon, I discovered that it was difficult to execute case studies in the Netherlands related to that topic, as holistic approaches to the smart city concept were not realised yet. Therefore, I am very glad that I have changed my topic of research towards planning support systems, by which I could relate my findings to the Dutch practice of urban development. However, much time was lost in researching smart city approaches and eventually I delayed the approval of my research proposal in order to create a concise and consistent proposal for the next P2 possibility. During the subsequent semester, I spent a lot of time to the literature review, starting with a background in GIS technologies and spatial decision support systems. The abundance of literature related to the tool-specific details has led to an understanding in the limitations and developments in GIS and related GPS and multi-criteria decision-making technologies. However, these topics were not crucial to my research. Consequently, I have lost much time in reading scientific articles. As students are supported to work independently on their research, I continued to keep reading until the next P2 moment. In retrospect, I should have got more often in contact with my mentor to better keep on track.

As my former second mentor has received a new job at the same research lab as my first mentor, it I needed to search for a new second mentor. Luckily, my first mentor helped me to get in touch with Ruud. With a new direction in my research and a new second mentor I was resolute to finish this graduation research in a new way. I tried to consult my mentors more often and with the approval of my research proposal I could finally execute the research. In the end it turned out that my mentors had both different perspectives on systems theory. Although it took me some extra time to internalise systems theory, it balanced my view on the subject well and enabled me to structure the issues and complexity of urban development processes. Therefore, I am glad that I decided to use this theory in my research.

I have learnt a lot from executing this research, but I am glad that I am almost finished. This research project was by far the most difficult project I needed to accomplish during my studies in Delft. I found it quite difficult to work totally individually at a project, as I prefer to collaborate with other people. I especially missed to have a common goal and to share the highs and lows of the research project with fellow students. Also, I have regretted that this research is quite theoretical. Although, I have executed case studies and have been in contact with many practitioners, I prefer to work in a more solution-oriented way. However, by executing this research I have learnt more about myself, and about what I want to do, and not want do, after my graduation. Therefore, I look forward to the new challenges that lie ahead.

10. BIBLIOGRAPHY

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11. APPENDICES*

** The names of the interviewees in appendix A are confidential, just as the interview transcriptions (appendix D). Additionallly the background information of the PSS case studies are confidential (Appendices G, H, J, K, & L). These appendices are only intended for inspection by the graduation mentors.*

APPENDIX A LIST OF INTERVIEWEEES

No.	Date	Name	Organization	Type of interview	Location
1	09-01-15	*Confidential*	SITE UD	Orientation	SITE Urban Development
2	15-01-15	*Confidential*	TU Delft / AMS	Orientation	Faculty of Architecture
3	30-01-15	*Confidential*	TU Delft / AMS	Orientation	Faculty of Architecture
4	11-02-15	*Confidential*	TU Delft / AMS	Orientation	Faculty of Architecture
5	23-02-15	*Confidential*	TNO	Orientation	Via Skype
6	27-02-15	*Confidential*	AMS	Orientation	AMS institute
7	02-07-15	*Confidential*	WUR	Orientation	Faculty of Architecture
8	13-07-15	*Confidential*	Tygron	PSS developer	Tygron
9	13-07-15	*Confidential*	TNO	PSS developer	TNO Utrecht
10	15-07-15	*Confidential*	Mapsup	PSS developer	Faculty of Architecture
11	07-08-15	*Confidential*	TNO	PSS developer	Via Skype
12	09-09-15	*Confidential*	Planmaat	PSS developer	Planmaat
13	31-07-15	*Confidential*	UU	PSS expert	Via telefoon
14	03-09-15	*Confidential*	Geo-Col GIS	PSS expert / developer	AMS insitute
		Urban Strategy case SUMP Tilburg			
15	27-08-15	*Confidential*	TNO	PSS case 1	TNO Delft
16	09-09-15	*Confidential*	TNO		TNO Delft
17	10-12-15	*Confidential*	SUMP Tilburg		
		Urban Strategy case GVU			
18	02-09-15	*Confidential*	TNO	PSS case 2	TNO Utrecht
19	11-09-15	*Confidential*	Posad		Posad
20	05-10-15	*Confidential*	Rijkswaterstaat		Rijkswaterstaat Westraven
		Maptable case provincie Utrecht			
21	27-08-15	*Confidential*	Province of Utrecht		Provinciehuis Utrecht
	27-08-15	*Confidential*	Province of Utrecht		Provinciehuis Utrecht
22	03-09-15	*Confidential*	Municipality Woudenberg	PSS case 3	Via telefoon
23	07-09-15	*Confidential*	Atelier Dutch	PSS case 3	Via telefoon
24	15-09-15	*Confidential*	Province of Utrecht		Provinciehuis Utrecht
	15-09-15	*Confidential*	Province of Utrecht		Provinciehuis Utrecht
25	29-09-15	*Confidential*	Municipality Stichtse Vecht	PSS case 4	Gemeentehuis Stichtse Vecht
	29-09-15	*Confidential*	Municipality Stichtse Vecht	PSS case 4	Gemeentehuis Stichtse Vecht
	29-09-15	*Confidential*	Municipality Stichtse Vecht	PSS case 4	Gemeentehuis Stichtse Vecht
		Buiksloterham			
26	15-09-15	*Confidential*	WUR (ACC)		Nationale wetenschapsagendc
27	28-09-15	*Confidential*	Citylab Buiksloterham		New Energy Docks, Amsterdam
28	09-10-15	*Confidential*	Play the City	PSS expert / developer	Faculty of Architecture

APPENDIX B INTERVIEW FORMAT PSS DEVELOPERS

Date, time, location.

- **Mijn achtergrond en een introductie van mijn afstudeer onderzoek**

- **Achtergrond geïnterviewde**
  - Heeft u ook ervaring met andere PSS?

- **Introductie in de tool**
  - Hoe werkt het?
  - Welke functies heeft de tool?
  - Wat zijn voordelen van de tool?
  - Wat zijn beperkingen van de tool?
  - Hoe heeft de tool zich afgelopen jaren ontwikkeld?
  - Hoe betrouwbaar is de software?
  - Voor welk doel wordt de tool toegepast?
  - Voor wat voor projecten wordt de tool toegepast?
  - Op welk moment in het proces wordt jullie tool voornamelijk toegepast?
  - Wat onderscheidt de tool van andere tools?
    - Waarom kiezen opdrachtgevers voor de toepassing van jullie tool in hun projecten?

- **Inhoudelijke vragen**
  - Evalueren jullie de software onder gebruikers?
  - Wat zijn de ervaringen van gebruikers?
  - Hoe bewust zijn de gebruikers van de beperkingen en mogelijkheden van de tool?
  - Gaan de gebruikers makkelijk met de software om?
    - Hoe proberen jullie de gebruikers daar in te begeleiden?
  - Hoe wordt er gereageerd op de resultaten van de tool?
  - Worden de resultaten later ook daadwerkelijk gebruikt in de besluitvorming?
  - Wat viel u op aan het PhD onderzoek van Peter Pelzer?
  - Wat zou u nog meer graag willen weten?
  - Wat vind u relevant in mijn onderzoeksvoorstel?
  - Welke cases zouden goed bij mijn onderzoeksvoorstel passen?
  - Heeft u verder nog vragen of opmerkingen?

Afsluiting gesprek

APPENDIX C INTERVIEW FORMAT PSS USERS (PARTLY BASED ON PELZER, 2015)

Date, time, location.

Introduction research

Background of respondent
– What is your job?
– What was your role within this particular project?
– Have you used PSS before?

Elaboration of PSS application:
– What was the aim of the project?
– Why did you apply this support tool?
– Why this support tool?
– Which functions did you use of the tool? / Which tasks did the tool execute?

Planning issue: Elaboration of the of planning issue in relation to the support tool:
– What is exactly the problem that required a planning intervention?
– How did the support tool provide insight into this problem?
– What were the strengths and weaknesses of the support tool?
– What were the dimensions the support tool had problems with?
– How were uncertainties handled?
– How were complexities handled?

Planning process: Explanation of the planning process in relation to the support tool:
– In what phase of the planning process was the tool applied?
– What was the background of the involved stakeholders in the project?
– How were interests of stakeholders managed?
– How was the collaboration among stakeholders from different organizations?
– How was the collaboration with politics?

Stakeholders: Elaboration of the involved stakeholders in relation to the support tool:
– Experiences support tool by involved stakeholders?
– Differences among involved stakeholders?
– Explanation for relevant differences among stakeholders?
– Frictions between stakeholders?
– Influence support tool on interaction among stakeholders?
– Did the involved actors accept the results of the PSS workshop?

Planning outcome: Elaboration of the planning outcome in relation to the support tool:
– In what way has the PSS influenced the outcome of the project?
– How are the results of the PSS workshop translated into the plan?
– Which changes are made after the PSS workshop?
– Why are these changes made?

General: Some more generic questions, also to ensure all topics are covered:
– What was the most added value of the tool for your project?
– Do it again in next project? / would you try another tool?
– Any additions?
Closure

APPENDIX E GEBIEDSTYPEN EN MKP'S MKP-MAPTABLE

Centrum stedelijk	
Ligging	In centrum van steden, maar ook centraal gelegen wijken net buiten het centrum.
Functie	Zeer sterke menging van de functies: - wonen - werken (detailhandel, dienstverlening, cultuur) - recreëren Grote diversiteit aan voorzieningen.
Dichtheid	Hoog (tussen de 30 -70 woningen per hectare).
Gebruiksintensiteit	Hoog
Infrastructuur	Goede bereikbaarheid met openbaar vervoer en fiets.
Openbare ruimte	Aandeel openbare ruimte laag en aandeel onverharde ruimte beperkt. Dus een beperkte ruimte voor openbaar groen en water.
Buiten-centrum	
Ligging	In de overgangszone tussen het stadshart en de buitenwijken.
Functie	Hoofdfunctie: - wonen Nevenfuncties: - werken - recreëren Allerlei kleinere voorzieningen, winkels en kantoorruimtes.
Dichtheid	Hoog in de intensieve woongebieden (tussen de 30-70 woningen per hectare) Matig in de minder intensieve woongebieden (tussen de 30-50 woningen per hectare). Gestapelde woonvorm komt veelvuldig voor.
Gebruiksintensiteit	Matig
Infrastructuur	Goede bereikbaarheid met auto en fiets. Matige ontsluiting met openbaar vervoer.
Openbare ruimte	Aandeel openbare ruimte is laag en aandeel onverharde ruimte beperkt. Dus een beperkte ruimte voor openbaar groen en water.
Groen stedelijk	
Ligging	Overwegend aan de rand van de stad, in de overgangszone naar het buitengebied.
Functie	Hoofdfunctie: - wonen Nevenfuncties: - geen, tenzij buurtcentrum
Dichtheid	Laag (meestal tussen de 15-30 woningen per hectare).
Gebruiksintensiteit	Laag-matig
Infrastructuur	Goede bereikbaarheid met auto. Lage ontsluiting met openbaar vervoer.
Openbare ruimte	Groen en rustig karakter, vanwege het openbaar groen (parken) en de waterpartijen, maar ook door het privé-groen.
Centrum dorps	
Ligging	In het centrum van dorpen, maar ook omliggende wijken met een redelijke dichtheid.
Functie	Sterke menging van de functies: - wonen - werken - recreëren
Dichtheid	Matig (tussen de 30-50 woningen per hectare).
Gebruiksintensiteit	Matig
Infrastructuur	Goede bereikbaarheid met auto en fiets. Matige ontsluiting met openbaar vervoer.
Openbare ruimte	De ruimte voor openbaar groen en water is groter dan bij Centrum stedelijk.
Industrie	
Ligging	Speciaal aangewezen gebieden voor zwaardere (milieu)bedrijvigheid. Vaak op grotere afstand van woonwijken.
Functie	Hoofdfunctie: - bedrijven in de zwaardere milieu-categorie 4 en 5 en de zwaardere bedrijven van categorie 3, alsmede bedrijven met veiligheidsrisico's. Nevenfuncties: geen
Dichtheid	Laag-matig
Gebruiksintensiteit	Hoog 24-uurs
Infrastructuur	Bedrijvigheid genereert zwaar (auto) transportverkeer. Directe ontsluiting via de hoofdstructuur van wegen, water of spoor van groot belang.
Openbare ruimte	Vaak sprake van een zeer hoge gebruiksintensiteit van de openbare ruimte door continue aan- en afvoer van met name goederen.
Bedrijven	
Ligging	Bedrijventerreinen aan de rand van de woonbebouwing. Vaak is er een overgangsgebied van wonen naar werken.
Functie	Hoofdfunctie: - bedrijven in de lichtere milieucategorieën 2 en 3 en in specifieke gevallen categorie 4 Nevenfuncties: - kantoren en grootschalige detailhandel Combinatie werken/wonen (eenmansbedrijve
Dichtheid	Matig
Gebruiksintensiteit	Hoog Met name overdag in bedrijf. Kan intensieve publieksaantrekkende functies bezitten.
Infrastructuur	Veel voorkomende sectoren op deze terreinen zijn transport-, distributie-, opslag- en aannemersbedrijven. Directe ontsluiting via de hoofdweginfrastructuur van groot belang.
Openbare ruimte	Vaak sprake van een zeer hoge gebruiksintensiteit van de openbare ruimte door continue aan- en afvoer van met name goederen.

Kantoren en publieksintensieve voorzieningen	
Ligging	Overwegend in of nabij het hart van de stad en aan de rand van de stad.
Functie	Functies: - kantoren en kantoorachtige bedrijven grootschalige ontwikkelingen met een grote publieksaantrekkende werking (detailhandel, ziekenhuizen, onderwijs, zorginstellingen, horecavoorzieningen, discotheken, sportcomplexen etc.
Dichtheid	Hoog
Gebruiksintensiteit	Hoog
Infrastructuur	Goede autobereikbaarheid van groot belang. Ontsluiting met hoogwaardig openbaar vervoer is, gelet op de arbeids- intensiteit van de kantoorfunctie, van groot belang.
Openbare ruimte	In het algemeen is in de intensieve werkgebieden relatief veel ruimte voor openbaar groen en water aanwezig.
Landelijk gebied: stedelijk uitloopgebied	
Ligging	In het Landelijk gebied aansluitend aan stedelijke gebieden.
Functie	Functies in intensieve delen, o.m.: - sportcomplexen - volkstuinen - agrarisch gebruik - dagrecreatie-terreinen - tuinbouw Functies in extensieve delen, o.m.: recreatief groen met fiets- en wandelroutes en natuurterreinen.
Dichtheid	Laag (minder dan 20 woningen per hectare).
Gebruiksintensiteit	Matig
Infrastructuur	Goede fiets- en wandelpaden van groot belang i.v.m. recreatiefunctie stedelijk gebied.
Openbare ruimte	Overwegend recreatief groen, agrarisch gebruik en kleine natuurgebieden.
Landelijk gebied: agrarisch	
Ligging	In het buitengebied.
Functie	Hoofdfunctie: - zowel grondgebonden als niet grondgebonden landbouw. Nevenfunctie: recreatief medegebruik.
Dichtheid	Laag (minder dan 10 woningen per hectare).
Gebruiksintensiteit	Laag
Infrastructuur	Geen bijzonderheden.
Openbare ruimte	Gebied bevat ook kleine recreatie- en natuurgebieden en ecologische verbindingszones.
Landelijk gebied: verweving van functies	
Ligging	In het buitengebied.
Functie	Afwisselend gebied met verweving van functies, m.n.: - landbouw - natuur - recreatie - (in enkele gevallen) zeer intensieve woonmilieus Doorgaans landschappelijk en ecologisch waardevolle gebied. Verweving van functies zowel op perceelsniveau (zoals intensief recreatief gebruik op Utrechtse Heuvelrug) als op mozaïek van gescheiden functies (zoals delen van Langbroek Wetering).
Dichtheid	Laag (minder dan 10 woningen per hectare).
Gebruiksintensiteit	Laag
Infrastructuur	Geen bijzonderheden.
Openbare ruimte	Vanwege ecologische waarden in dit gebied is stimulering van productie van groene diensten en verbreding en verdieping van landbouw van belang. gestreefd moet worden naar brede groenblauwe zones en voorkoming van verdere versnippering van de natuurfunctie.
Landelijk gebied: hoofdfunctie natuur	
Ligging	In het buitengebied.
Functie	Bestaande en als nieuwe natuur aan te leggen natuurgebieden, beide vaak met recreatief medegebruik. Geen woningen. Mogelijk natuurgerelateerde bedrijvigheid.
Dichtheid	Zeer laag
Gebruiksintensiteit	Zeer laag
Infrastructuur	Geen bijzonderheden.
Openbare ruimte	Behoud en versterking aantrekkelijkheid staat centraal.

APPENDIX F INDICATOREN EN SCORINGSSYSTEEM MKP-MAPTABLE

Het betreft hier een algemene uitwerking van de indicatoren waarmee een goed inzicht wordt verkregen hoe de kwaliteitswaarden worden bepaald. Voor een meer gedetailleerde verantwoording kunt u contact opnemen met de provincie Utrecht.

1. ENERGIEGEBRUIK

Het gebouwgebonden energiegebruik in de wijk.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Nieuwbouw: gemiddeld EPC van de woningen en utiliteitsbouw **Bestaande bouw:** gemiddeld energielabel van de woningen en utiliteitsbouw.		Score 6	Score 10	Lineair	Voor nieuwbouw is de referentie (score 6) het Bouwbesluit. Voor bestaande bouw is energielabel D (landelijk gemiddeld) de referentie.
	Nieuwbouw	EPC 0,6	EPC 0		
	Bestaande bouw	Label D	Label A^+		
	Geen onderscheid tussen overige gebiedstypen.				

2. OPWEKKING DUURZAME ENERGIE

De hoeveelheid duurzame energie die in de wijk wordt opgewekt.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
% duurzame energie opgewekt in het gebied (PV, WKO, wind- molens, etc.) als percentage van de energievraag (gebouwgebonden + huishoudelijk gebruik).		Score 6	Score 10	Logaritmisch	Door formule bepaald.
	Nieuwbouw	10%	60%		
	Bestaande bouw	5%	20%		

3. MATERIAALGEBRUIK

De milieulast van het materiaalgebruik bij de bouw van woningen en utiliteitsbouw.

INDICATOR	SCORE PER GEBIEDSTYPE	SOORT FORMULE	TOELICHTING & BRONNEN
GPR score voor materialen	GPR materiaal score 6 = 6 GPR materiaal score 10 = 10 Voor alle gebiedstypen.	Lineair	GPR Gebouw (www.gprgebouw.nl) kent een aparte score voor materiaalgebruik.

4. WATER IN DE WIJK / HET GEBIED

De hoeveelheid open water in de wijk tbv waterberging, ecologie en leefbaarheid.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
% open water		Gebiedstype	Score 6	Score 10	Lineair	Door formule bepaald.
		Centrum stedelijk	4%	7%		
		Buiten centrum	5%	8%		
		Groen stedelijk	6%	10%		
		Centrum dorps	6%	10%		
		Industrie	3%	5%		
		Bedrijven	6%	10%		
		Kantoren en publieksintensieve voorzieningen	4%	7%		
		Landelijk gebied: stedelijk uitloopgebied	10%	17%		
		Landelijk gebied: agrarisch	10%	17%		

5. WATER – NATUURVRIENDELIJKE OEVERS

Deel van de oevers dat natuurvriendelijk is ingericht.

INDICATOR	SCORE PER GEBIEDSTYPE	SOORT FORMULE	TOELICHTING & BRONNEN
% van de oever ecologisch / natuurvriendelijk ingericht		Lineair	In de gebiedstypen centrum stedelijk en industrie zijn ecologische oevers vaak niet wenselijk en wordt dit aspect daarom niet meegenomen

Gebiedstype	Score 6	Score 10
Centrum stedelijk	nvt	nvt
Buiten centrum	8%	15%
Groen stedelijk	15%	25%
Centrum dorps	15%	25%
Industrie	nvt	nvt
Bedrijven	15%	25%
Kantoren en publieksintensieve voorzieningen	15%	25%
Landelijk gebied: stedelijk uitloopgebied	15%	25%
Landelijk gebied: agrarisch	15%	25%

6. WATER – VASTHOUDEN REGE

INDICATOR	SCORE PER GEBIEDSTYPE	SOORT FORMULE	TOELICHTING & BRONNEN
% onverhard en halfverhard oppervlak, groene daken en wadi's. Inclusief tuinen.		Rechtevenredig	

Gebiedstype	Score 6	Score 10
Centrum stedelijk	20%	33%
Buiten centrum	30%	50%
Groen stedelijk	40%	67%
Centrum dorps	40%	67%
Industrie	15%	25%
Bedrijven	20%	33%
Kantoren en publieksintensieve voorzieningen	20%	33%
Landelijk gebied: stedelijk uitloopgebied	60%	100%
Landelijk gebied: agrarisch	60%	100%

7. HEMELWATERAFVOER

De mate waarin regenwater wordt gescheiden van het gemengde riool (afkoppeling) en wordt geïnfiltreerd in de bodem of hergebruikt voor bijvoorbeeld industrie, het toilet, auto's wassen, sproeien, etc.

INDICATOR	SCORE PER GEBIEDSTYPE	SOORT FORMULE	TOELICHTING & BRONNEN
De mate van afkoppeling, infiltratie en hergebruik van regenwater.		Lineair	In sommige gebieden gelden speciale normen, bv in de Utrechtse heuvelrug. In gebieden waar infiltratie onwenselijk is, dient dit aspect niet meegenomen te worden (aspect uitvinken).

	Score 6	Score 10
Nieuwbouw	100% afgekoppeld	100% afgekoppeld icm hergebruik of infiltratie
Bestaande bouw	20% afgekoppeld	35% afgekoppeld
Industrie bestaand	10% afgekoppeld	10% afgekoppeld icm hergebruik
Industrie nieuw	60% afgekoppeld	60% afgekoppeld icm hergebruik

8. WATERVEILIGHEID
De gevolgen van een doorbraak van primaire keringen ingedeeld in vijf klassen: Snel en diep, Snel en ondiep, Langzaam en diep, Langzaam en ondiep, Blijft droog. Het risico wordt beoordeeld ter plaatse van bebouwing.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Aantal woningen/utilite itsbouw in risicogebieden doorbraak primaire kering.		Score 6	Score 10	Lineair	Woningen/gebouwen kunnen gemarkeerd worden als "klimaatrobuust". Dit staat symbool voor een aantal maatregelen aan gebouw en gebied om de schade bij overstroming te beperken (zie handreiking overstromingsrobuust bouwen).
	Alle gebieds-typen	Woningen/ utiliteitsbouw zijn gebouwd in gebied 'langzaam en ondiep'; geen maatregelen aan de woning of buurt.	Woningen/ utiliteitsbouw zijn gebouwd in gebied 'blijft droog' of 'klimaatrobuust' gebouwd.		

9. BODEM - BODEMKWALITEIT
Diffuse bodemkwaliteit.

INDICATOR	SCORE PER GEBIEDSTYPE	SOORT FORMULE	TOELICHTING & BRONNEN
Bodemkwaliteit in relatie tot de functie	Er wordt beoordeeld of de bodemkwaliteit matcht met de functie. Dus: voor woongebied: klasse wonen = 6 voor bedrijventerrein: klasse industrie = 6. etc.	Overschrijdingen krijgen weeg-factor obv oppervlak en ernst overschrijding.	

10. AARDKUNDIGE WAARDE
In hoeverre worden aardkundig waardevolle elementen intact gehouden en zichtbaar gemaakt in de wijk.

INDICATOR	SCORE PER GEBIEDSTYPE	SOORT FORMULE	TOELICHTING & BRONNEN
Mate van behoud en zichtbaarheid aardkundige waarden	Score 6: Inpassen in plan, bv als park, met licht grondverzet Score 10: Aardkundige waarde blijft in huidige vorm bestaan en is 'leesbaar' voor publiek. geen onderscheid gebiedstypen.	"Ladder"; gemiddelde op basis van oppervlakte	(Zie 11. Draagkracht van de bodem) voor een uitgebreidere toelichting op de categorieën.

11. DRAAGKRACHT VAN DE BODEM

INDICA-TOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Zetting-gevoelig-heid		Score 6	Score 10	Lineair	De score kan ook verbeterd worden door be- bouwing aan te merken als 'zettingbestendig'. Dit staat symbool voor een aantal maatregelen aan gebouwen en gebied om de schade door zetting te beperken, bijvoorbeeld wegen op piepschuim of drijvende woningen. In veel gevallen brengt dit extra investeringskosten, maar lagere beheerskosten met zich mee.
	Alle gebieds-typen	Woningen/ utiliteitsbouw zijn gebouwd in gebied met zettinggevoelig-heidsklasse 6	Woningen/ utiliteitsbouw zijn gebouwd in gebied met zettinggevoelig-heidsklasse 9		

12. GROEN IN DE WIJK

De hoeveelheid en kwalitatieve inrichting van het open water in de wijk tbv waterberging, ecologie en leefbaarheid.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Percentage groen en kwaliteit.	Gebiedstype	Score 6	Score 10	Lineair	
	Centrum stedelijk Kantoren en publieks-intensieve voorzieningen	10% groen waarvan ca. 10% met extra kwaliteit.	15% groen waarvan ca. 20% met extra kwaliteit.		
	Buiten centrum Bedrijven	15% groen waarvan ca. 10% met extra kwaliteit.	22,5% groen waarvan ca. 20% met extra kwaliteit.		
	Groen stedelijk Centrum dorps	20% groen waarvan ca. 10% met extra kwaliteit.	30% groen waarvan ca. 20% met extra kwaliteit.		
	Landelijk gebied: stedelijk uitloopgebied Landelijk gebied: agrarisch	60% groen waarvan ca. 10% met extra kwaliteit.	90% groen waarvan ca. 20% met extra kwaliteit.		
	Industrie	10% groen waarvan ca. 0% met extra kwaliteit.	15% groen waarvan ca. 10% met extra kwaliteit.		

13. GELUIDBELASTING WEGVERKEER, SPOORWEGVERKEER EN LUCHTVAART

Geluidbelasting op woningen als gevolg van wegverkeer, spoorwegverkeer en luchtvaart en (waar relevant) het belaste oppervlak.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Aantal woningen per geluidscontour van: 18a. wegverkeer (dB Lden) 18b. spoorwegverkeer (dB Lden) 18c. luchtvaart (dB Lden) Belasting per oppervlak (waar relevant)	Gebiedstype	Score 6	Score 10	1/x, met oplopende weegwaarden per dB categorie	18a, 18b, 18c en 18d worden los berekend. De score van de relevante geluidsbronnen wordt weergegeven. Bij wegverkeerslawaai gaat het om de cumulatieve weergave van de geluidbijdrage van de verschillende verkeerswegen. Bij de rekenresultaten moet aangegeven worden of de geluidbijdrage in- of exclusief correctie ex art. 110 Wgh is. Voor de gebiedstypen 'Industrie' en 'Natuur' betreft het de gecumuleerde geluid-bijdrage. De genoemde geluid-ambities gelden voor het grootste deel van het gebied. Met name aan de randen van gebiedstypen zullen zeker overgangszones bestaan vanwege de aanwezigheid van drukke verkeerswegen langs de gebiedtypen.
	Centrum stedelijk	40% 58 < Lden < 63 60% Lden < 58	100% woningen < 48 dB Lden		
	Buiten centrum	20% 58 < Lden < 63 80% Lden < 58	100% woningen < 48 dB Lden		
	Groen stedelijk	20% 48 < Lden < 53 80% Lden < 48	100% < 43 dB Lden		
	Centrum dorps	20% 58 < Lden < 63 80% Lden < 58	100% < 48 dB Lden		
	Industrie	90% geluidbelast opp. < 63	50% geluidbelast opp. < 53		
	Bedrijven	50% 58 < Lden < 63 50% Lden < 58	100% < 48 dB Lden		
	Kantoren en publieksintensieve voorzieningen	25% 58 < Lden < 63 75% Lden < 58	100% < 48 dB Lden		
	Landelijk gebied: stedelijk uitloopgebied	20% 48 < Lden < 53 80% Lden < 48 80% geluidbelast opp. < 53	100% < 43 dB Lden 50% geluidbelast opp. < 43		
	Landelijk gebied: agrarisch	20% 48 < Lden < 53 80% Lden < 48 80% geluidbelast opp. < 53	100% < 45 dB Lden 50% geluidbelast opp. < 48		
	Landelijk gebied: verweving	20% 48 < Lden < 53 80% Lden < 48 80% geluidbelast opp. < 53	100% < 43 dB Lden 50% geluidbelast opp. < 48		
	Landelijk gebied: natuur	90% geluidbelast opp. < 47	90% geluidbelast opp. < 40		

14. GELUIDBELASTING INDUSTRIE

Geluidbelasting op woningen als gevolg van industrie en (waar relevant) het belaste oppervlak.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Aantal woningen per geluids-contour van: 18d. industrie (Letm dB(A)). Belasting per oppervlak (waar relevant)	Gebiedstype	Score 6	Score 10		18a, 18b, 18c en 18d worden los berekend. De score van de relevante geluidsbronnen wordt weergegeven.
	Centrum stedelijk	90% van de woningen < 50 Letm dB(A)	100% van de woningen < 45 Letm dB(A)		
	Buiten centrum Centrum dorps	95% van de woningen < 50 Letm dB(A) 5% 50 db(A) < Letm < 55 dB(A)	100% van de woningen < 45 Letm dB(A)		
	Groen stedelijk	90% geluidbelast opp. <63	100% van de woningen < 40 Letm dB(A)		
	Industrie	90% geluidbelast opp. < 63	50% geluidbelast opp. < 53		
	Bedrijven	100% van de woningen < 60 5% van de woningen 50 < dB(A) < 55	100% van de woningen < 50		
	Kantoren en publieksintensieve voorzieningen	100% van de woningen < 50 Letm dB(A)	100% van de woningen < 45 Letm dB(A)		
	Landelijk gebied: stedelijk uitloopgebied	100% van de woningen < 50 Letm dB(A)	100% van de woningen < 40 Letm dB(A)		
	Landelijk gebied: agrarisch	100% van de woningen < 50 Letm dB(A)	100% van de woningen < 45 Letm dB(A)		

15. A. LUCHTKWALITEIT – NO2

Luchtkwaliteit (NO2) ter plaatse van woningen en (waar relevant) het belaste oppervlak.

INDICA-TOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Aantal woningen per NO2-contour. 100% van de woning-en < 50 Letm dB(A) Belasting per oppervlak (waar relevant)	Gebiedstype	Score 6	Score 10	1/x, met oplopende weegwaarden per concentratie-categorie.	In de MKP wordt gekeken ter plaatse van woningen om het stedenbouwkundig ontwerp te kunnen optimaliseren op de luchtkwaliteit voor bewoners. De Wet luchtkwaliteit zegt dat overal in het plangebied voldaan moet worden aan de wettelijke normen. De MKP zijn dus niet afdoende om te controleren of aan de wetgeving wordt voldaan. De genoemde luchtkwaliteitsambities gelden voor het grootste deel van het gebied. Met name aan de randen van gebiedstypen zullen zeker overgangszones bestaan vanwege de aanwezigheid van drukke verkeerswegen langs de gebiedtypen.
	Centrum stedelijk	100% woningen < 40 µg/m3	100% woningen < 30 µg/m3		
	Buiten centrum	100% woningen < 40 µg/m3	100% woningen < 30 µg/m3		
	Centrum dorps	100% woningen < 36 µg/m3	100% woningen < 25 µg/m3		
	Groen stedelijk	100% woningen < 36 µg/m3	100% woningen < 25 µg/m3		
	Industrie	100% oppervlak < 40 µg/m3	100% oppervlak < 35 µg/m3		
	Bedrijven	100% woningen < 40 µg/m3 100% oppervlak < 40 µg/m3	100% woningen < 30 µg/m3 100% oppervlak < 33 µg/m3		
	Kantoren en publieksintensieve voorzieningen	100% woningen < 40 µg/m3 100% oppervlak < 40 µg/m3	100% woningen < 30 µg/m3 100% oppervlak < 30 µg/m3		
	Landelijk gebied: stedelijk uitloopgebied	100% woningen < 35 µg/m3 100% oppervlak < 33 µg/m3	100% woningen < 25 µg/m3 100% oppervlak = achtergrondwaarde		
	Landelijk gebied: agrarisch	100% woningen < 40 µg/m3 100% oppervlak < 40 µg/m3	100% woningen < 30 µg/m3 100% oppervlak < 30 µg/m3		
	Landelijk gebied: verweving	100% woningen < 36 µg/m3 100% oppervlak < 33 µg/m3	100% woningen < 25 µg/m3 100% oppervlak = achtergrondwaarde		
	Landelijk gebied: natuur	90% oppervlak = achtergrondwaarde	100% oppervlak = achtergrondwaarde		

15. B. LUCHTKWALITEIT – PM10
Luchtkwaliteit (PM10) ter plaatse van woningen.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Aantal woningen per PM10-contour	Gebiedstype	Score 6	Score 10	1/x, met oplopende weegwaarden per concentratie categorie.	Een jaargemiddelde concentratie van 31,9 µg/m3 komt statistisch gezien overeen met de daggemiddelde grenswaarde voor PM10 (de strengste norm). Dit is daarom gehanteerd als minimale kwaliteit (score 6) De genoemde luchtkwaliteitsambities gelden voor het grootste deel van het gebied. Met name aan de randen van gebiedstypen zullen zeker overgangszones bestaan vanwege de aanwezigheid van drukke verkeers-wegen langs de gebiedtypen.
	Centrum stedelijk	100% woningen < 31,9 µg/m3	100% woningen < 30 µg/m3		
	Buiten centrum	100% woningen < 31,9 µg/m3	100% woningen < 30 µg/m3		
	Centrum dorps	100% woningen < 31,9 µg/m3	100% woningen < 25 µg/m3		
	Groen stedelijk	100% woningen < 31,9 µg/m3	100% woningen < 25 µg/m3		
	Industrie	100% woningen < 31,9 µg/m3	100% woningen < 30 µg/m3		
	Bedrijven	100% woningen < 31,9 µg/m3	100% woningen < 30 µg/m3		
	Kantoren en publieksintensie-ve voorzieningen	100% woningen < 31,9 µg/m3	100% woningen < 30 µg/m3		
	Landelijk gebied: stedelijk uitloopgebied	100% woningen < 31,9 µg/m3 100% oppervlak < 31,9 µg/m3	100% woningen < 25 µg/m3 100% oppervlak = achtergrondwaarde		
	Landelijk gebied: agrarisch	100% woningen < 31,9 µg/m3 100% oppervlak < 31,9 µg/m3	100% woningen < 30 µg/m3 100% oppervlak < 30 µg/m3		
	Landelijk gebied: verweving	100% woningen < 31,9 µg/m3 100% oppervlak < 31,9 µg/m3	100% woningen < 25 µg/m3 100% oppervlak = achtergrondwaarde		
	Landelijk gebied: natuur	90% oppervlak = achtergrond-waarde	100% oppervlak = achtergrondwaarde		

16. EXTERNE VEILIGHEID – PLAATSGEBONDEN RISICO
Het aantal woningen en (zeer) kwetsbare functies in plaatsgebonden risicocontouren.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Het aantal woningen en (zeer) kwetsbare functies in plaatsgebonden risicocontouren.		Score 6	Score 10	1/x, met oplopende weegwaarden per risicocategorie.	Kwetsbare functies: Woningen, kantoren, winkels Beperkt kwetsbare functies: Sporthallen, zwembaden en speeltuinen, bedrijfswoningen, bedrijfsgebouwen, kampeerterrein Zeer kwetsbare functies: Kinderdagverblijven, ziekenhuis scholen, verpleeg- en verzorgingshuis, gevangenis, asielzoekers-centra (dit is een versimpelde versie. Omdat voo de tafel een onderscheid in kleine en grote kantoren te ver voert, zijn deze gerekend als kwetsbare functie.)
	Alle gebieds-typen	Geen kwetsbare functies binnen 10-6 contour	Geen kwetsbare functies in 10-8 contour of invloedsgebied		
		Geen beperkt kwetsbare functies binnen 10-5 contour	Geen beperkt kwetsbare functies in 10-8 contour of invloedsgebied		
		Geen zeer kwetsbare functies binnen 10-7 contour	Geen zeer kwetsbare functies in 10-8 contour of invloedsgebied		

17. EXTERNE VEILIGHEID – GROEPSRISICO
Deel van het gebied boven de oriëntatiewaarde van het groepsrisico.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Hoogte groepsrisico		Score 6	Score 10	1/x, met oplopende weegwaarden per risicocategorie; Gemiddelde naar aantal ha.	
	Alle gebieds - typen	Oriëntatiewaarde groepsrisico	< 0,1* OW		

18. GEURHINDER

Het aantal woningen binnen geurcontouren van landbouw en industrie.

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Aantal woningen in geurcontouren		Score 6	Score 10	1/x, met oplopende weeg-waarden per hinder-categorie	
	Alle ge-bieds-typen	100% van woningen 0,5 - 1 ge/m3 of: 5% woningen tussen 1 - 3 ge/m3 en 95% < 0,5 ge/m3	100% van woningen ge/m3 (< 0,5 ge/m3		

19. LICHTHINDER

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Hemelhelderheid. De achterliggende grootheid is hemelhelderheid met eenheid mcd/m2, 'communicatie-grootheid' is aantal zichtbare sterren.	Gebiedstype	Score 6	Score 10	1/x, met oplopende weegwaarden per categorie	Omrekening: > 890 sterren <=> 510-890 sterren <=> 270-510 sterren <=> 140-270 sterren <=> < 140 sterren <=> < 1 mcd/m2 1-2 mcd/m2 2-4 mcd/m2 4-8 mcd/m2 > 8 mcd/m2
	Centrum stedelijk	< 140 sterren	140-270 sterren		
	Buiten centrum	140-270	270-510		
	Centrum dorps	140-270	510-890		
	Groen stedelijk	270-510	510-890		
	Industrie	140-270	270-510		
	Bedrijven	140-270	270-510		
	Kantoren en publieksintensieve voorzieningen	< 140	270-510		
	Landelijk gebied: stedelijk uitloop-gebied & agrarisch	270-510	> 890		

20. BEREIKBAARHEID OPENBAAR VERVOER

Het aanbod van trein, bus en HOV voor bewoners van de wijk; het aantal woningen/bedrijven nabij haltes

INDICATOR	SCORE PER GEBIEDSTYPE			SOORT FORMULE	TOELICHTING & BRONNEN
Aantal woningen binnen 400 m van OV halte (bus, tram) of HOV halte (metro, sneltram); Afstand tot het station.	Gebiedstype	Score 6	Score 10	1/x, met oplo-pende weeg-waarden per concen-tratie-catego-rie.	Er zijn meerdere combinaties mogelijk om de scores 6 en 10 te bereiken. (ontbreken trein com-penseren met extra bussen of HOV, etc.)
	Centrum stedelijk Kantoren en publieksintensieve voorzieningen	Intercitystation op 1 km, elke woning binnen 400 m van 2 haltes.	Intercitystation in de wijk, elke woning binnen 400 m van 1 bus- en 1 HOV-halte.		
	Buiten centrum	Stoptrein station op 2 km, intercity station op 4 km, elke woning ligt binnen 400 m van bushalte; 50% binnen 400 m van 2 haltes.	Stoptrein station in de wijk, intercity station op 4 km, elke woning ligt binnen 400 m van 2 bushaltes.		
	Centrum dorps	Elke woning < 400 m van halte.	Stoptrein op 1,5 km en elke woning < 400 m van halte.		
	Groen stedelijk	Stoptrein station op 2 km en elke woning ligt binnen 400 m van bushalte.	Stoptrein station op 1 km en elke woning ligt binnen 400 m van HOV-halte.		
	Industrie, Bedrijven	Stoptreinstation op 1 km elk bedrijf < 400 m van bushalte.	Stoptreinstation op het terrain en elk bedrijf <400m van bushalte		
	Landelijk gebied: stedelijk uitloop-gebied & agrarisch	50% woningen < 400 m van halte.	100% woningen < 400 m van halte.		

APPENDIX I (I) INDICATOREN URBAN STRATEGY

Aspect	Medium	Indicator
Geluid verkeer/ industrie/spoor / tram	Kaart	Geluidscontour Lden
		Gezondheidseffectscreening contour (GES)
	Grafiek	# blootgestelde boven 48dB per gebied
		# gehinderde per gebied
Luchtkwaliteit	Kaart	Luchtcontour NO2, PM10, PM2,5
		Gezondheidseffectscreening contour (GES)
		Overschrijdingen grenswaarde NO2, PM10, PM2,5
		Stikstofdepositiecontour
	Grafiek	Weglengte overschrijdingen per gebied
		Oppervlakte overschrijdingen per gebied
		# blootgestelde boven grenswaarde per gebied
Verkeer	Kaart	Intensiteiten per wegvak
		Intensiteit - capaciteit verhouding per wegvak
Bereikbaarheid (Bewegen)	Kaart	Bereikbaarheid van objecten naar objecten inclusief weerstand
	Grafiek	Meerdere manieren qua weergave afh. Object
Groen	Kaart	Hoeveelheid groen in straal van ..m
		Hoeveelheid groen in straal van .. m per gebied
Bezonning	Kaart	Hoeveelheid zonuren per gebouw
	Grafiek	Hoeveelheid zonuren per gebied
Hitte	Kaart	DeltaT per gebied
	Grafiek	% verschillend type landgebruik
		Sky view factor per gebied
		Sun hours per gebied
		DeltaT per gebied
CO2	Kaart	CO2 eq wegen
	Grafiek	CO2 eq wegen per gebied
Energie	3D	EPC
	Kaart/Grafiek	potentieel PV
	Grafiek	Elektriciteit per wijk/district
		Warmte per wijk/district
Externe Veiligheid	3D	Individueel risicocontour
	Grafiek	Groepsrisico
Kosten	Grafiek	Totaal investeringen, individuele investeringskosten

APPENDIX I (II) INTERACTIELIJST URBAN STRATEGY

Module	Handeling	Detail
Verkeer	Wegen	Weg verwijderen
		Weg aanleggen
		Weg verleggen
	Attributen van wegen aanpassen	Snelheid
		Capaciteit / # banen
		Afsluiten beide richtingen
		Afsluiten een richting
	Gebouwen	Gebouw verwijderen
		Gebouw aanleggen
		Gebouw verplaatsen
	Attributen gebouwen aanpassen	Gebouwfunctie veranderen
		Aantal aanwezigen
Geluid verkeer	Wegen	Intensiteit
		Wegdekcode
		Hoogte
		Verwijderen
		Bijplaatsen / Intekenen
	Attributen van wegen aanpassen	Percentage licht - middel - zwaar aanpassen (milieuzone)
		Snelheid
	Gebouwen	Gebouw verwijderen
		Gebouw aanleggen
		Gebouw verplaatsen
	Attributen gebouwen aanpassen	Hoogte
		Vorm
	Geluidsschermen	Verwijderen
		Bijplaatsen / Intekenen
	Attributen van schermen wijzigen	Hoogte
		Slope
		Materiaal
		Top width
Geluid industrie	Industriebronnen	Aan / uit
	Attributen bronnen aanpassen	Intensiteit
		Reducties (groep of individueel)
	Gebouwen	Gebouw verwijderen
		Gebouw aanleggen
		Gebouw verplaatsen
	Attributen gebouwen aanpassen	Hoogte
		Vorm
	Geluidschermen	Verwijderen
		Bijplaatsen / Intekenen
	Attributen van schermen aanpassen	Hoogte
		Slope
		Materiaal
		Top width
Geluid Tram	Spoorweg attribuut	Status aan/uit
		Spoor verleggen
Geluid Rail	Spoorweg attribuut	Status aan/uit
		Spoor verleggen
Lucht	Weg attributen aanpassen	Status Aan / Uit
		Intensiteit
		Wegdekcode
		Hoogte

		Verwijderen
		Bijplaatsen / Intekenen
	Geluidsschermen aanpassen	Verwijderen
		Bijplaatsen / Intekenen
	Attributen van schermen wijzigen	Hoogte
		Slope
		Materiaal
		Top width
	Bronnen stikstofdepositie wijzigen	Factor
Externe veiligheid Stationair	Ongeluk scenario's per stat. bron	Aan / Uit
	Gebouwen	Verwijderen
		Bijplaatsen / Intekenen
	Gebouw attributen aanpassen	Wijzigen aantal inwoners
Externe veiligheid Transport	Transport bronnen	Transportroute wijzigen
		Ongeluk scenario's wijzigen
Duurzaamheid (CO2) Verkeer, wegen en gebouwen	Wegen	Intensiteit
	Gebouwen	Bouwjaar
Leefbaarheid groen Hoeveelheid groen per gebouw	Land use attributen veranderen	Grondgebruik aanpassen
Leefbaarheid sun/sky Aantal zonne-uren per gebouw	Gebouwen veranderen	Bijplaatsen
		Weghalen
		Editen
	Gebouw attributen aanpassen	Hoogte veranderen
Beweegmodule	Speelobjecten	Toevoegen objecten
		Weghalen objecten
	Speelobjecten attributen aanpassen	Type veranderen
	Gebouw attributen aanpassen	# kinderen categorie A
		# kinderen categorie B
		# kinderen categorie C
	Land use attributen veranderen	Grondgebruik aanpassen
	Weg attribuut aanpassen (Weerstand)	Intensiteit
Energy (PV) Potentie zonne-energie	Gebouwen	Gebouw verwijderen
		Gebouw aanleggen
		Gebouw verplaatsen
	Attributen gebouwen aanpassen	Benut dakoppervlak
		Oriëntatie PV
		Soort PV
		Helling
Energy (Consumptie) Geschatte hoeveelheid energie gebruik	Gebouwen	Plaatsen gebouwen
		Verwijderen
	Gebouw attributen aanpassen	Bouwjaar
		Energylabel
		Aantal personen
Kosten Bouwkosten	Gebouwen	Typen
	Geluidschermen	Typen
	Grondgebruik	Typen
	Wegen	Typen
	Wegen Wegdektype	Typen