Planning Support Tools in Urban Adaptation Practice

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Dissertation

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Summary

Planning Support Tools in Urban Adaptation Practice

In the face of a changing climate, many cities are engaged in adaptation planning and are using workshops to involve stakeholders in planning, design and decision making activities. A range of different tools are available to support these collaborative planning workshops. Planning support tools aim to improve the way of working, the quality of the work products and the other outcomes, such as learning. However, their effects and effectiveness in practice remain unclear.

Gaps in planning support tool research

Planning support tool research has so far focused largely on tools' functionality and potential, on questions of usability and usefulness, and on tools adoption (or lack thereof) by planners. Much of this research has relied on the reflections of tool developers and on workshops designed and carried out to test a particular tool. While this earlier research has provided valuable insights into instrumental aspects of tools and their use in workshop settings, rigorous evaluations are hardly made of planning support tool use in real, context-rich planning processes.

The dearth of systematic evaluations of planning support tools in practice has resulted in a knowledge gap comprising four parts. First, there is no definitive guidance on how planning support tools should be evaluated in practice. Second, how planning support tools influence real planning workshops and their direct results is unclear. Third, whether and how planning support tool workshops influence subsequent steps of the planning processes they aim to improve has not yet been measured. Fourth and finally, the influence of contextual factors on planning support tools' use and effectiveness is widely acknowledged, but remains largely unexplored. These knowledge gaps highlight the need for systematic and comprehensive evaluations of planning support tools in practice.

This research aims to enhance understanding of what roles planning support tools play in collaborative planning workshops, what effects they have on the planning processes in which they are used, and how context influences both factors.

Studying planning support tools in practice

While this research is concerned with planning support tools in general, it focuses particularly on a tool called the Adaptation Support Tool (AST). The AST represents a particular category of tools, called Planning Support Systems (PSS), which are spatial tools that aim to integrate analytical and communicative support for collaborative planning.

The AST is a map-based tool used on a touch table. It was developed to support small groups in exploring and designing spatial adaptation plans for their urban environment, in the conceptual phase of planning. Using the AST, groups can select adaptation measures from the tool's library and implement them in a digital map of the project area. The AST ranks the measures according to basic input conditions for the area and adaptation targets, such as pluvial flooding and heat reduction. Once measures are implemented in the map, the AST provides real-time feedback on their cost and effectiveness. The performance indicators show a percentage of each adaptation target achieved and detailed information is provided on the contribution of each measure. The tool's main objective is to support and inform group discussions about where and how to adapt in a local context. The AST has been used in the Netherlands, England, Mozambique, the United States, Mexico, Germany, and Ecuador, among others.

The research carried out in this study is interdisciplinary in nature. Starting from a policy analysis lens, it draws from the fields of participatory and collaborative planning, adaptation and resilience planning, and planning support tool and PSS research. Together, these fields informed the assumed views on planning workshops and processes, and how they should be evaluated. A second characteristic of this research is its practice orientation, a natural result of the study's objective. As such, the research approach employed empirical methods to observe and analyse tools in use in adaptation planning practice. The research involved four consecutive steps:

1. A literature review was made of collaborative planning, urban adaptation planning, and planning support tools, including their use and current evaluation practices. Along with multi-actor policy analysis theory, this review provided the theoretical basis of the evaluation framework that was used in the remainder of the project.
2. Two semi-controlled experiments using repeated simulated workshops were carried out to compare three different planning support tools (one being the AST) and a tool-free approach. These evaluations focused on how different tools affect the working process and direct results of collaborative planning workshops. In

total, three to four simulated workshops were carried out for each tool, involving 98 participants in total.

3. A longitudinal case study was made of the AST. This case study, based in Berlin, Germany, was used to evaluate how the tool influenced not only a real planning workshop, but also its effects on the planning process and outcomes. The case study lasted 18 months.
4. A second case study was made using the AST in a new context, in Guayaquil, Ecuador. This case study explored how contextual factors relating to the workshop itself, the planning process in which it took place, and the project setting, influenced the use and added value of the tool. This study was carried out over one year.

The consecutive nature of the research approach allowed each step to build upon the lessons learned in earlier ones.

Results

The evaluation framework developed in this research is characterized by two features. First, the framework's nested structure reflects tool use within a workshop, carried out in a planning process, which occurs within a larger context. This structure allows tools to be evaluated in practice. Second, the framework is broad and flexible in nature. This makes the framework widely applicable and capable of producing comprehensive and comparable results for different tools in different settings. The framework was operationalized and applied in the simulated and case study workshops.

The simulated and case study workshops indicate that planning support tools influence how a workshop plays out and its direct results. In the simulated workshops, different tools were found to result in consistent differences in learning, in the development of shared understanding within groups, in the types of plans that were produced, and in the group's way of working. Moreover, workshops and their results appear to reflect characteristics of the tool that is used. For instance, groups using the AST produced more technical plans that focused at the spatial scale shown in the map interface, compared to groups using tools without a map. While only the AST was evaluated in the case study workshops, these results appear to support the finding that a tool and its particular characteristics influence how a workshop plays out and its direct results.

This research focused particularly on workshops in the conceptual phase of design. Planning support tools used in this phase were found to be unlikely to have concrete and directly causal effects on the remainder of the planning process. Instead, the

effects of tool use were characterized by their contributory, indirect and less tangible nature. Furthermore, the effects of tool use on the remainder of the planning process were influenced by context, exhibited emergent behaviour, and seemed more likely to result from 'soft' outcomes like learning, than from work products, like plans. Not only were 'soft' outcomes more effectual, they were also more valued by participants. When identifying the added value of tool use, workshop participants consistently named learning, collaboration and communication, as more important than the plans that were produced.

While the results of the simulated and case study workshops showed that planning support tools do affect the workshops in which they are used, the results also showed that contextual factors influence, or even determine, a tool's use and value in the workshop, and whether or how the planning process and outcomes are impacted. In the case of Guayaquil, the way the tool was used and the local project setting proved the most important contextual factors in determining the use and added value of the AST in the workshop. In both Berlin and Guayaquil, contextual factors relating to the planning process and the local setting were most important for achieving impacts on the overall project and planning outcomes.

This work contributes to the fields of planning support tool and adaptation planning research and practice. First, this research offers a framework for evaluating planning support tools in use. Additionally, it offers insights into the effects of planning support tools in workshops by comparing different tools in simulated workshops and by evaluating one tool in two in-depth case studies. Furthermore, this research offers a longitudinal study of a tool's effects over the duration of a planning process, as well as a dedicated study of the role of context in a tool's use and added value, both novel contributions to planning support tool research. Finally, this research introduces a policy analysis framing to evaluating planning support tools, by conceptualizing tool use within workshops, planning processes and context. This perspective provided a structure in which to place current knowledge of tools while exploring bigger picture questions about their effects and effectiveness in real world planning and decision making.

This research's practice-orientation is meant to inform both practice and theory. As such, it aims to inform three main audiences: tool researchers, tool developers and tool practitioners (e.g. the facilitators and organizers of tool-based planning workshops). For the field of urban adaptation planning, this research is especially timely in offering insights for cities facing the challenge of how to involve stakeholders in an effective

manner. The findings of this research shed light on the role planning support tools can play in urban adaptation practice.

Samenvatting

Planning Support Tools in Stedelijke Adaptatieprocessen

Veel steden gebruiken workshops om deskundigen en belanghebbenden te betrekken bij het opstellen van klimaatadaptatieplannen. En een keur aan tools is beschikbaar om deze werkwijze te ondersteunen. Deze zogeheten Planning Support Tools zijn bedoeld om de kwaliteit van de plannen te vergroten en het planproces te structureren. Desondanks blijven de effecten van deze tools en hun effectiviteit in de praktijk onduidelijk.

Kennislacunes

Het onderzoek naar deze planning support tools heeft zich tot nu toe voornamelijk gericht op de functionaliteit en de bruikbaarheid van de tools, alsmede op het (beperkte) gebruik van de tools door stedenbouwers en andere planners. Dit onderzoek had voornamelijk tot doel om bepaalde tools te testen. Het geeft de reflecties weer van de toolontwikkelaars zelf op de werking van hun producten. Dit onderzoek heeft waardevolle inzichten geleverd over de instrumentele aspecten van de tools en hun gebruik tijdens workshops. Het ontbreekt echter aan diepgaande evaluaties over het gebruik van planning support tools in de praktijk, in contextrijke planprocessen.

Dit gebrek aan diepgaande, systematische evaluaties leidt tot een viertal belangrijke kennislacunes. Ten eerste ontbreekt het aan een algemeen geaccepteerde methode om de effecten van planning support tools in de praktijk te evalueren. Ten tweede is het onduidelijk hoe planning support tools de planningsworkshops zelf en de uitkomsten ervan beïnvloeden. Ten derde is nog niet gemeten of, en zo ja hoe, zulke workshops het vervolg van het planproces beïnvloeden. En ten slotte is de – weliswaar breed erkende - invloed van de context op de effectiviteit van planning support tools nog goeddeels onbekend. Deze vier kennislacunes vormen de aanleiding tot een systematische en inhoudelijke evaluatie van het gebruik van planning support tools in ruimtelijke planprocessen.

Het doel van deze studie is te onderzoeken welke effecten planning support tools hebben op de werkwijze en de uitkomsten van planningsworkshops, welk effect deze tools hebben op het planproces als geheel, en hoe de context van invloed is op hun effectiviteit.

Onderzoek van planning support tools in de praktijk

Hoewel dit onderzoek gaat over planning support tools in het algemeen richt het zich met name op het gebruik van de Adaptation Support Tool (AST). De AST is kenmerkend voor een specifieke categorie Planning Support Systemen (PSS). Dit zijn systemen die tot doel hebben om de dialoog over het plan te ondersteunen met ruimtelijke en analytische informatie.

De AST is een tool die werkt met kaart-informatie op een touch table. De AST is ontwikkeld om betrokkenen te ondersteunen in het verkennen en ontwerpen van ruimtelijke adaptatieplannen voor een stedelijke omgeving, in de conceptuele fase van het planproces. Met behulp van de AST kunnen de deelnemers adaptatiemaatregelen selecteren uit de bibliotheek van maatregelen, om ze vervolgens toe te passen op een digitaal beeld van het plangebied. De AST rangschikt de maatregelen op basis van de eigenschappen van het gebied en de adaptatieopgaven, zoals wateroverlast en hittereductie. De AST levert dan real-time feedback over de te verwachten kosten en effectiviteit van de maatregelen. De effectiviteit van de maatregelen wordt vervolgens weergegeven als percentage van de adaptatieopgaven. De tool is bedoeld om de dialoog tussen de deelnemers te ondersteunen, ze te informeren over welke maatregelen waar in het plangebied toegepast kunnen worden en hoe effectief dit zal zijn in de plaatselijke context. De AST is onder andere gebruikt in Nederland, Engeland, Mozambique, de Verenigde Staten, Mexico, Duitsland en Ecuador.

Het onderzoek is interdisciplinair van aard. Vanuit een beleidsanalytisch perspectief wordt kennis samengebracht over participatieve planning, klimaatadaptatie en ruimtelijke planvorming, planning support tools en planning support systemen.

Al deze onderzoeksterreinen bieden eigen, kenmerkende perspectieven op de uitvoeren en de evaluatie van planprocessen en planningsworkshops. Een tweede kenmerk van dit onderzoek is de praktijkgerichte benadering - een logisch gevolg van de onderzoeksdoelstelling. De aanpak van het onderzoek maakt daarom gebruik van empirische methoden om de toepassing en de effectiviteit van de tools in planningsworkshops te observeren en te analyseren. Het onderzoek omvat vier opeenvolgende onderdelen:

1. Een literatuurstudie over beleidsanalyse, participatieve planning, klimaatadaptatie, ruimtelijke planvorming, en planning support tools. Het onderdeel over de tools is vooral gericht op de evaluatie van hun invloed op de werkwijze en de uitkomsten van het gebruik in de praktijk. Daarnaast levert deze studie vanuit een

beleidsanalytisch kader de theoretische basis voor de evaluatiemethode die in de volgend onderdelen van het onderzoek gebruikt wordt.

2. Twee semi-gecontroleerde experimenten om drie verschillende planning support tools (waarvan één de AST) en een toolvrije aanpak te vergelijken. Daartoe zijn gesimuleerde workshops uitgevoerd; dit zijn workshops waarin het werkelijke planproces wordt nagebootst door de inzet van multidisciplinaire teams van deskundige studenten. Deze vergelijking was gericht op de manier waarop verschillende tools de werkprocessen en uitkomsten van participatieve planningsworkshops beïnvloeden. In totaal zijn vier gesimuleerde workshops uitgevoerd voor elke tool, met 98 deelnemers in totaal.
3. Een longitudinale casestudie naar de effecten van de inzet van de AST. Deze studie vond plaats in Berlijn, Duitsland, en is gebruikt om te evalueren hoe de tool niet alleen een daadwerkelijke planningsworkshop beïnvloedt, maar ook de resultaten na 18 maanden.
4. Een tweede casestudie is uitgevoerd om te onderzoeken hoe de context van de workshop van invloed is op de toegevoegde waarde van de tool. Daartoe is de AST toegepast in een andere omgeving: Guayaquil, Ecuador. Onderzocht is hoe factoren als de uitvoering van de workshop, het planningsproces waar de workshop deel van uitmaakt en de achtergrond van het project van invloed zijn op de effectiviteit. Deze studie duurde meer dan een jaar.

De stapsgewijze opbouw van het onderzoek leverde de mogelijkheid om in elk onderdeel voort te bouwen op de lessen van de eerdere stappen.

Resultaten

De evaluatiemethode die is ontwikkeld in dit onderzoek heeft twee specifieke kenmerken. Het eerste is de geneste structuur: tools worden gebruikt binnen een workshop die wordt uitgevoerd als onderdeel van een planningsproces dat zich afspeelt in een bredere context. Deze geneste structuur vormt de basis voor de evaluatie van planning support tools in de praktijk en maakt de methode breed toepasbaar. De geneste structuur van de evaluatiemethode maakt het mogelijk om de effecten van verschillende tools in verschillende toepassingssituaties te vergelijken. De methode is dan ook toegepast in zowel de gesimuleerde als de casestudie workshops.

Het onderzoek van de gesimuleerde en de casestudie workshops geeft aan dat planning support tools zowel van invloed zijn op de werkwijze tijdens de workshop als op de resultaten. In de gesimuleerde workshop zijn verschillende tools gebruikt

door verschillende groepen deelnemers. Dit resulteerde in consistente verschikken in de mate van leren, in de ontwikkeling van begrip binnen deelnemersgroepen, in het type plannen dat werd gemaakt, en in de manier van werken. De workshops en de uitkomsten lijken dus afhankelijk te zijn van de gebruikte tool. Zo maakten groepen die de AST gebruikten bijvoorbeeld technisch gedetailleerdere plannen dan groepen die tools gebruikten zonder landkaart. En hoewel enkel de AST werd geëvalueerd in de casestudie workshops, lijken ook die resultaten te bevestigen dat specifieke eigenschappen van een planning support tool van invloed zijn op de manier van werken tijdens de workshop en op de resultaten.

Dit onderzoek is gericht op workshops in de conceptuele fase van het planproces. Planning support tools die in deze fase worden gebruikt hebben waarschijnlijk geen concrete, causale effecten op de keuzes die worden gemaakt tijdens het verdere verloop van het planproces. In plaats daarvan zagen we medebepalende, indirecte en niet-tastbare effecten van de tool. Bovendien worden die effecten beïnvloed door de context van het planproces. Ook vertoont het verloop van het planproces emergent gedrag. De invloed van de tool op het verdere proces lijkt eerder het gevolg van 'softe' directe effecten zoals leren en de dialoog tussen de betrokkenen, dan van de producten die tijdens de workshops werden gemaakt, zoals de plannen. Niet alleen waren de 'softe' resultaten doeltreffender, ze werden ook meer gewaardeerd door deelnemers. Wanneer deelnemers werden gevraagd de toegevoegde waarde van het gebruik van tools te benoemen, werden leren, samenwerking en communicatie meestal als belangrijker gewaardeerd dan de gemaakte plannen.

De resultaten van de gesimuleerde en casestudie workshops laten ook zien dat omgevingsfactoren het gebruik van een tool in de workshop en de waarde ervan beïnvloeden, en soms zelfs bepalen, net als dat omgevingsfactoren invloed hebben op het planningsproces en de resultaten. In de casus Guayaquil bleken de manier waarop de tool werd gebruikt en de lokale projectomgeving de twee belangrijkste omgevingsfactoren voor de toegevoegde waarde van de AST in de workshop zelf. En zowel in Berlijn als in Guayaquil bleken de plek van de workshop in het planproces en de lokale setting van de workshop de belangrijkste factoren voor de invloed op het project als geheel.

Deze studie draagt bij aan de onderzoeksgebieden rond planning support tools en klimaatadaptatieplanning. Ten eerste levert deze studie een beleidsanalytisch kader en – daaruit afgeleid – een methode om toepassingen van planning support tools te evalueren. De evaluatie wordt opgebouwd vanuit een geneste structuur, door het

gebruik van tools in workshops, planning processen en context te conceptualiseren. Dit perspectief biedt een structuur waarin huidige kennis over tools geplaatst kan worden, terwijl het onderzoek over hun effecten op en effectiviteit in planvorming en besluitvorming in de praktijk verkend kunnen worden. Het onderzoek verschaft inzicht in de effecten van verschillende planning support tools in workshop door deze tools in gesimuleerde workshops te vergelijken, en door één van die tool in twee case studies diepgaand te evalueren. Het onderzoek omvat zowel een longitudinale studie naar de effecten van die tool op het verdere planproces, als een studie die gericht is op de invloed van context (omgevingsfactoren) op het gebruik en de toegevoegde waarde van de tool. Beide onderdelen leverden verrassende bijdragen aan planning support tool onderzoek.

De uitkomsten van dit onderzoek zijn van groot belang voor zowel de praktijk als voor de onderzoekers, zeker nu planning support tools worden ingezet bij het opstellen van klimaatadaptatieplannen. Drie specifieke doelgroepen kunnen de resultaten goed gebruiken, te weten toolontwikkelaars, toolonderzoekers en mensen die beroepshalve de tool gebruiken, zoals organisatoren en faciliteren van planningsworkshops. Aan hen allen biedt dit onderzoek antwoord op de vraag hoe ze de relevante deskundigen en belanghebbenden op een effectieve manier kunnen betrekken bij het planproces door de inzet van planning support tools.

1

Introduction

Cities increasingly face the need to adapt existing urban spaces. A changing climate, rising populations, shifting societal needs and technological innovations require cities to adapt to new conditions (Anguelovski et al., 2014; Da Silva et al., 2012). Such adaptation requires urban planning, an inherently complex, social and dynamic process (Innes and Booher, 1999; Taylor, 1998). The multi-stakeholder and multi-disciplinary character of urban planning means that there are no optimal solutions, only negotiated choices (Kunze et al., 2012; Taylor, 1998). In this context, stakeholder involvement is considered important for the quality of planning processes and outcomes (Anguelovski et al., 2014; Kunze et al., 2012). A great challenge in realizing these planning processes is balancing stakeholder values, knowledge and perspectives with objective facts and information, so that plans are technically viable and socially acceptable.

This dissertation focuses on tools that are used to support stakeholder involvement in planning. More specifically, this research is concerned with the use and effects of planning support tools employed in collaborative planning workshops for climate change adaptation, in the early, conceptual phase of design. The remainder of this chapter elaborates what this means and why it is important to study.

1.1 Background

Climate change is an important driver for urban adaptation. Not only do the high concentration of people and capital in cities increase the climate-related risks from conditions like intense rainfall, heat waves, rising sea levels and storms, but the very structure of cities often exacerbate the impacts (Da Silva et al., 2012; Tyler and Moench, 2012). For instance, the high proportion of paved surfaces in urban areas contributes to the urban heat island effect and concentrates rainfall runoff in streets and storm drains, raising the risk of both heat stress and pluvial flooding. Moreover, the deep uncertainty around local effects of climate change requires cities to not only adapt, but to become adaptive to unpredictable future conditions (Tyler and Moench, 2012; Wardekker et al., 2010). Adaptation planning offers cities the challenge and opportunity to reduce climate-related vulnerabilities, as well as to provide attractive, liveable environments for citizens and businesses.

Like any other urban planning process, adaptation planning ideally follows a series of steps or phases, starting with initiation, through conceptual planning, preliminary and detailed designs, and ending with a decision to implement (van de Ven et al., 2016). Planning processes are, of course, not as linear or well defined as the simplified

schematic in Figure 1 implies. In reality, planning is messy, involving parallel activities, dead ends, and iterations. The conceptual planning phase, the focus of this research, is concerned with the exploration of solutions. This is a divergent phase of planning, in which creativity and a diversity of perspectives and values enrich the solution space and dialogue. The results of conceptual planning are meant to provide input to more detailed analysis and design phases, but may also be used to revise and refine the criteria and aims defined during initiation.

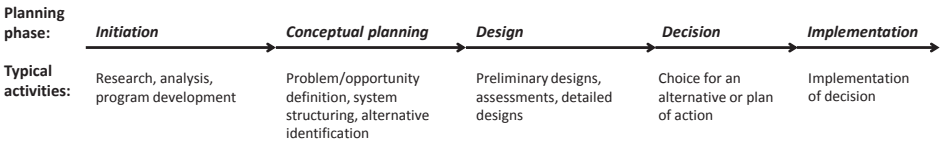

Figure 1. Schematic representation of planning phases and typical activities in each phase (Modified from van de Ven et al., 2016)

Urban planning is innately social. It is "a form of *social action*, or a *social practice*. It is about intervening in the world to protect or change it in some way – to make it other than it would otherwise be" (Taylor, 1998, p. 164). The added complexity of adapting existing spaces means that planning urban adaptation involves many stakeholders, with their own knowledge, priorities and values. Involving stakeholders in planning is generally meant to provide substantive benefits, like better informed decisions, procedural advantages, like increased legitimacy, and to reflect social values like inclusiveness and equity (Chu et al., 2016; Shi et al., 2016; Wesselink et al., 2011). In adaptation planning specifically, learning is also an important reason for engaging stakeholders, because learning builds individuals' and institutions' adaptive capacity (Anguelovski et al., 2014; Birkmann et al., 2014; Tyler and Moench, 2012), and it facilitates interdisciplinary communication (Pelzer and Geertman, 2014).

While stakeholder involvement has value in every phase of planning, conceptual design is a particularly timely opportunity, as it combines openness to new ideas and the flexibility to adjust and refine the problem understanding, with the concreteness of design and decision making. For example, an urban greening initiative is a nice proposal that most stakeholders will support, but in conceptual design, the real questions of where to green and what the implications may be for different stakeholders must be faced. This requires communication and negotiation. If done well, stakeholder involvement in the conceptual design leads to higher quality plans and more successful planning processes.

Engaging stakeholders in a meaningful way is not easy. A common approach is through collaborative planning workshops in the conceptual phase of design. In these workshops, stakeholders work together to understand the problem and explore solutions. Such workshops take many forms, but they must all find a way to efficiently and effectively structure a collaborative working process and relevant substantive content. The need to incorporate different types of information and to support interdisciplinary communication between stakeholders with different backgrounds and perspectives is a challenge for workshop organizers and facilitators (Pelzer et al., 2015b). Planning support tools offer a promising solution in their capacity to support the process and content of collaborative planning workshops (Pelzer, 2017).

1.1.1 Planning support tools

In the last two decades, a variety of tools has been developed to support collaborative planning workshops (Geertman et al., 2013; Geurts and Joldersma, 2001; Healey, 2006). These tools vary in form and function, from workbooks that walk users through relevant planning questions, to simulation models that quantify the impact of different scenarios or planning interventions. Regardless of the type of tool, their purpose is to improve a planning workshop's process and results (te Brömmelstroet, 2013). In supporting a workshop process, a tool may aim to encourage communication and collaboration, and to provide substantive content that informs dialogue (Pelzer, 2017; te Brömmelstroet, 2016). In supporting a workshop's results, tools are typically used to create some kind of work product, such as a plan, and less tangible outcomes, like learning (Pelzer and Geertman, 2014; te Brömmelstroet, 2013). The inherent assumption behind planning support tools is that improvements in a workshop's process and outcomes will positively impact subsequent phases of the overall planning process, and ultimately lead to better plans and decisions (Pelzer, 2017). Different tools may be required at different times in a planning process; a tool should be well aligned with a workshop's aims and the phase of planning in which it is used (Geertman, 2006; Pelzer and Geertman, 2014).

This research focuses on one type of planning support tool, called Planning Support Systems (PSS). PSS are defined as "geo-information based tools intended to support planners in planning tasks such as information handling, communication and analysis in planning processes" (Vonk and Geertman, 2008). In practice, these tools are characterized by their use of digital maps, often in horizontal touch tables or projected onto vertical screens, and by their provision of information, such as impact analysis for different plans or interventions. PSS aim to provide communicative and analytical support to collaborative planning activities (Eikelboom and Janssen, 2017; Pelzer,

2017). The communicative support refers to the collaborative nature of planning and the need for knowledge exchange. Analytical support refers to individuals' understanding of the planning problem and of the other stakeholders' perspectives (Pelzer, 2017; Vonk, 2006).

1.1.2 Effectiveness of planning support tools

Evaluating planning support tools

Despite the number and assortment of available planning support tools, evaluations are rare and those carried out reveal a number of shortcomings (Midgley et al., 2013; Rowe, 2004; Rowe and Frewer, 2000). In general, when assessments are made, they take one of two forms. The first are evaluations of tools in laboratory settings, or simulated workshops, the second are evaluations of tools used in a real planning workshop.

Evaluations made in laboratory settings, often relying on student participants, offer the benefits of relatively controlled conditions and the possibility of repeating the simulated workshops. The rigor of these evaluations is useful for testing particular, detailed aspects of a tool. For instance, Arciniegas (2013), studied tool users' abilities to understand and use information presented at different levels of complexity. However, the representativeness of results from laboratory tests is limited by not using real stakeholders facing consequential decisions (Arciniegas et al., 2013; Eikelboom and Janssen, 2017; Pelzer et al., 2016).

In contrast, evaluations of tools in real planning workshops are meant to offer richer and more representative insights. However, these evaluations are typically less systematic and based largely on the reflections of the workshop facilitators or organizers (Innes and Booher, 1999; Midgley et al., 2013). While these assessments can be insightful for a specific tool and application, they are usually not objective nor rigorous enough to offer reliable or comparable results. Furthermore, tools are often evaluated by the developers themselves and in workshops designed for the purpose of testing a particular tool (see for instance Arciniegas and Janssen, 2012; Mayer et al., 2005; Sellberg et al., 2015). These conditions call into question the independence of the evaluations in relation to the application context and evaluator.

In both simulated and real workshops, evaluations focus on instrumental characteristics of the planning support tool and the workshop in which it is used. In doing so, evaluations ignore the context-rich planning processes in which tools are used and

that they aim to influence. The narrow focus of planning support tool evaluations limits the value of their results and ultimately, scientific understanding of the tools' use and effectiveness in practice. More than a decade ago, Geertman (2006) highlighted the importance of context for understanding planning support tools. Since then, many researchers have acknowledged context, without giving it explicit attention. Moreover, by limiting the scope of evaluations to workshops, the results do not capture longer term effects on the planning process and participants (Midgley et al., 2013). This is a curious omission given that the ultimate goal of planning support tools is to effect change in planning processes and outcomes. Understanding context can help in understanding how a tool's ability to support workshops and achieve particular outcomes is influenced by different conditions.

In summary, the focus of current evaluations does not provide a holistic and realistic understanding of planning support tools in use in real collaborative planning workshops. Evaluations are needed that connect the tools to the context and planning processes in which they are used.

Evaluating Planning Support Systems

As a subset of planning support tools, PSS, have been evaluated more thoroughly than the field as a whole. This is likely due to the dedicated sub-field of PSS research (Pelzer et al., 2014). PSS evaluations have made important contributions to understanding how these particular tools support interdisciplinary communication, their perceived added value and their usefulness, among others (Pelzer et al., 2014; Pelzer and Geertman, 2014; Russo et al., 2018a; te Brömmelstroet, 2016). A variety of methods have been used in this field of research, from extensive interviews (e.g. Pelzer et al., 2015b) to experimental studies (e.g. Arciniegas et al., 2013; Eikelboom and Janssen, 2015; McEvoy et al., 2018).

Nevertheless, despite the valuable insights into PSS effectiveness, these evaluations mirror the shortcomings observed in the broader field of planning support tool research. First, PSS evaluations have focused exclusively on tool use in workshops (real or simulated) and have not followed up on the outcomes and their effect on the planning process. Also, PSS evaluations do not account for in-situ contextual factors of workshops, planning processes, or the larger setting in which they are used. Finally, PSS are not often compared to other types of tools, and PSS evaluations are not generic enough to enable this comparison. Addressing these shortcomings will provide much needed insights to PSS practice and theory. These insights would also enrich the broader knowledge of what roles planning support tools play in workshops,

what the tools contribute to workshop results, whether these results influence planning processes, and how contextual factors may influence the role of the tool.

1.1.3 The knowledge gap

Current evaluations of planning support tools, and of PSS more specifically, have so far failed to link tool use in collaborative planning workshops to the larger picture of planning processes. This gap in knowledge has four parts: 1) there is no definitive guidance on how planning support tools should be evaluated in practice, 2) PSS are not compared with other types of planning support tools, 3) longer term effects of PSS on planning processes have not been measured, and 4) the influence of contextual factors on PSS and what they achieve is unknown. This knowledge gap implies that there is a need for more structured and systematic evaluations of planning support tools in real planning processes.

1.2 Research objectives and questions

This research aims to study the roles that planning support tools, and PSS more specifically, play in collaborative planning workshops, in workshop outcomes, and in the planning processes in which they are used. It does so by addressing four research questions:

RQ 1. How should collaborative planning support tools be evaluated?
RQ 2. How do planning support tools influence the workshops in which they are used?
RQ 3. How does a planning support tool used in a workshop influence the overall planning process?
RQ 4. How do contextual factors influence a planning support tool's role in a workshop and the overall planning process?

1.3 Research approach

This research is interdisciplinary in nature. As a starting point, it was informed by multi-actor policy analysis (see Thissen and Walker, 2013). From this lens, collaborative planning workshops are viewed as policy analytic activities (see. Thissen and Twaalfhoven, 2001) embedded within decision making processes. By extension, adaptation more broadly is viewed as a complex, multi-actor problem. However,

this work is also informed by the field of planning, namely the areas of adaptation, resilience and collaborative planning. These areas of planning made specific the aims and challenges of adaptation and resilience planning, and the principles and types of stakeholder engagement in planning activities, which informed the evaluation framework and research approach. In connecting to the broader lens of policy analysis, planning is viewed as a complex social adaptive system that displays emergent behaviour (See Innes and Booher, 1999). Finally, this work is informed by planning support tool research, and PSS, in particular, which contributed specific ideas about tool evaluations, the purpose of planning support tools and how they are used.

In designing the research approach, the most consequential choice was to focus on planning support tools in use. This was inspired by a curiosity about how tools affect real workshops and planning processes, a recognized gap in planning support tool literature. By definition, studying tools in use requires empirical observations and analysis. A second choice in designing the research approach was to employ mixed methods, combining semi-controlled experiments using simulated workshops with in-depth case studies of real planning workshops. Case studies offer rich, detailed data and results, which have arguably been lacking in planning support tool research, and which were necessary for addressing all four research questions. However, these case studies are inherently qualitative and descriptive in nature, due to the low number of participants in collaborative planning workshops and the low number of cases that could be carried out in the time of this doctoral research project. The simulated workshops contributed breadth, by comparing different types of tools. The simulated workshops also served to test the evaluation instruments on a large number of participants, prior to their application in the case studies.

To support more reliable, and therefore meaningful, results, the choice was made to focus on one particular tool, the Adaptation Support Tool (AST). This allowed for comparisons between the tool's performance in different settings. The AST was chosen for two reasons. First, the AST is a PSS, which was a desirable type of tool to evaluate, as they are more thoroughly studied than other planning support tools and therefore offer a foundation of knowledge on which to build. PSS are also particularly interesting, as their combination of communicative and analytical support promises real improvements to traditional planning practice, but they have yet to be widely adopted or evaluated in real workshops (Geertman and Stillwell, 2009; Russo et al., 2018b). Second, the AST was a pragmatic choice, as access to the tool and cases was offered by Deltares, in the context of the European project GRACeFUL, of which this research was a part. While making in-depth studies of one tool offers richer insights,

the generalizability of the findings is naturally narrowed by this choice. To minimize this limitation, the evaluations were based on a generic framework and method, so that they can be applied to other tools and cases for robust comparisons in the future.

The research was carried out in four consecutive steps, roughly aligned with the research questions.

1. A literature review was made of collaborative and urban adaptation planning, as well as planning support tools, their use and current evaluation practices. This review contributed to answering Research Question 1 and formed the base of input to the evaluation framework that was used in the remainder of the project.
2. Two semi-controlled experiments using repeated simulated workshops were carried out to compare three different types of planning support tools and a tool-free workshop. This evaluation focused on how a tool affects the working process and outcomes of collaborative planning workshops. In total, three or four simulated workshops were carried out for each tool, involving 98 participants. The experiments primarily addressed Research Question 2, and also contributed to Research Question 1.
3. A longitudinal case study was made of one of the planning support tools, the AST, which had been tested in the experiments. This case study, from Berlin, Germany, was used to explore how the tool influenced not only the workshop itself, but also the longer-term planning process and outcomes. The longitudinal case study primarily addressed Research Question 3, but also contributed to Research Questions 1, 2 and 4.
4. A case study was made using the AST in a new context, in Guayaquil, Ecuador. This case study explored contextual factors relating to the workshop itself, the planning process and the project setting. This case study primarily addressed Research Question 4, but also enriched the findings on Research Questions 1, 2 and 3.

As a result of the consecutive nature of the research approach, each step could build upon the lessons learned in earlier ones.

The particular research design and methods employed in each step of the research approach (Figure 2) are detailed in Chapters 2, 3 and 4. The implications and limitations of the overall research approach are reflected on in Chapter 6, including the ways in which bias was addressed in this study.

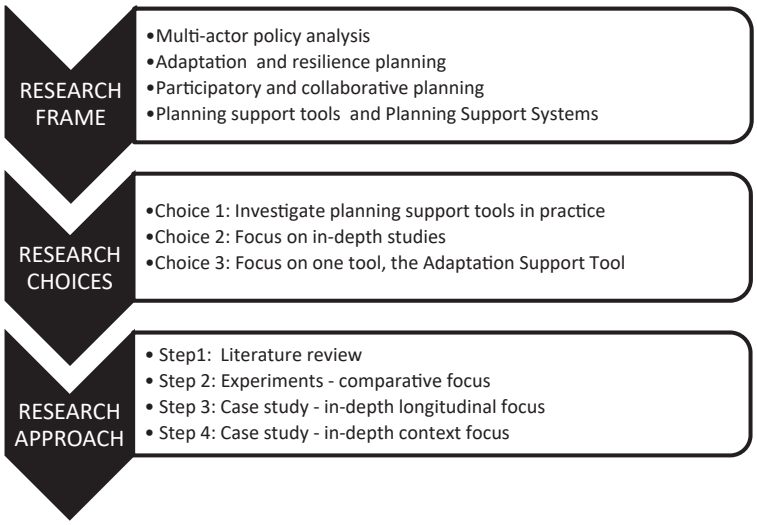

Figure 2. Schematic synthesis of the research frame, choices and approach for this dissertation

1.4 Contribution and originality of the research

This work contributes to the field of planning support tools, and PSS more specifically, as well as to adaptation planning practice. First, this research offers a framework for evaluating planning support tools in use. Additionally, this research makes a methodical comparison of PSS to other types of planning support tools. Furthermore, this research offers the first known longitudinal study of a tool's effect on the overall planning process in which it is used, and the first dedicated study of the role of context on a tool's use and added value. Finally, this research takes an interdisciplinary approach to evaluating planning support tools, while current evaluations of PSS are based in tool development and spatial planning, focusing on instrumental aspects of tool use and usefulness. The policy analysis framing used in this research leads to a nested view of tools used within workshops, planning processes and context. This perspective provided a structure in which to place the current knowledge of PSS and to explore bigger picture questions about tools' effects and effectiveness in real world planning and decision making.

This research takes a practice-orientation, meant to inform both practice and theory. As such, this research aims to inform three audiences: tool researchers (science), tool developers (science and practice) and tool practitioners, or the facilitators and organizers of tool-based planning workshops (practice). For the field of urban

adaptation planning in particular, this research offers timely insights for cities currently facing the challenge of how to effectively involve stakeholders in adaptation planning processes, how to make use of the tools available to support them, and what to expect of such tools.

1.5 Reading guide

Chapter 2: Effects of planning support tools in adaptation workshops: experimental results

This chapter introduces the nested evaluation framework used throughout this research and the results from two laboratory experiments that tested three different types of planning support tools and a tool-free approach, in a series of simulated workshops. The findings indicate that different tools lead to differences in groups' working processes, the plans produced and the achievement of learning and shared understanding. This chapter primarily addresses Research Questions 1 and 2.

Chapter 3: Effects of a planning support tool on a workshop and planning process: a case study from Berlin, Germany

This chapter moves from the comparative approach of the experiments to an in-depth case study of the AST's use in a planning workshop in Berlin, Germany, and its effects on the overall planning process and outcomes. This chapter operationalizes the evaluation framework presented in Chapter 2, by providing criteria and a case-based evaluation method, and applies the framework to a workshop and planning process. The case study results show that the tool supported learning and improved communication. However, the results also show that contextual factors, such as the project's schedule and local environmental regulations, limited the tool's effects on the planning process and the decisions made. This chapter primarily addresses Research Question 3 and contributes to Research Questions 1 and 2.

Chapter 4: Influence of context on the use and added value of planning support tools: a case study from Guayaquil, Ecuador

This chapter reports on a second in-depth case study of the AST. This time, the case study explores how contextual factors affect the use and added value of the tool. The results of this study indicate that contextual factors of the workshop itself, the overall planning process, and the local project setting, all played a role in defining the use and value of the tool in the workshop, as well as its ability to affect the planning process. This chapter primarily addresses Research Question 4, but also contributes to Research Questions 1, 2 and 3.

Chapter 5: Returning to the research questions
This chapter addresses each of the research questions, based on the findings in Chapters 2, 3 and 4 and adds new insights based on the cumulative results.

Chapter: 6 Reflections on the research and suggestions for future inquiry
The final chapter reflects on the contributions and limitations of this research, and the future of research on planning support tools in practice. Key findings are also summarized for the main audiences of this research: tool researchers, developers and practitioners.

Chapters 2, 3 and 4 of this dissertation are based on articles published or under review in scientific journals. The articles have been left largely in their original form. As such, there is some overlap, particularly in the introduction and background sections of these chapters. The literature is slightly different in each chapter to address the particular topic of the article. Hence, full inclusion is warranted. Similarly, each article contains its own research design and methods section, as well as a discussion of the respective methods. Therefore, a separate chapter dedicated to research methods is not included in this dissertation. Instead, the overall research approach has been summarized in this introduction and is reflected upon in Chapter 6.

An additional consequence of the choice to leave Chapters 2, 3 and 4 in the form of articles is that the evolution of terminology and thinking over the course of the doctoral research is apparent. This shift is most notable in the use of "participatory policy analytic activities" in Chapter 2, while Chapters 3 and 4 refer to "collaborative planning workshops". The most significant change between these two terms is the use of "participatory", which connotes public participation. This term was used in Chapter 2 because local citizen and business representatives were included in the simulated workshops and were expected to be included in the future case study workshops. Ultimately, the case study workshops focused on expert stakeholder sessions, which are more accurately described as "collaborative" than "participatory". Collaborative planning can, but does not especially require, the inclusion of the public. The choice for "collaborative planning" also makes an intentional connection to the growing "collaborative design" movement. The shift from "policy analytic activities" to simply "workshops" reflects the shift from policy analysis framing to planning practice.

2

Effects of planning support tools in adaptation workshops: experimental results

The content of this chapter was published in:
McEvoy, S., van de Ven, F.H., Blind, M.W., Slinger, J.H., 2018. Planning Support Tools and their Effects in participatory urban adaptation workshops. Journal of Environmental Management. 207, 319-333. doi:10.1016/j.jenvman.2017.10.041

Supplementary material for this chapter is provided in Appendix A

The need for improved evaluations of planning support tools was introduced in the previous chapter. A key gap in current planning support tool research is rigorous comparison of different types of planning support tools. To address this gap, a series of experiments was carried out using three distinct tools and a tool free approach. Their performance was compared on four criteria: the working process, the plans produced, the learning effects and the development of shared understanding.

This aim of this chapter is to present the findings on the different planning support tools that were evaluated and to contribute to answering the first and second research questions posed in this dissertation. Section 2.1 elaborates the need for more rigorous evaluations, while the conceptual framework of tool use within planning workshops and overall planning processes is introduced in Section 2.2. The research design and methods of data analysis for the experiments are explained in Section 2.3 and the results are presented in Section 2.4. The implications of the findings are discussed in 2.5, and finally, conclusions are drawn in Section 2.6.

Abstract

In the face of a changing climate, many cities are engaged in adaptation planning and are using participatory workshops to involve stakeholders in these initiatives. Different tools are being used to structure the process and content of participatory planning workshops, but it is unclear what effect the tools have on the workshops and their results. We evaluated three different tools (Group Model Building, the Adaptation Support Tool, and the Stress Test Guideline) and a tool-free approach in repeated simulated workshops, to observe and compare the way workshops played out and the direct outcomes that were achieved. Tools appear to influence both aspects. Specifically, we measured differences in the learning effects in groups, in the development of shared understanding within groups, in the types of plans that were developed by groups, and in the nature of participation during the workshops. Further research is needed to test these results in planning practice, but this is a first step in advancing knowledge about the influence of tools in participatory planning workshops.

2.1 Introduction

In recent years, a field of research and practice has emerged around how to make cities resilient to the effects of climate change. Subsequently, a number of frameworks and initiatives have been created to guide cities in their planning efforts (Sellberg et al., 2015). A common characteristic of these approaches is stakeholder participation in the planning process (e.g. Ahern, 2011; Sharma et al., 2014; Tyler and Moench, 2012).

Calls for participation are based on the expectation that involving stakeholders provides substantive benefits, such as better informed decisions, and procedural advantages, like increased legitimacy (Beierle and Konisky, 2000; Wesselink et al., 2011). However, achieving meaningful outcomes from participation can be difficult and success is often determined by the contextual factors of individual cases (Kallis et al., 2006; Ker Rault et al., 2013). In adaptation planning, stakeholder participation is mostly carried out through participatory *activities*, such as workshops. A tool is typically used to structure an activity's content (information, data, etc.) and process (steps, actions, interactions, etc.). In practice, the tools vary widely in form and function, from role playing games to workbook exercises, and dialogue sessions to simulation models (Tyler and Moench, 2012; van de Ven et al., 2016; Wardekker et al., 2010).

Despite the number and diversity of available tools, little attention is paid to which tools work, how they work, and in which contexts they are suitable. Evaluations of tools are rare, or are *ad hoc* reflections, at best (Rowe, 2004; Rowe and Frewer, 2000). Without systematic comparisons of tools in use, empirical evidence is missing about the role and influence of tools in planning activities. Consequently, cities lack substantiated guidance on how to select appropriate tools to support their planning aims and local context.

The goal of this research is to explore the influence of tools on participatory activities in urban adaptation planning. To this end we carried out two experiments, in which we evaluated three different tools and a tool-free approach, using multiple simulated planning workshops with post-graduate students from the Delft University of Technology, in the Netherlands. Our results show that using different tools indeed leads to differences in the nature of participation during activities (e.g., how groups work together) and in the outcomes of activities (e.g., characteristics of adaptation plans that are developed). This systematic evaluation of tools is meant as a first step in building evidence on the effects of tools in participatory planning activities for urban adaptation.

In the following sections of this article we present the theoretical background for our evaluation of tools in participatory planning activities, followed by a description of our research design. Next, we present our findings, reflect on their meaning, and, finally, share our conclusions.

2.2 Evaluating planning activities and the influence of tools

2.2.1 Conceptualizing tools, activities and processes in planning

Broadly speaking, planning involves a series of steps taken toward achieving a particular goal, such as adapting a city for climate change, and can be conceptualized by three core dimensions: planning process, context and outcomes (Hassenforder et al., 2015).

The *planning process* refers to how the steps or procedures are carried out and who is involved. Planning processes are not necessarily linear nor as well defined, as the simplified schematic in Figure 3 may imply. In reality, planning processes are often messy, involving parallel activities, dead ends, and iterations. Our figure simply

represents planning as a process that encompasses different activities carried out over time, and that the process happens within a context and produces outcomes of some type. When a planning process includes stakeholders in some of the steps, it is considered a participatory planning process (Geurts and Joldersma, 2001; Hassenforder et al., 2015). Stakeholder participation can take many forms and involve different stakeholders in different capacities and at different times in the process (Arnstein, 1969; Rowe, 2004; Wesselink et al., 2011).

Planning processes happen within a *context* that is created by different factors, such as local political climate, regulations, physical characteristics of a site, and economic conditions. Context plays an important role in how a planning process unfolds and the kinds of outcomes that can be achieved (Basco-Carrera et al., 2017; Hassenforder et al., 2015; Rowe and Frewer, 2000).

The *outcomes* of a planning process are the impacts on the system and the actors involved. Outcomes can be of various types and occur over different time scales (Hassenforder et al., 2015; Thissen and Twaalfhoven, 2001). Examples include less tangible impacts like improved cooperation between different authorities, and more concrete impacts like an agreement on preferred adaptation measures.

The steps taken in a planning process include different activities, such as data collection, modeling and meetings, which are carried out to achieve specific aims. We borrow the notion of *activities* from Thissen and Twaalfhoven (2001), who define policy analytic activities as a "specific analytic effort delimited in time and scope and oriented towards a specific policy issue" (p. 628). In this conceptualization, a distinction is made between the content and process elements of an activity. *Process* elements relate to how an activity is organized and plays out, including, for example, the interaction and communication between participants. *Content* elements relate to the substance of

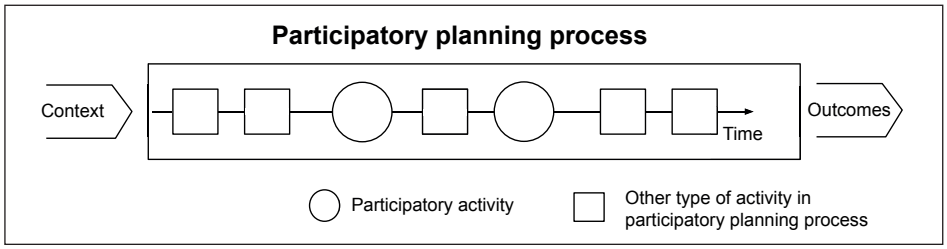

Figure 3. A simplified schematic of participatory planning, composed of context, process and outcomes. Different types of activities are carried out over time, in the planning process.

the activity, such as the knowledge or information that is shared and used. The *input* to an activity includes aspects related to its process and content, such as who is included and what data is available. Input is what is provided to an activity, it is not the opinions or information provided by participants during an activity, which is considered content. *Results* are the direct products of an activity, such as plans, agreements or models. The *effects* of an activity come from two sources: via the use of results in the planning process, and directly from the activity itself (Figure 4). One example of a direct effect is improved understanding about a problem. An effect through the use of results could be the selection of an alternative that was developed during an activity. A *participatory activity* is a single event, such as a workshop, that involves stakeholders to support problem-structuring, solution-finding, decision-making, or implementation. Participatory activities can be organized by authorities or by grassroots initiatives and they can be carried out in any part of a planning process. There may be multiple participatory activities during the course of a participatory planning process.

In participatory activities, *tools* are often used to structure the process and content. Tools can fill several functions, such as providing information, facilitating communication among participants, and supporting the procedures that are carried out (Al-Kodmany, 1999; Geurts and Joldersma, 2001). Tools take different forms, from simple role playing games to computer-based models.

Relations between tools, activities and processes

The use of tools is embedded within activities, which happen in the course of planning processes (Figure 5). This conceptualization assumes underlying causal relationships in the direction of the arrows shown in Figure 5. At the planning level, the context

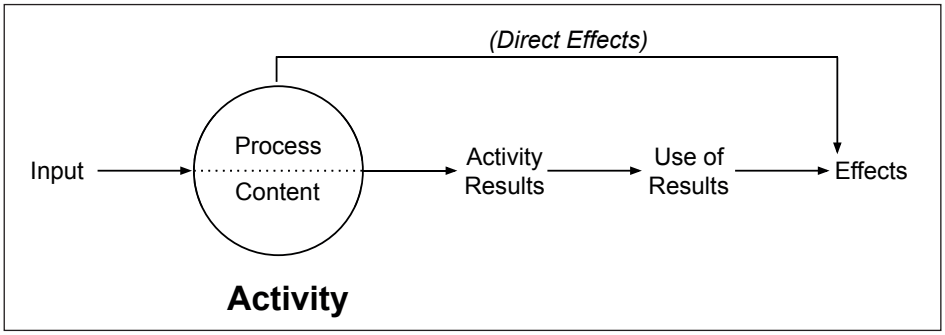

Figure 4. Conceptualization of activities, distinguishing the process and content of an activity, as well as the input to the activity, its direct results, their use and effects (Thissen and Twaalfhoven, 2001).

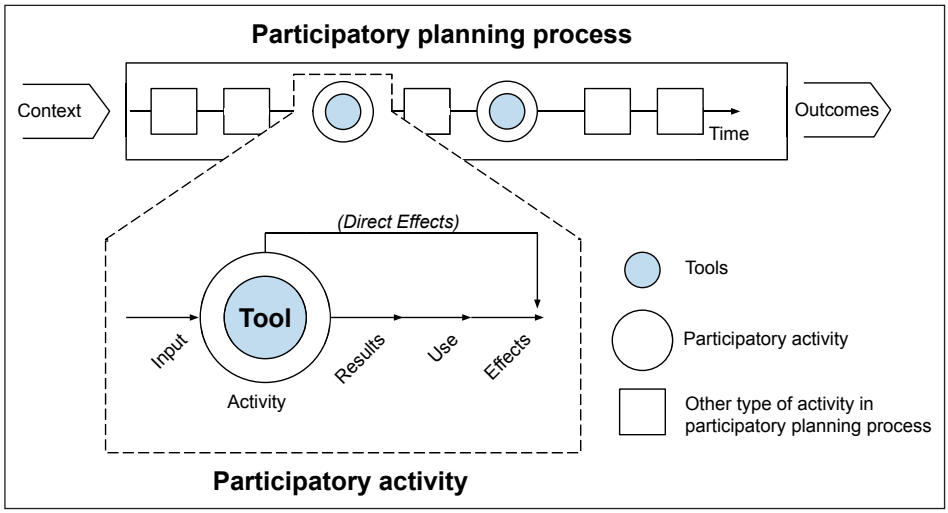

Figure 5 Schematic representation of the nested relationships of tool use within activities, such as workshops, which take place in particpatory planning processes

influences the planning process, which in turn, impacts the outcomes of the planning process. Similarly, at the activity level, the input to an activity influences the activity, which impacts the results of the activity, their use and their effects. There are two interactions between a planning process and an activity. First, a planning process influences the input conditions of an activity. Second, the results and effects of an activity feed back into the planning process and influence its subsequent steps and outcomes. There is another relation to consider that is largely ignored in literature: the effect of the tool on the activity. The purpose of our study is to explore whether using different tools in participatory planning activities creates any differences in the activity itself, and its results and effects. This is the first step toward understanding the influence of tools in planning processes. Such insights are needed to improve the selection and design of tools to support effective participatory planning processes, based on the context and desired outcomes of individual cases.

2.2.2 Relevance to adaptation planning

A growing body of work focuses on evaluating participatory processes to understand how they can be carried out effectively and designed to meet particular aims (Abelson et al., 2003; Hassenforder et al., 2015; Rowe and Frewer, 2000). These studies focus on the planning process as the unit of analysis and relate it to the context and outcomes. Evaluations at this resolution offer insights into the factors that support successful

planning processes, or specific kinds of achievements. However, these evaluations do not capture the individual activities that are carried out, and their contributions to the overall process. Hassenforder et al. (2015) provide an illustrative example of this with their Comparison of Participatory Processes framework. After applying the framework to five cases, the authors found that it delivered sufficiently "clear and consistent descriptions" (p.91) to compare different processes. But, the authors noted that they could not distinguish differences in their cases resulting from the use of different tools. In fact, the authors acknowledge that the results of their evaluations lead to the hypothesis that "specific methods [tools] are easily replaceable" (Hassenforder et al., 2015, p.91). This begs the question, are tools really interchangeable? Or does the resolution of current evaluation frameworks fail to capture differences resulting from the use of particular tools? Indeed, Hassenforder et al. , among others, call for a better understanding of individual tools, with respect to their effectiveness and the conditions under which they are appropriate (Hassenforder et al., 2015; Jones et al., 2009; Rowe, 2004; Thissen and Twaalfhoven, 2001). Our research makes a first step in addressing this gap by systematically evaluating three different tools and a tool-free approach in simulated participatory planning activities.

2.2.3 Evaluating tool use in participatory activities

The first step of evaluation is to define metrics that will provide robust and relevant indicators. Determining what to measure and how to measure it is a complex task complicated by issues such as the generalizability of metrics and whose perspectives are represented in the evaluation (Rowe, 2004). In selecting the metrics to evaluate tools in simulated planning workshops, we considered five criteria: (1) the metrics must reflect our conceptualization of activities; (2) the metrics should help us identify meaningful differences between tools; (3) the metrics should be relevant to the broader context of a participatory planning process; (4) there should be multiple ways to measure each metric; and (5) the metrics must be measurable in the context of our simulated workshops setting, without demanding excessive time from participants. To ensure that the metrics would be relevant to participatory planning processes, we looked to literature in this field, and reviewed the tools currently being used in adaptation planning practice (e.g. Al-Kodmany, 1999; Pelzer et al., 2013; Sellberg et al., 2015; Voskamp and van de Ven, 2015; Wardekker et al., 2010), as well as existing evaluation frameworks and research agendas (Hassenforder et al., 2015; Jones et al., 2009; Rowe, 2004; Thissen and Twaalfhoven, 2001). The four metrics selected are learning effects, the development of shared understanding, the work products developed in the activity, and the nature of participation during the activity.

Metric 1: Learning effects

Learning is a common goal of participatory activities and is also a touted benefit of many tools (Armitage et al., 2008; Basco-Carrera et al., 2017; Evers et al., 2012; Hare, 2011). As such, learning is an important direct effect of participatory activities that is measurable in the experimental setting. Learning is also significant from the participatory process perspective, because learning that happens in an activity should influence the perceptions and actions of participants in later stages of the planning process (Smajgl and Ward, 2013; Thissen and Twaalfhoven, 2001). In this study, we focus on learning that happens within a group. This broad view includes social and individual learning. An important distinction is that the learning of individuals in a group can be high, without creating a common understanding of the problem or solutions. In other words, participants may learn different lessons during a participatory activity. Therefore, it is important to also capture the development of shared understanding.

Metric 2: Development of shared understanding

Developing shared understanding is another common goal of participatory activities in adaptation planning (Mayer et al., 2005), and is a direct effect that is measurable within the experimental setting. For the participatory process, the development of shared understanding is important for its potential to influence participants' later actions and decisions (Smajgl and Ward, 2013). The development of shared understanding reflects the convergence of mental models of the participants in a group (Doyle et al., 1996). By contrast, learning is any change in mental model or understanding of individuals or groups (Raadgever, 2009), nevertheless, learning is a mechanism by which shared understanding is developed (Armitage et al., 2008; Muro and Jeffrey, 2008).

Metric 3: Work products developed in the activity

Work products are the results of activities. The rationale for participation and the objectives of a particular activity should determine the type and form of the results (Hassenforder et al., 2015; Jones et al., 2009; Thissen and Twaalfhoven, 2001; Wesselink et al., 2011). It is also important that participants are able to represent their own interests in the work product and that they find it satisfactory (Thissen and Twaalfhoven, 2001). Evaluating work products is essential in identifying whether particular tools produce specific types of results. This has clear importance for participatory planning processes, in which activity results are used. In addition, specific claims are sometimes made about work products developed using particular types of tools, for example that computational models lead to more evidence-based plans (Mayer et al., 2005; van de Ven et al., 2016). Evaluations should provide feedback on such claims.

Metric 4: Nature of participation during the activity

The nature of participation relates to the process of a participatory activity and how it is carried out. This includes, for example, the procedures that are followed, the interactions between participants, and the interpersonal dynamics within a group (Thissen and Twaalfhoven, 2001). This metric is important for characterizing whether different tools create different types of participation during an activity, which provides insights into when specific tools are suitable or what procedural elements promote successful participation with a given tool.

2.3 Research design

In the following section we introduce our research design. Specifically, we discuss choices in the research design and explain the experimental set-up and the methods employed for measuring each metric and making our analysis.

2.3.1 Choices in the research design

An experimental approach was selected for three reasons. First, the lack of systematic and standardized evaluations of participatory planning activities in urban adaptation planning means there are insufficient data for making meaningful comparisons between tools used in real cases. Second, to examine differences in tools in use, it is expedient to do so in a controlled environment, where the case and context are constant and the main difference between the participatory activities lies in the use of different tools. Third, the ability to repeat the experiments with different groups using the same tool is useful for surfacing patterns in the data.

Participatory activities can take many forms and occur in every phase of a planning process, from initiation to implementation. We focus on activities that engage stakeholders, such as water authorities, planning departments, local residents and businesses in structured participatory adaptation planning workshops that address the conceptual phase of planning. A wide variety of tools is used to carry out participatory workshops in this phase; most aim at supporting problem understanding and exploring solutions. We selected three tools that approach this in sufficiently different ways from one another. Additional criteria in selecting the tools were: (1) each tool had been used in real cases of urban adaptation planning; (2) each tool could be considered representative of a type of tool used in practice and reported in literature, to make the outcomes more widely relevant than the specific tools; and (3) we could secure access to each tool and to trained facilitators for the workshops.

For our experiments, we selected the following tools: (1) a qualitative problem structuring approach, Group Model Building; (2) a computer-based visualization tool for exploring solutions, the Adaptation Support Tool; (3) and a procedural protocol, the Stress Test Guideline. In addition to these tools, a dialogue-based "Tool-free Approach" was used as a baseline for comparison.

Group Model Building

Group Model Building (GMB) is an analytical tool for structuring and exploring systems in small groups. In GMB sessions, a facilitator-led group develops a system model, using causal loop or stock-and-flow diagrams. The resulting diagram represents the negotiated mental model of the group, and the modelling process is viewed as equally important as the resulting model. GMB aims to create shared understanding of complex systems through social learning (Vennix, 1996). It is traditionally used in organizational and operational settings, but is also popular in other areas, such as environmental resources management (Voinov and Bousquet, 2010). GMB has been used in adaptation planning, in the city of Rotterdam, in the Netherlands (Wardekker et al., 2010).

Adaptation Support Tool

The Adaptation Support Tool (AST) is a map-based touch table application for small groups to explore spatial adaptation of their urban environment. Using the AST, groups can select adaptation measures from a library and place them on the map of the project area. The library offers an interactive library of measures with pictures and information about each measure. The tool provides real-time feedback on the effectiveness of the individual measures and combinations of measures, in terms of cost and adaptation targets, like pluvial flooding and heat stress reduction. The AST delivers quantitative, evidence based performance indicators to support and inform group discussions about where and how to adapt in a local context. Collaborative learning is implicit through discussions "around the table". The AST has been used in Utrecht and Tilburg, in the Netherlands, as well as in Beira, in Mozambique, in Oaxaca City, in Mexico and in Berlin, in Germany (Deltares, n.d.; van de Ven et al., 2016)

Stress Test Guideline

The Stress Test Guideline (STG) is a stepwise approach for assessing the resilience of urban areas and planning potential interventions. The guideline focuses on two phases: a vulnerability scan, in which information about vulnerabilities and opportunities is collected in a series of tasks, and adaptation planning, in which solutions are developed. These steps are carried out with the participation of stakeholders (Deltaprogramma,

2014). The STG has been used in Arnhem and Sittard-Geleen, among other municipalities, in the Netherlands (Deltaprogramma, 2015).

Tool-free Approach

A Tool-free Approach (TA) was used as a baseline for comparison in these experiments. In this dialogue-based approach, stakeholder groups, often led by an organizer, such as public works engineers or urban planners, sit together and use their combined expertise, available information and knowledge to decide on how to approach the problems and form design solutions, without the structure of a pre-defined process or tool. The Tool-free Approach was used in the real case that served as the design challenge in the experiments.

2.3.2 Experimental Set-up

The experiments were set up as design competitions, at Delft University of Technology, in the Netherlands. Full-day competitions were carried out in May 2015 and 2016, as part of an annual interdisciplinary course on urban water management. The challenge was to develop an adaptation plan for the Stadspolder neighbourhood, in the city of Dordrecht. Participants were postgraduate students from the university, studying urban planning and architecture (Faculty of Architecture), water management (Faculty of Civil Engineering) and policy analysis (Faculty of Technology, Policy and Management). All groups in both years were given the same case, information and design challenge.

Before the workshops, students were advised of the day's programme. Following their arrival, a plenary session was held to review the schedule and the aims of the day, and to present the case and the design challenge. A representative from the city of Dordrecht's water department introduced the real case in a presentation, reviewing the available data, explaining the design criteria, and offering social and historical context, including different stakeholder priorities (for more details, see Appendix A). In the plenary session, students were informed that the workshop was part of a research project being carried out by a doctoral candidate at the same university. A consent form for participating in the study was reviewed in the plenary session and students were informed that while participation in the workshop was mandatory for their course, participation in the study was entirely voluntary and would not influence their grade. No students chose to opt out of the study.

Following the plenary session, the students were divided into groups, seven groups of eight, in 2015, and seven groups of six, in 2016 (Table 1). As there were more men

than women, more Dutch than other nationalities, and more engineering students than planners or policy analysts, care was taken to control for these factors in group composition. Each group was arbitrarily assigned one of the four participatory planning tools to use in the workshop to develop their plan(s); they were not informed that other groups were using different tools. Each group was assigned a separate designated workspace, and was provided with a packet containing case information and data, stakeholder roles, instructions for the design challenge, and a timetable for the day.

Table 1. Number of groups using each planning support tool in each experiment

	Group Model Building	**Adaptation Support Tool**	**Stress Test Guideline**	**Tool-free Approach**
Number of Groups				
2015	2	1	2	2
2016	2	3	1	1
Total	*4*	*4*	*3*	*3*
Number of participants				
2015	16	8	16	16
2016	12	18	6	6
Total	*28*	*26*	*22*	*22*
Set-up				
2015 & 2016	AM: facilitated group modelling session PM: group design work	All day access to the tool for group design work	All day access to the guideline for group design work	All day group design work, without an assigned tool

A facilitator was assigned to each group. Facilitators served three purposes: to introduce each group to the tool they would be using during the workshop, to answer questions about the tool or design challenge during the workshop, and to observe their group. Before the workshop, all facilitators were given instructions for presenting their tool and scripts for interacting with their group. This helped to ensure the instruction was the same for all groups using the same tool. In the Group Model Building groups, the facilitators also led the modelling process.

Participants adopted stakeholder roles from a prescribed list. The roles included representatives from the spatial planning department, the city water authority, the environmental protection agency, local business and local residents. Each role was taken by one student per group. Additionally, one participant adopted the role of

group recorder. In 2015 two extra roles were used, emergency services representative and group spokesperson. These roles were later removed, based on analysis of the 2015 workshops, and the lower number of participants in 2016.

During the workshop, groups worked independently on their designs throughout the day. All groups had access to the same information and data about the case. The procedures and the role of facilitators for each tool are summarized below:

- **Group Model Building** groups had facilitated modelling sessions in the morning, in which they developed qualitative causal loop diagrams of the case. The afternoon was reserved for developing the adaptation plans. Facilitators led the modelling session and supported the design phase only by answering questions. GMB facilitation was non-directive, meaning that facilitators did not influence what factors and relations were included in the models, and they did not contribute to the selection of measures, or the creation of designs. However, by guiding groups through the modelling session, facilitators provided structure to the process and problem. This is standard for GMB practice (Vennix, 1996; Voinov and Bousquet, 2010) and can, in a way, be considered the tool itself.
- **Adaptation Support Tool** groups had the touch table available to them for the full day. The case area and information was loaded into the tool before the workshop. Facilitators provided each AST group with a tutorial of the tool and were available for technical support and to answer questions throughout the day. AST facilitators did not provide guidance in the working process, in problem structuring or in design input. This deviates from practice, where facilitators are urban adaptation experts, who guide groups through the design process, while providing information and knowledge. This approach is directive in process and content, and so was not used in the workshops. Instead, facilitation of the AST was deliberately minimal, in order to not advantage groups using this tool, and to separate the effects of facilitation from the effects of the tool.
- **Stress Test Guideline** groups were provided with the guideline at the beginning of the day and facilitators explained how to use it. Facilitators were available to support groups and answer questions throughout the day. In practice, there is no formal role for facilitators in the STG.
- **Tool-free Approach** groups were advised to rely on their training and knowledge in their respective fields, and to work together to develop an adaptation plan. Facilitators were available to answer questions. In practice, there is no formal role for facilitators in the TA.

At the end of the day, a plenary session was held. The students were informed that different tools had been used by different groups during the workshop. Each group presented their design and explained their planning rationale to a panel of judges and the other participants in five minute pitches, followed by questions. The panel of judges was the same for both years and included a professor of urban water management (Faculty of Civil Engineering), a professor of urbanism (Faculty of Architecture), a researcher from policy analysis (Faculty of Technology, Policy and Management), and the representative from the city of Dordrecht's water department who had presented the case. The judges evaluated and ranked each design independently and together selected a winner. The winning team was awarded a small prize.

The design challenge

The design challenge for the experiments used the real case of the Stadspolder district, in Dordrecht, the Netherlands. The design challenge was to develop an adaptation plan that addressed current problems, as well as expected impacts of climate change in Stadspolder, over the next thirty years.

Stadspolder is a mostly residential neighbourhood developed in the 1980s and '90s. It is a mixed neighbourhood that includes schools, small businesses, public and private housing, young families and immigrants. Within the neighbourhood, walking and cycling are widely used modes of transportation. Stadspolder is well connected to the rest of Dordrecht and beyond the city by public transport.

Stadspolder is characterised by a "cauliflower" structure, with one main access road forming a ring around the neighbourhood and active street life within its boundary. Street parking is available in front of homes, but is insufficient for current demand. Low threshold sidewalks and doors in the area do little to prevent flooding when water collects in the streets. The sewer type is partly combined and partly separated, with multiple outflow points into local surface water.

Currently, the greatest concerns of the community are insufficient parking and improving aesthetic and social qualities of the neighbourhood. In addition to these issues, the municipality is concerned that existing problems of pluvial flooding, water quality and heat stress are worsening with climate change. Drought is another potential problem; however it has not yet been studied by the city. Owing to budget constraints, the municipality aims to implement adaptation plans by mainstreaming them in existing and future urban development and renewal projects. Priorities for the city are finding multiple-benefit solutions and supporting community engagement and action.

In the design challenge, a Dordrecht official presented the case of Stadspolder to the students and provided an information packet with the city's multi-year investment plan for the area, flood risk maps, overviews of the local water system and discharge locations, different stakeholder interests and critical infrastructure maps. During the workshop, students could also access public data for Stadspolder, through national databases and city websites. The stakeholder roles used by students were informed by the prominent stakeholders in the real adaptation planning process for Stadspolder: the spatial planning department, the city water department, an environmental department, local businesses and residents.

Data

The following data were collected throughout the workshops:

Questionnaires: Questionnaires were a primary source of data in this study. All ninety-eight participants were given multiple questionnaires throughout the day. Two different questionnaires were used: a "short questionnaire" and longer "reflection questionnaire". The short questionnaire asked participants from the perspective of their stakeholder role to list the three factors they felt were most important to making Stadspolder more resilient to the effects of climate change. Each participant completed this short questionnaire two times, at the beginning and end of their group work. Participants in GMB groups completed this questionnaire an additional time, between the morning modelling session and the afternoon design phase. This was done to differentiate effects of the modelling from the design work. The longer reflection questionnaire was completed by all participants once, at the end of their group work, but before the plenary session. The reflection questionnaire consists of multiple open questions. The first half of the questionnaire asked participants to respond from the perspective of their stakeholder role, while the second half asked participants for their personal perspectives, based on their academic background (e.g. civil engineer, urban planner, etc.). Altogether, three questionnaires were filled out per participant (two short questionnaires and one longer reflection) and four, in the case of GMB group participants (one extra short questionnaire). Because time was allocated to completing the questionnaires in the workshop, all participants responded.

In the 2015 questionnaires, some participants offered unsolicited feedback on what they liked or disliked about the tool they had used. Their comments provided rich insights. In 2016, a question was added at the end of the reflection questionnaire, asking the participants what they liked least and most about the tool they used.

Observations: Each facilitator served as an observer of their group. The students were not explicitly aware of this second role of the facilitators. Two designated researchers moved between groups to make comparative observations throughout the day. Interpersonal dynamics within groups, interaction with the assigned tool, organization of work, decision making process, and approach to the design challenge were of particular interest. Observations were reported to the lead researcher.

Process records: In each group one student took the role of recorder and was instructed to keep a written log of the working procedures, group organization and decision making processes in their group. These written records were handed over to the lead researcher at the end of the day.

Models: Images of the causal loop diagrams developed by Group Model Building groups were captured during and after the modelling sessions, and again at the end of each day, if groups had modified or marked them during the design phase. The diagrams were later recreated for clarity and analysis.

Presentations: Each group provided the lead researcher with a digital copy of the slides from their final presentation. The presentations include images of the final spatial designs, maps, sketches, cross-sections, and descriptions of other components of the plans, such as financing, the group's design justifications, and how the plan meets the design challenge. Notes were taken by the judges during the presentations and shared with the lead researcher at the end of the workshop.

Plans: The plans developed by each group, which included maps, sketches, sections and text, were documented at the end of each workshop via the presentations.

2.3.3 Analysis methods and metrics

Data analysis methods

A text analysis of the questionnaires from each group was made by the lead author. This was used to surface (1) changes in perceptions of the problem over time for individual participants and groups as a whole; (2) group convergence in perceptions of the problem and use of language within groups; (3) the development of thematic topics within groups; (4) individual leaders and outliers in groups; (5) views of group work and final design; and (6) experiences with the assigned tool and role.

A text analysis of the process records and observation notes was made by the lead author to surface: (1) insights into group dynamics and roles; (2) the development of thematic topics within groups; (3) the decision-making process; and (4) experiences with the assigned tool. The findings from the analysis of the questionnaires from the two analyses were reviewed together and compared.

The presentations, plans, and models (in the case of GMB groups), were reviewed and analysed for (1) the themes in the design; (2) the topics and solutions included in the design; (3) the rationale for design choices; and (5) the characteristics of the design, such as the level of integration and holistic thinking.

The findings of the analyses on the questionnaires, on the records and observations, and on the presentations, plans and models were first compared to one another, and then evaluated as a whole. Finally, the findings were summarized by group, by tool in use, and by year. The data for each year were analysed separately, then compared and re-analysed together.

The analysis for the 2015 workshop was used to inform the workshop in 2016. Effort was made to replicate the 2015 experiment as exactly as possible in 2016.

Metrics of analysis

Given the experimental context of the evaluations, we limited ourselves to the four metrics explained earlier, namely: learning effects, the development of shared understanding, the work products, and the nature of participation during the activity. To ensure robust evaluations, each metric was measured in multiple ways.

Learning effects

Learning effects were measured in three ways:

1. The mean change in priorities for each group was taken as an indicator of individual learning within each group. This was measured in the short questionnaires. The number of priorities that changed from one survey to the next was counted per participant and averaged for each group.
2. Convergence in language for each group was taken as an indicator of social learning. Convergence in language was measured through the development of the use of shared terms in responses to both the short questionnaires and longer reflection questionnaires.
3. The strength of the convergence in language was measured by the number of participants per group who used the shared terms, and the precision of the shared

language (e.g. words and phrases are repeated verbatim or different variations are used).

The development of shared understanding

Developing shared understanding was measured in three ways:

1. A common description of a group's design was taken as an indicator of shared understanding. In the reflection questionnaires at the end of the day, each participant was asked to describe their group's design. The descriptions for each group were analysed for the presence of common elements, qualities, and functionalities that indicated a collective view of the design.
2. Group convergence in thematic topics, such as social engagement or greening, is taken as an indicator of shared understanding. Group convergence was measured through the development of thematic topics in the responses to the short questionnaires and longer reflection questionnaires. In this way, themes could be captured in the views of the problem, or system, and the solutions. Thematic topics are different from shared language, in that the same words and terms are not necessarily used. As an example, "greening" would be a thematic topic that captures measures such as "trees", "green roofs" and "bioswales". By contrast, an example of shared language would be the term "green retention areas" repeated by multiple participants in a group.
3. The strength of convergence in thematic topics was measured by the number of participants per group who included the thematic topic in their responses, and the total number of themes (e.g. there could be many weak themes, a few strong ones, a combination, or none).

Work products

The work products were evaluated in four ways:

1. The extent to which the selected measures composed a coherent plan, versus a collection of measures without an overarching strategy. This factor arose after clear differences in the type of plans became apparent during the group presentations of designs and in reviewing the process records and reflection questionnaires. Coherence shows an important difference in the types of results (plans, in this case) developed using different tools. This was measured by analysing the final designs, the group records, facilitator notes, and the presentations.
2. The extent to which plans were holistic and integrated in nature, with consideration for multiple-benefit solutions, cost-effectiveness and social impacts. This factor represents the city of Dordrecht's priorities, which were communicated in the design challenge and were judged by the panel. This reflects the ability of the different

tools to address the aims of the specific case, which are in turn common aims in participatory planning. The extent to which plans were holistic and integrated was measured by analysing the content of the final designs and presentations.

3. The satisfaction of group members with their design. This factor was measured in survey questions at the end of the day and reflects participants' ability to realize their own interests in a group activity, and how they feel about the work products
4. The satisfaction of group members with the technical quality of their design. This factor was devised to identify differences in satisfaction between groups using more or less technical tools. Participants were asked about this in the reflection questionnaire at the end of the day.

The nature of participation during the activity

The nature of participation during the activity was measured in five ways:

1. How closely each group adhered to their tool's intended process.
2. How each group organized their work and the process.
3. The interpersonal dynamics within a group, while working together (e.g. confrontational versus cooperative work, collective group work versus division into subgroups, the ability of some members to dominate their group).
4. The ability of individuals to achieve their particular stakeholder interests within the group discussions and designs.
5. Individual's positive or negative feelings about the tool they used.

Records from the group facilitators and recorders, as well as the designated observers were used to assess the first three factors for each group. Participants were asked about the last two factors in the reflection questionnaires at the end of the day.

2.4 Findings

In the following section we summarize the results for each tool in use and discuss the meaning, in terms of the metrics of evaluation.

2.4.1 Tool-free Approach

The mean change in priorities for TA groups is roughly fifty per cent and no convergence in language or thematic topics was observed (Table 2). These results are consistent and are taken as the baseline for learning effects and the development of shared understanding.

Table 2. Results for Tool-free Approach groups, reported per group, per experiment

Year	2015		2016
TA group	**1**	**2**	**1**
Mean change in priorities per group	53%	58%	56%
Development of thematic topics in the group	None observed	None observed	None observed
Development of shared language in the group	None observed	None observed	None observed
Ways of working	Self-structured and organized work process. Lack of guidance slowed process.	Self-structured approach, however process perceived as "chaotic"	Self-organization, no confidence in structure. Poor dynamic, little interaction.
Noted positive elements of tool[1]	None reported	None reported	Starting from stakeholder perspectives, lack of interference
Noted negative elements of tool[2]	Lack of data impeded decision making	Lack of data was problematic	Lack of guidance, structure, information: "Nothing to hold onto. Nothing to guide process"
Perception of the design	Reported satisfaction with design and technical quality	Mixed views of design and technical quality. Very different justifications for views	Acceptable design, but different justifications. Low views of technical quality.

1. This was explicitly asked only in 2016. Some unsolicited comments were made in 2015 and are also included.
2. This was explicitly asked only in 2016. Some unsolicited comments were made in 2015 and are also included.

The plans developed by TA groups are characterised by smaller scale measures in "patchwork" solutions. Strategic planning and holistic designs are not found in TA group work; however, consideration for non-technical issues and measures are evident in the plans. Satisfaction with the designs and their technical quality is mixed. It is a theme in TA groups that very different reasoning is given by participants for their positive or negative perceptions of their group's design and its technical quality. This indicates that these groups did not have shared expectations for their plans and what would constitute success.

With respect to the nature of participation, TA groups reported struggling with the lack of information, structure and guidance in the process. These conditions were a felt hindrance in decision making. TA groups organized their work in similar ways

to each other and to groups using other tools, particularly the STG, but expressed more uncertainty and lower confidence in their working process and products than other groups. Furthermore, these groups felt that they lacked data and information, despite having the same material as other groups. In 2016 the participant role of spokesperson was dropped for all groups, however, this may have affected the process for the TA group in particular. Without any guidance from a tool or leader to direct the group work, the 2016 TA group struggled to cooperate, and to structure their tasks and efforts. However, it was also observed that the 2016 TA group had a poor inter-personal dynamic, with noticeably lower dialogue than other groups and several passive members.

TA's lack of structure did not seem to inspire these groups to find creative new approaches to the design process, but instead seemed to create three potential pitfalls:

1. Without a mechanism or process for extending or challenging the group's thinking, a group can focus on one area and neglect or miss what they do not know or understand. This could lead to misunderstanding or misrepresentation of the problem, and incomplete or poor solutions. This was observed in the 2016 workshop.
2. The lack of structure, focus and process can lead to a group's focus being too general or too narrow. This was observed in 2015 and 2016.
3. Without rules of interaction, the participatory process is vulnerable to the interpersonal dynamics within a group. More vocal members can dominate a group, as was observed in the 2016 workshop.

Overall, the TA group results seem appropriate to use as a baseline for comparing with other tools.

2.4.2 Adaptation Support Tool

From Table 3, the change in priorities for AST groups is roughly fifty per cent, but there is notable deviation between groups. There is no observed convergence in language or thematic topics. One group, demonstrated some shared description of the design, but another group showed conflicting descriptions. Likewise, it is notable that in 2016, AST Group 2 shows divergence in priorities over the course of the workshop. Overall, these results indicate that the AST does not support better than average learning nor the development of shared understanding.

The plans created by AST groups are characterized by pragmatic combinations of measures to meet the aims of the design challenge, as opposed to strategic approaches

Table 3. Results for Adaptation Support Tool groups, reported per group, per experiment

Year	**2015**	**2016**		
AST group	**1**	**1**	**2**	**3**
Mean change in priorities per group	59%	50%	56%	39%
Development of thematic topics in the group	Inconclusive, due to poor reporting in first short survey	No convergence in themes, but convergence in description of design	Divergence during workshop, more overlap in first short survey than second	No convergence in themes. Contradictory descriptions of design
Development of shared language in the group	Inconclusive, due to poor reporting in first short survey	No convergence in language	No convergence in language	No convergence in language
Ways of working	AST was used to compare measures for attractiveness, effectiveness, cost, etc. The results were used in discussions to decide which measures to take. Measures were combined "randomly"	AST only used at the end, to place selected measures. Group divided tasks and worked in sub-groups.	AST used in beginning to identify possible measures and at the end to implement the selected measures. Group divided work until the end.	AST was used in the beginning to become familiar with the area and different measures. Group split into sub groups and did not use the tool or work together again.
Noted positive elements of tool[1]	None noted.	One participant liked the library of measures and placing them on the map	Several positive comments about library of measures	One appreciative comment that tool was "very visual"
Noted negative elements of tool[2]	Process was chaotic, long and lacked structure. Tool's inability to include aesthetic and qualitative elements was problematic.	Distrust of tool's evaluations, difficulty familiarizing with tool, dislike of the tool, "too generic for local adaptation"	Several remarks about difficulty getting results from tool (bugs, usability), tool limited creative thinking about solutions.	Difficulty familiarizing and using the tool, found it "distracting".
Perception of the design	Low satisfaction with the technical quality.	Moderate satisfaction with design, low satisfaction with technical quality.	Satisfaction with the design and its technical quality.	Negative view of the design and its technical quality.

1. This was explicitly asked only in 2016. Some unsolicited comments were made in 2015 and are also included.
2. This was explicitly asked only in 2016. Some unsolicited comments were made in 2015 and are also included.

or holistic designs. AST plans tended to show a low focus on integration and there was little consideration for connectivity of plans or measures between different spatial scales. The latter is likely due, in part, to the visual framing of the project area by the map table. Two of the four AST groups used values provided by the tool's evaluations to justify their designs. Satisfaction with the designs and their technical quality was low. Overall, these results indicate that the AST supports finding technical solutions for a defined project area and objective. This is consistent with the intended use of the tool (Ven et al., 2016).

Responses to the tool itself were mixed. The interactive library of measures that is part of the AST library was reviewed positively. Participants appreciated seeing different options and being able to read descriptions, see pictures, and learn about different measures. There were also positive responses to being able to place measures on the map and visualize the plan. These responses indicate a kind of individual learning occurred, which was not included in our evaluations. The negative responses to the AST can be categorized as complaints that the tool limited creativity, and problems with usability. The former came mostly from participants with an urban planning background, who preferred drawing to using the tool. Planners found drawing an easier and more effective way to communicate. Complaints about usability stem in part from the fact that the tool was operated by the students instead of their facilitators (as per instructions), and from periodic problems with the internet connection (the AST is web-based). Participants also expressed doubts about the trustworthiness of the tool's results.

Currently there is no way to include non-technical measures or values in the tool or its evaluations. This was a problem for the 2015 group, when urban planners could not show the aesthetic value of measures they preferred over more technically effective measures that were favored by engineers. Similarly, because it is not possible to enter new measures into the tool, only the existing measures can be accounted for in the evaluation of costs and effects. This was a problem in 2016, when AST Group 3 chose to do their own evaluations instead of using the tool, because it did not include a measure they wanted to use. Despite the fact that the AST does not contain non-technical measures or evaluation metrics, and seems to create a technical frame for adaptation, social issues were identified as important in survey responses and designs of AST groups in 2015 and 2016. This is attributed to group discussions in the design process and preconceived ideas of urban systems.

There is no formalized process for using the AST in practice; it is used in different ways to adapt to the needs and conditions of different cases. However, in its most complete application, the AST can be used to understand an area using the map interface, explore possible adaptation measures in the library, compare the effectiveness and costs of different measures using the tool's assessment functions, and finally, develop an informed plan in the tool's map interface. In the experimental workshops, different groups used the tool in different ways and at different points in their design process. The 2015 AST group used the tool most fully. This group reported a contentious process, in which engineers used the technical measures and evaluations provided by the tool to pressure urban planners, who could not offer quantified impacts on values like creating community space and aesthetic quality. The different ways that groups used the tool in their design process shows that it is flexible to different processes or steps in design; however, there was a tendency for groups to divide during the workshop, instead of working together.

As previously mentioned, during the experiments, facilitation of the tool was deliberately minimal and students operated the tool themselves, except when technical support was needed. This may account for some of the participants' negative perceptions, such as poor usability, low satisfaction with the results, and doubts about the trustworthiness of the tool. The minimal facilitation cannot account for other issues, namely limiting creativity and the inability to add new measures or include different evaluation metrics. Since the tool was not used with expert guidance, with process support from facilitators, or with real stakeholders, results likely show more drawbacks and fewer benefits than can be expected in real, facilitated workshops. However, none of the tools were used in their full capacity in the workshop.

2.4.3 Stress Test Guideline

From Table 4, the change in priorities for STG groups vary from slightly above to well below average. Convergence in language and themes is consistently low, with no shared descriptions of design. Overall these results do not suggest that the STG reliably supports the development of shared understanding or learning.

In all groups in 2015 and 2016, the survey responses and plans are notably technical in their focus. STG groups missed integrated thinking and consideration of social factors, but did not recognize this or express concern about the breadth or depth of their designs. In fact, satisfaction with the designs and their technical quality is particularly high in STG groups. Moreover, the guideline was also widely liked by participants, who found it a useful way to structure work. The stepwise approach and particularly the vulnerability assessment were most valued.

Table 4. Results for Stress Test Guideline groups, reported per group, per experiment

Year	**2015**		**2016**
STG group	**1**	**2**	**1**
Mean change in priorities per group	50%	63%	22%
Development of thematic topics in the group	Weak themes, no shared description of design	Weak themes, no shared description of design	Some weak themes, no shared description of design
Development of shared language in the group	Low convergence in language	Low convergence in language	Notably low convergence in language
Ways of working	Vulnerability analysis and prescribed steps were central to organizing work. Groups used divide and conquer approach to complete challenge. No overarching or systems view of problems. No strategic or integrated thinking about solutions.		Worked as group, following steps.
Noted positive elements of tool[1]	Logic from the guideline steps gives confidence in outcomes, despite the lack of data and time for analyses	Efficient way of organizing work given the time and data available. Learning reported through interdisciplinary work.	Stepwise guidance was helpful for organizing work
Noted negative elements of tool[2]	None noted	Lack of ability to analyse effectiveness of measures	Urban planner felt guide limited creative thinking
Perception of the design	High satisfaction with design and technical quality	High satisfaction with design and technical quality	Satisfaction with design

1. This was explicitly asked only in 2016. Some unsolicited comments were made in 2015 and are also included.
2. This was explicitly asked only in 2016. Some unsolicited comments were made in 2015 and are also included.

Group work was organized around the steps given in the guideline. STG groups experienced little conflict, but mostly divided tasks by the prescribed steps and worked individually or in sub-groups. These groups did not take strategic or systemic views of the problems or solutions. It seems that following the steps of the guideline does not promote analytic or reflective group processes like problem structuring and knowledge negotiation.

The positive perceptions of group designs and the tool in use are attributed to the assurance provided by the structure of the guideline. In other words, knowing how to organize the process and what steps to take next leaves participants feeling confident in their work and its products. This confidence may come at the cost of critical reflection by the group.

2.4.4 Group Model Building

Table 5. Results for Group Model Building groups, reported per group, per experiment

Year	**2015**		**2016**	
GMB group	**1**	**2**	**1**	**2**
Mean change in priorities per group, over modelling session	88%	75%	50%	86%
Mean change in priorities per group, over design session	67%	67%	22%	62%
Development of thematic topics in the group	Strong convergence. Stronger after the modelling session than after design.	Very strong convergence in themes after modelling session and in description of design.	Strong convergence after modelling session, some divergence after the design phase. Group started with many common topics.	Very strong convergence, slightly more so after modelling and in description of design. Group started with no overlapping topics.
Development of shared language in the group	Convergence in language.	Strong convergence in language.	Convergence in language.	Very strong convergence in language throughout workshop.
Ways of working	All GMB groups used the models to identify key problems and drivers in the system, and as a basis for solutions. All GMB groups notably continued to work as a group during the design phase, after their modelling session. All GMB groups took a strategic approach to their designs.			
Noted positive elements of tool[1]	None noted.	None noted.	Very positive response to discussions in modelling process, relating issues and using the model to find solutions.	Very positive response to building the model, the model itself and the group discussions.
Noted negative elements of tool[2]	None noted.	One comment about lacking information about measures and their effectiveness, too many assumptions.	Some found process scattered and messy.	One comment that the model was "a bit confusing, at the end".
Perception of the design	General satisfaction with the design, slightly lower for technical quality. Shared justifications for view of the design.	High satisfaction with the design, some doubts about the technical quality.	Satisfaction with design and technical quality.	Positive and shared view of the design and technical quality. Some comments that it was not very technical, but did not see this as a problem.

1. This was explicitly asked only in 2016. Some unsolicited comments were made in 2015 and are also included.
2. This was explicitly asked only in 2016. Some unsolicited comments were made in 2015 and are also included.

There is a notably high change in priorities for GMB groups. Convergence in thematic topics and shared language is also consistently present and particularly strong in these groups. The data show that convergence tended to peak during the modelling session, and reduce slightly during the design phase. The high change in priorities, strong convergence and shared descriptions of design all indicate that GMB supports learning and the development of shared understanding. These findings are consistent with the aim of GMB, which was developed to create shared understanding through social learning (Vennix, 1996; Voinov and Bousquet, 2010). However, it is unclear from our findings if the effects on learning and shared understanding last beyond the modelling session.

In 2016, the first questionnaires for GMB Group 1 show remarkably strong common topics and few "loose end" topics. The low change in priorities for this group is due to this common starting point. In the same year, the first questionnaires of GMB Group 2 show not a single common topic and myriad loose ends. In the second survey, after modelling, however, both groups show strong common themes and language. This indicates that GMB is a robust tool for developing learning and shared understanding, given different starting points.

GMB groups cooperated well in the facilitated modelling sessions and continued working as groups during the design phase. GMB groups were not instructed to use their models during the design phase, but all groups reported finding it a useful way to understand system drivers and identify solutions. The models were particularly useful for identifying multiple-benefit solutions. In one GMB group each year, there were notably dominant and outspoken participants. In both cases, the priorities of these participants did not dictate their group's themes or discussions, and the facilitators were able to make space for all group members to contribute. Participants in GMB groups liked the tool and reported positive experiences with it. These results indicate that GMB supports successful participation during the activity and can be used to manage interpersonal dynamics in groups with different kinds of participants. Overall, these results suggest that GMB creates strong collaborative group work that is valued by participants.

By coincidence, GMB Group 2 in both years had less experienced facilitators, who were observed to have weaker skills and less confidence than the facilitators for GMB Group 1. This is a possible reason for the slightly lower convergence in thematic topics and language in the GMB Group 2. It could also explain the higher satisfaction and more positive experiences in the groups with better facilitation. The quality of

facilitation appears to be important for results, in terms of learning effects and shared understanding, as well as for the positive perception of the tool and experience with the process. This is consistent with GMB theory and practice (Vennix, 1999).

The survey responses, models and plans from GMB groups show holistic views of the problems and integrated thinking in the designs. The technical detail of the plans was typically low, but physical systems and technical solutions are included in GMB group plans. Participants reported that lack of data and information input in the GMB process, particularly about the urban system, climate change impacts and the effectiveness of different measures, limited their technical designs and analyses. These effects are believed to be accentuated in the experimental workshops because participants did not have the local knowledge and expertise of real stakeholder that is a cornerstone of GMB practice (Berard, 2010; Vennix, 1999). A second issue for participants was the reduced time for design due to the modelling session. A real application of GMB should allow more time for modelling, information gathering and design, either in multiple sessions or in supplementary work before and after a session. Even so, satisfaction with the designs and their technical quality did not seem to suffer from the qualitative GMB approach. Participants reported positively on their work products and felt the quality of their conceptual designs was more important than the technical details. GMB appears to support integrated and holistic plans that lack technical detail, but are widely supported by participants.

2.5 Implications of the findings

It is not the purpose of this study to label particular tools as "good" or "bad", but to observe them in use and draw comparisons. The results of our study indicate that different tools lead to different types of participation during the activity, and yield different types of results and effects. The implication is that different tools may be suitable under different input conditions, or to achieve different objectives. This is consistent with participatory policy analysis theory (Geurts and Joldersma, 2001). In this section we make a comparative analysis of the tools evaluated, propose preliminary insights for practice, and reflect on our metrics and experimental approach.

2.5.1 Comparative analysis of the tools

In the following table a comparison of the tools is summarized for each metric. Despite the limitations of an experimental context, our findings offer some insights for using the tools in practice.

Table 6. Comparison of the performance for the three tools and tool-free approach, reported by evaluation metric

Metric	Tool-free Approach	Adaptation Support Tool	Stress Test Guideline	Group Model Building
Learning effects	Consistently no effect on learning.	Consistently no effect on learning measured, but indications of other types of learning	Mixed results, but it does not appear to support greater than average learning.	Strongest and most consistent results creating learning.
Development of shared understanding	Consistently no effect on creating shared understanding.	Some mixed results, but does not seem to support creation of shared understanding.	Consistently no effect on creating shared understanding.	Strongest and most consistent results creating shared understanding.
Work products developed in the activity	Technical focus, with some attempt to include non-technical issues and solutions. No strategic approach, mixed feelings about designs and technical quality. Low confidence in results.	Plans tended to be technical and pragmatic, but participants recognized more holistic issues than they were able to incorporate in the design. Satisfaction was lowest.	Most technical and narrow designs, without strategic approach or holistic planning, but highest satisfaction with designs and technical quality.	Most holistic and integrated plans, consistent use of strategic planning approach, technical detail was low, but satisfaction was relatively high.
Nature of participation during the activity	Difficulty working as groups, low confidence and satisfaction in process.	Most diverse group processes; tool can be useful in different ways. Some groups struggled working together and satisfaction in the process was low.	Shallow level of cooperation, but most positive responses from participants.	Strongest cooperation in groups; consistently positive participation during the activity. Second most positive responses from participants.

Tool-free Approach

The TA does not offer benefits compared to the tool-based approaches that we evaluated. The TA's lack of structure is unlikely to lead to new, creative or innovative approaches to design, but leaves groups frustrated and vulnerable to pitfalls, which may result in poor adaptation plans and participatory processes. Based purely on these findings, TA does not seem advisable.

Adaptation Support Tool

The AST is a suitable tool for exploring technical, spatial adaptation solutions. The AST can help groups develop conceptual plans for a well-defined adaptation problem, in a delineated area. The library of measures is useful for learning about potential adaptation measures, but it may limit thinking "outside the box". Similarly,

the map-based interface seems to focus groups on the single spatial scale shown in the tool for the selected case. The facilitation of the tool, the way groups use it, and the interpersonal dynamic in groups appear to be important for ensuring a positive experiences for users.

Stress Test Guideline

The STG is a suitable tool for structuring adaptation planning when process and positive experience are important. The vulnerabilities and opportunities analysis that is central to STG has a unifying effect on groups and directs the planning focus. However, careful consideration should be given to ensuring that "going through the steps" does not replace thorough reflection and analysis by the group.

Group Model Building

GMB seems to be a suitable tool for exploring adaptation from a problem, or systems starting point. This tool appears useful in situations where vulnerable or less vocal stakeholders are participating, or when learning and the development of shared understanding are a priority. GMB also seems a good choice for developing holistic and integrated plans, and dealing with ill-defined or complex problems. Trained facilitators are important to the success of this tool, and consideration should be given to the role of knowledge and information if GMB is used to support technical designs.

2.5.2 Preliminary insights for practice

Due to the multi-faceted nature of tools and the experimental setting of our workshops we do not extrapolate our findings to other tools. However, we share the following insights, which may be useful when considering tools for participatory adaptation planning activities.

Process and content in activities

GMB and STG are characterized by structured processes that offer guidance in how to approach the challenge at hand. These tools produced the highest satisfaction among participants, in terms of their experiences with the tools and the quality of the work products. GMB and STG group work was also cooperative and exhibited low conflict. By contrast, the AST, which provides markedly more content than the other tools, with its library of measures, map interface and evaluative functions, produced low satisfaction and less cooperative groups in the minimally facilitated setting of our experimental workshops. In these aspects, results from the AST are in line with the TA groups. These results are surprising because the AST offers the information and evaluative capacity that participants in other groups reported missing. Furthermore,

experience in real-world facilitated AST workshops has been positive, as reported by Ven et al. (2016). However, taken together, the results of all four tools suggest that when it comes to participants' experiences and perceptions of the work products, the process of a participatory activity may be more important than the content. There are two important points to keep in mind with respect to this proposition. First, a structured process may influence the *perception* of an activity and its work products, but it does not appear to influence the actual *quality* of the outcomes (e.g. plans) or the effects on learning or shared understanding. We see this in the results of GMB and STG groups, which, despite sharing high satisfaction and cooperative groups, have starkly different results in learning, shared understanding and types of work products. Similarly, AST groups had technical evidence-based designs, but reported low satisfaction with their quality. Second, the simulated nature and relatively short time frame of the experimental workshops may mean that the content was undervalued by participants, when compared to stakeholders faced with making decisions in a real case. To further explore these findings, research and evaluations of participatory activities in actual planning processes are needed. Nevertheless, the implication of our findings is that tools that include a structured process for participation will lead to more positive experiences of activities and perceptions of the work products.

Flexibility of tools

The AST offers a library of adaptation measures with information about the effectiveness and costs of each. While the library feature was valued by participants for learning about different measures, these groups reported that it "restricted" their options in planning. The inability to include new factors and measures was a felt constraint, as were the fixed indicators used in the evaluative function. Groups using other tools did not report valuing the flexibility of their tools, but did not make the same complaints about feeling restricted by limitations of their tools. This finding suggests that participants value tools that are flexible enough to represent the full array of factors, solutions and values that arise in participatory planning activities. However, when comparing the constraints of the AST with the flexibility of GMB, for example, there is a trade-off between the former's capacity to quantify and provide evidence for decision making, and the latter's capacity to freely reflect the ideas of the group, but without content and without a check on the correctness of assumptions and conclusions. Quantification and flexibility are not mutually exclusive, but practical limits on what can be included in models often result in this trade-off. Participants do not seem aware that the advantage of content and quantification comes at the cost of some flexibility.

Facilitation of activities

In GMB the facilitation of the modelling is part of the tool. For this reason, GMB groups had the most active facilitation during the workshop. Successful facilitation was observed to influence the way GMB groups worked together, compared to groups using other tools. In GMB groups, facilitators ensured dominant group members did not take over the group discussions and actively encouraged quieter group members to contribute. This established more equal participation and communication during the modelling session, which carried over into the design phase of the workshop. GMB group members reported high satisfaction with their experiences and with their ability to address their individual stakeholder aims within their groups. The fact that facilitation can play an important role in the process and individual's experiences in participatory planning activities is not a surprising finding. However the implication is that facilitation could be especially important in groups where some participants may be less comfortable speaking up and contributing to the activity.

Effects of visualization

Both GMB and the AST involve a visual element, which appears to influence a group's perceptions of a problem and the plans they develop. The causal loop diagrams that are created in GMB sessions provide a visualization of the factors and the relations that the group finds important to the system dynamics. The GMB diagrams created in the workshops were complex and dense with causal relations. While these models were not visually clear or easily digestible, GMB groups appeared to view the design challenge in a more holistic and integrated way than other groups. The plans proposed by GMB groups reflect this perspective, in their strategic quality, their inclusion of different spatial and time scales, and their use of social and technical solutions. In the AST delineating a project area in the map interface is the first step of using the tool. The measures selected from the library can be taken within the project area. In their problem understanding and adaptation plans, AST groups focused on the spatial scale that was shown in the tool. These groups did not use the zooming feature to analyse problems or solutions at the larger (city or greater) or smaller (building or individual) levels. Both GMB and the AST are used in processes that reflect the visual element of the respective tool. Therefore, we cannot say how much of the framing comes from the process supported by the tool and how much from the visual element of the tool. Our impression is that both factors play a role.

In practice, the weakness of one tool may be compensated by formal or informal modifications during an activity or in other steps of a participatory process. For example, data and technical experts included in a GMB session could support more

informed and technical designs. An overview of AST applications found that process support was important in certain contexts (van de Ven et al., 2016), which is consistent with our findings. Such modifications could change the relative differences between tools that were measured in the experiments. However, the experimental results give valuable insights into what kinds of modifications are needed to enhance the use of different kinds of tools in practice. Research into the effects of such modifications during activities or within longer participatory processes would provide useful insights.

2.5.3 Usefulness and suitability of the metrics

We found the four metrics used in our evaluations to produce consistent and measurable results in the experimental context, and to be useful for capturing differences between groups that used different tools. Importantly, for the experimental setting, the metrics could be measured efficiently, with minimal time and effort required from participants.

Despite the usefulness of the metrics, we consider the measurements for learning effects require improvement. Our surveys captured the mean change in priorities and the development of shared language within a group. We took these as indicators of learning, based on simplified practices from Group Model Building (Fokkinga et al., 2009; Rouwette et al., 2016). Though efficient and informative, we consider our measurements to be too limited in scope. Our evaluation focused on learning at a system level, and on changes in mental models, but overlooked other important types of learning. For example, our measurements did not capture if participants in AST groups learned about different adaptation measures through use of the tool's library of measures and evaluations. Such learning would constitute valuable capacity building. In future studies, learning would need to be measured in a way that is equally applicable to different types of tools and can capture broader learning effects.

In contrast, the remaining metrics (the development of shared understanding, the nature of participation during the activity, and the work products) were found to be effective in the experimental context, and equally suited to the tools evaluated.

2.5.4 Reflection on the experimental approach

The experimental approach was a useful and efficient way of making observations and comparisons between different tools in use. However, the choice to use experiments for our evaluations has implications for our results. We found the following three factors to be most important: first, using a simulated workshop in place of real planning activities, second, having student participants in the workshops instead of real stakeholders, and third, using the tools in a limited and controlled way.

Simulated workshops

Using simulated workshops afforded the substantial advantage of replication. Having multiple comparable groups use each tool on the same case to address the same design challenge was particularly helpful in identifying patterns in the data. The repeated use of each tool with different groups also strengthened our understanding and claims of attribution.

One drawback of using simulated workshops was the limited time available for groups to become familiar with the case and the tool being used, and to develop a plan. This affected groups differently. For example, AST groups reported the most problems learning how to use their tool, while the modeling session for GMB groups left them with less time for design. Real cases, of course, are rarely ideal and there is often limited time for collecting information, developing designs and learning. A second drawback of using simulated workshops was that our group formation could not control for group dynamics based on individual personalities. It is clear that the individuals making up a group are important for the nature of participation, and, to some extent, the work products and effects, like learning (Muro and Jeffrey, 2008). This is true for our experimental setting and the real world. To account for differences in group dynamics in our evaluations, we used observations and group records, as well as the replications of the workshop for each tool.

Student participants

Using student participants in the experiments had two important advantages. First, there were enough participants with comparable backgrounds to carry out multiple workshops with each tool. This allowed us to surface consistent differences between tools. Second, the make-up of postgraduate students from Delft University of Technology's faculties of Civil Engineering, Architecture and Technology, Policy and Management ensured that the participants were knowledgeable about the subject matter covered in the design challenge and were familiar with most of the prescribed stakeholder roles and the Dutch context (even international students had at least one year post-graduate work in the Netherlands, prior to the workshop).

However, despite their academic backgrounds and the provision of information about the case and stakeholder roles, the student participants lacked local, embodied knowledge and true stakes in the case. This is important for our results, because to achieve effects like learning some tools rely more heavily than others on stakeholders bringing and sharing their knowledge. This is the case for the AST, which claims that the dialogue between local stakeholders and technical experts creates learning and

locally appropriate and informed designs (van de Ven et al., 2016). The implication is that, when used with real stakeholders, such tools should perform better in some respects than the experimental results would suggest. If true, this could take two forms: first, individual tools could perform better or worse relative to one another; or, second, all tools could perform consistently better with real stakeholders and the relative differences observed between the tools in the experiments remains.

A further challenge from using student participants was their backgrounds. As post-graduate students at a technical university, the participants' backgrounds were better suited to some stakeholder roles than others. For example, water management students felt more confident representing the local water authority than a business owner. Despite studying in different faculties, the students shared a common baseline of knowledge and skills that is not necessarily representative of all participants in planning workshops. While different nationalities, cultures, languages and genders were represented in the groups, diversity in social background and education was minimal. These conditions keep us from extrapolating our findings to the broader general public. However, the type of planning workshops we simulated do include participants with similar backgrounds to the students, therefore, for our purposes, we found the students an acceptable if imperfect substitute for real stakeholders.

Use of tools

Given the nature of the experimental approach, the tools were applied in a limited capacity, compared to their intended use in real cases. This was due to time constraints, the need for the activities of groups using different tools to be comparable, and the use of student participants in an assigned design challenge. The limitations for the different tools were comparable, but not the same. This may influence the results for each tool differently. For example, GMB usually consists of more than one session to develop and validate a system model, while the AST is normally facilitated by an adaptation planning expert, who supports the design discussions and process. Because the experimental results for each tool may be affected in different ways, it is conceivable that the performance of the individual tools, and the relative differences that were observed between them, could change in full applications. However, we argue that the basic characteristics of both the tools and their influence on the participatory activities as measured in this study are representative and we expect them to hold true in real cases.

One shared limitation in the way the tools were used in the experimental workshops is that the activities were evaluated in isolation of a larger participatory planning

process. This allowed us to observe and compare tools without the complicating contextual factors of real cases, and to make claims about the influence of tools, but it limits the meaning of our results. We cannot make claims on how or whether the differences observed between tools in participatory activities affect real participatory planning processes. Our results, therefore, do not conclusively disprove Hassenforder et al.'s 2015 hypothesis that tools are interchangeable, as we have not followed the influence of the different tools through longer participatory planning processes. It is possible that the differences observed at the resolution of a participatory activity are equalized, or change, over the course of a planning process. Additionally, there are many influences on participatory processes that may change the ultimate outcomes but are not considered within the scope of this research. Nevertheless, based on our conceptualization of participatory activities within a participatory planning process (Figure 5), it seems reasonable to infer that significant differences in the results and effects of the activities would influence subsequent stages in planning.

2.6 Conclusions

In this study we evaluated different tools used in participatory activities for urban adaptation planning. Specifically, our focus lay on activities that engage stakeholders, such as water authorities, planning departments, local residents and businesses in structured participatory adaptation workshops in the conceptual phase of planning. While our findings are limited by the constraints of the experimental setting, the results suggest that tools are not "easily replaceable" (Hassenforder et al., 2015, p. 91) at the resolution of participatory activities. In fact, when comparing different tools, there appear to be important differences both in how a participatory activity plays out, and the kinds of results and effects that are created. These differences likely influence the longer participatory planning processes of which the participatory activities are a part. However, in-situ studies linking the evaluation of tools, in real activities and processes would provide useful insights into whether differences observed at the resolution of activities propagate through overarching planning processes. Furthermore, such studies would address the complexities of real cases and stakeholders, and offer important contributions to participatory planning practice. If tools are interchangeable in a participatory process, there is no need to invest time and resources in developing "better" ones. If, however, tools are not interchangeable, practitioners, researchers and tool developers need more information on how tools can support the intended outcomes. In the meantime, our results suggest that those engaged in the organization or study of participatory adaptation planning activities,

such as stakeholder workshops, should give consideration to the characteristics of their tools, and their suitability to specific cases and conditions.

3

Effects of a planning support tool on a workshop and planning process: a case study from Berlin, Germany

The contents of this chapter have been submitted for publication in *Sustainability*: McEvoy, S., van de Ven, F.H., Brolsma, R., Slinger, J.H., *submitted*. Evaluating the effects of a Planning Support System on a workshop and planning process for urban adaptation in Berlin, Germany

Supplementary material for this chapter is presented in Appendix B.

In the previous chapter, experimental results indicated that a planning support tool's characteristics influence how a workshop plays out and the types of outcomes that are achieved. The results also indicated that among the tools tested, the Adaptation Support Tool (AST) did not stand out on any performance metric. However, experiments, such as simulated workshops, are limited in their capacity to represent real stakeholders and decision making. It was argued that the AST may be more valued in real workshop settings, as the substantive content it provides would be more useful to users making decisions. This motivated an in-depth evaluation of the AST's use and effects over time.

Current planning support tool research has focused on the effects of tools within workshop settings, such as improving communication between participants and creating learning. However, effects of tool use on the planning processes in which workshops take place have so far not been evaluated in a methodical way. To address this gap, a longitudinal case study was made of a collaborative planning workshop in Berlin, Germany, which made use of the AST. The aim of this chapter is to present the results of the case study and to contribute to answering the first and third research questions of this dissertation.

The remainder of this chapter comprises six sections. First, the current state of evaluating planning support tools and a list of challenges are summarized in Section 3.1. Next, the conceptual framework of tool use introduced in Chapter 2 is elaborated and operationalized for evaluating tools in a longitudinal case study in Section 3.2. The research design, including the case study description, and research methods are then introduced in 3.3. The results are presented 3.4 and discussed 3.5. Finally, conclusions are drawn in Section 3.6.

Abstract

Tools used to support collaborative planning workshops are increasingly employed in urban adaptation practice. Research has focused on developing such tools and evaluating their use in workshops, but has not measured tools' effects over time on the planning process, on the participants involved, and on the final outcomes. The role that tools play in adaptation planning, therefore, remains unclear. A longitudinal case study was made to evaluate a planning support tool (the Adaptation Support Tool) in a design workshop for sustainable urban water management, in Berlin, Germany. The case study also served to test an evaluation framework and to generate insights regarding systematic evaluations of tools in planning processes. The case study was carried out over eighteen months, to capture both the details of the workshop and its longer term effects on the project and participants. Our results show that the tool's most evident effects were 1) contributory and less tangible in nature (e.g. supporting learning), than directly causal and concrete (e.g. influencing the planning process), and 2) a function of the larger planning process and context in which the workshop took place. This study demonstrates that making systematic, longitudinal evaluations is valuable for studying the role of tools in adaptation planning.

3.1 Introduction

The unique challenges of climate change for cities have been recognized for some time, and have inspired the burgeoning field of research and practice in adaptation planning (Anguelovski et al., 2014; Masson et al., 2014). Adaptation planning is a complex undertaking, involving existing structures and infrastructures, interconnected urban systems, and myriad public and private stakeholders (Anguelovski et al., 2014; Eikelboom and Janssen, 2017; Mayer et al., 2005). As such, adaptation planning is inherently spatial, and deeply political (Eikelboom and Janssen, 2017; Henstra, 2016). Engaging stakeholders in the planning process is widely viewed as necessary to address the complexity and multi-actor nature of urban adaptation (Anguelovski et al., 2014; van de Ven et al., 2016). To this end, collaborative planning workshops are often held in the preliminary phases of a project, with the intention of building relationships between stakeholders, exchanging knowledge and views, clarifying problems, and identifying mutually acceptable and technically viable solutions (van de Ven et al., 2016). Whatever the aims of a specific workshop, ultimately, collaborative planning workshops are meant to positively affect the larger planning process of the adaptation project, the participants involved, and the final outcomes.

Collaborative planning workshops often make use of tools to support the way of working and the quality of the work products and other outcomes, such as learning (Al-Kodmany, 1999; Geurts and Joldersma, 2001; Pelzer et al., 2014). A variety of tools are used for providing information, structuring interdisciplinary communication, promoting learning and shared understanding, and for documenting discussions and results (Geertman et al., 2013). Planning Support Systems (PSS) are one type of tool, defined as "geo-information based tools intended to support planners in planning tasks such as information handling, communication and analysis in planning processes" (Vonk and Geertman, 2008). Despite the longstanding development and use of planning support tools and PSS, more specifically, the role they play in real collaborative planning workshops, and their effect on the planning process, on the participants involved, and on the final outcomes are not well documented.

Presently, evaluations of planning support tools are rare and those carried out reveal a number of shortcomings (Midgley et al., 2013; Rowe, 2004; Rowe and Frewer, 2000). Evaluations are often simple reflections of the workshop facilitators or organizers, and while these assessments can be insightful for a specific tool and application, they are usually not objective nor systematic enough to offer reliable or comparable results (Innes and Booher, 1999; Midgley et al., 2013). Furthermore, tools are often evaluated by the developers themselves and in workshops designed for the purpose of testing a particular tool (see for instance Arciniegas and Janssen, 2012; Mayer et al., 2005; Sellberg et al., 2015), calling into question how well the conditions represent typical planning workshops and how independent the evaluations are in relation to their application context and evaluator. More rigorous evaluations are sometimes made in laboratory settings. While this approach offers the benefits of relatively controlled conditions and repeated exercises, the results are limited by not using real stakeholders faced with consequential decisions (Arciniegas et al., 2013; Eikelboom and Janssen, 2017; Pelzer et al., 2016; te Brömmelstroet, 2015). In all of these cases, by focusing the evaluations only on the workshop and the tool, the results fail to capture longer term effects on planning processes, and on participants involved (Midgley et al., 2013). In contrast, the body of research on evaluating planning processes, particularly participatory ones, focusses on the big picture of a project or program, and fails to distinguish the influence of an individual tool used in a specific workshop (see for instance Abelson et al., 2003; Hassenforder et al., 2015), which may be one of many activities over the course of a planning process.

There is good reason for the shortcomings in current evaluations: evaluating the role of tools in adaptation planning is a challenging undertaking. While a tool may

play a vital role in a collaborative planning workshop at the start of a project, over time many factors will influence the planning process, the participants, and eventual outcomes. Identifying and teasing out elements that can be attributed in part or in full to a tool used in a workshop is no small task (Midgley et al., 2013). Furthermore, given the importance of less tangible outcomes in adaptation and collaborative planning, evaluation requires capturing hard-to-measure effects, like learning, moving the needle on certain topics, forming shared strategies, and creating spinoff initiatives (Innes and Booher, 1999). Together, these conditions lead to three challenges for evaluation:

1. Making evaluations specific enough to be locally meaningful, yet generic enough to offer broadly useful and usable insights for research and practice.
2. Making evaluations flexible enough to capture locally relevant factors, and unintended and unexpected effects, yet structured enough to be recognizable and comparable.
3. Capturing both the details of a tool used in a workshop, and the longer term global effects on the planning process, the participants and the outcomes.

There is a clear need to better understand the role of tools being used to support collaborative planning workshops in urban adaptation. Such knowledge will provide valuable insights to practice, and feedback to theory (Eikelboom and Janssen, 2017; Pelzer et al., 2014). The focus of our research is to understand how tools used in collaborative planning workshops influence these activities and their outcomes, and how such evaluations can be carried out. To this end, we undertook a single longitudinal case study of a collaborative adaptation planning workshop in Moabit West, a district of Berlin, Germany, which made use of a PSS called the Adaptation Support Tool (AST).

3.2 Conceptual framework of analysis

The use of a collaborative planning support tool can be conceptualized as nested within an activity, such as a workshop, that occurs during a planning process, which itself takes place within a larger context (McEvoy et al., 2018). Understanding the role of a tool requires examining these different layers and their inter-relations. Literature offers useful frameworks for evaluating participatory planning processes (Abelson et al., 2003; Hassenforder et al, 2015 among others), and individual activities (see Jones et al., 2009; Midgley et al., 2013; Rowe, 2004; Rowe and Frewer, 2000; Thissen and Twaalfhoven, 2001). However, we are unaware of a framework that accounts for the nested nature of tool use that is needed to study the role of planning support tools in

workshops. Another requirement of our framework is that it be useful for evaluating not only PSS, but other types of planning support tools.

We took a pragmatic approach to developing a framework for our aims, by borrowing from the existing frameworks for evaluating activities and processes. Here, we found a useful starting point in the conceptual structure of Thissen and Twaalfhoven's (2001) framework for evaluating policy analytic activities, which they define as "a specific analytic effort delimited in time and scope and oriented towards a specific policy issue" (p. 628). This framework identifies six factors from literature for evaluating activities: 1) the **input** to the activity, 2) the **process** of the activity, 3) the substantive **content** in the activity, 4) the **results** of the activity, 5) the **use** of results, and 6) the **effects** of the activity. We selected this framework as a starting point, because it explicitly links the input and the activity with the results and effects. This reflects our fundamental assumption of the relations between what happens in an activity (workshop) and the outcomes. Furthermore, this framework distinguishes between the process and content of an activity, which is useful for evaluating a tool-based workshop, as tools, and particularly PSS, aim to support both aspects (Pelzer et al., 2014). The original framework, however, is incomplete for our aims, as it focuses only on the activity, or workshop layer, and does not differentiate the tool used within the activity, nor does it explicitly account for the context or planning process in which the activity takes place. Nevertheless, if we take a collaborative planning workshop to be a policy analytic activity, we can use the structure of Thissen and Twaalfhoven's framework to look specifically at the role of the tool within each evaluation factor. We also add context to the framework. This leaves us with seven factors for evaluating the role of the tool, as detailed in Table 7.

3.3 Research design

3.3.1 Case study

The case study focuses on a workshop for designing sustainable urban water management measures in Moabit West, an area of the Moabit district in central Berlin, Germany (Figure 6). Moabit West faces pressures typical for Berlin and other European cities, namely the challenge of providing affordable housing to a growing population, supporting a dynamic economy, making systemic changes to address climate change (Climate KIC, n.d.), and adapting an already densely built environment (Green Moabit, 2013).

Table 7. Description of the evaluation factors, modified from Thissen and Twaalfhoven (2001)

Evaluation factors	
Context	The context in which a planning process and a specific activity take place has important implications for what can be achieved by a planning support tool (Geertman, 2006). Contextual factors can include political and physical conditions, social, technical and ecological systems, and what events have come before. The indicators for context are the most specific to an individual case, as what is relevant can vary significantly.
Input	The input to an activity encompasses everything that was provided to it, such as the data made available, the stakeholders related to the issue, and the objectives of the activity. Input to an activity is not to be confused with the input of participants during the activity, which is content.
Process	The process of an activity includes the procedures, communication and ways of working. This is not to be confused with the overall planning process, in which an activity takes place. Tools typically intend to support the process of the activity through improved interactions and communication.
Content	Content refers to the substantive material used during the activity, including data, information, knowledge, models, maps, perspectives and values that are shared by participants or provided by organizers. Planning support tools are typically an important source of substantive content.
Results	Results are the direct products and achievements of an activity, which include artefacts, like maps, models and planning documents, and less tangible outcomes like alliances and agreements. Tools are meant to improve the quality of workshop results through improved content and processes.
Use	The use of results includes the direct and indirect ways an activity's tangible and less tangible results are used over various time frames and by different actors, for different purposes. The use of results leads to effects and also captures the value and meaning of the results for different stakeholders.
Effects	Effects are the impacts of an activity on the system or actors involved. Assessing effects is complicated as they have different forms and are realized at different temporal and spatial scales. There are direct effects from an activity, such as learning and new relationships, and indirect effects through the use of results, such as influencing later decisions. Effects may be intended or unintended, and an activity may clearly be the cause of an effect, or only contribute to it. In adaptation and collaborative planning, less tangible effects, such as creating shared meaning, are as important as traditional more concrete ones (Innes and Booher, 1999; Mayer et al., 2005).

The design workshop studied in this research formed part of a larger project, Smart Sustainable District Moabit West (SSD-Moabit West) that was funded by Climate KIC and organized by CHORA Conscious City, at Berlin University of Technology (CCC-TUB). The SSD-Moabit West project focused on three themes: sustainable urban water management, energy efficiency and low-carbon mobility. The working groups for each theme included local public and private partners, European partners from Climate KIC's consortium, and the project managers at CCC-TUB. During the workshop, each working groups focused on finding pilot projects that could be implemented in Moabit West. A designated integration manager from CCC-TUB looked for opportunities to integrate the themes (more information at http://ssd-moabit.org)

The year-long project was initiated and designed by CCC-TUB and involved two Deep Dive Workshops between the local and European partners. The first workshop, in March 2016, addressed agenda setting, building relationships between the partners and deciding the role of the European partners. The second workshop, in September 2016, focused on designing pilot projects for each theme and exploring opportunities for integration. The event comprised:

- A short plenary introduction for all project partners and invited participants;
- Parallel half-day design sessions for each working group to propose pilot projects; and
- A plenary integration session to identify opportunities for collaboration between pilots from the different working groups.

The design session for the sustainable urban water management group (here forth: water group), forms the focus of this study and employed a PSS called the Adaptation Support Tool. A schedule of the day, activities, materials and outcomes is summarized in Appendix B.1.

Adaptation Support Tool

The Adaptation Support Tool (AST) is a web-based PSS for planning blue-green and grey spatial adaptation measures in the urban environment (Figure 7). The AST is designed for use in facilitated workshops, where groups of stakeholders co-create spatial adaptation plans at the neighbourhood to city scale. The tool is best used on large touch table, with groups of 5-10, where a facilitator guides the process of the

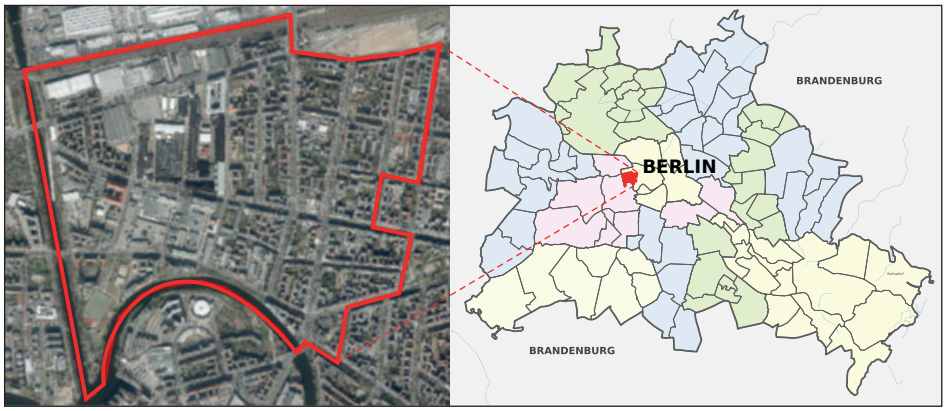

Figure 6. Map of case study location, Moabit West, Berlin, Germany. Modified from Sieker et al., 2016

design session, offers expert advice on adaptation measures, and provides technical support for the tool. More information on the AST can be found in van de Ven et al. (2016).

The touch table screen of the AST consists of three panels. The left panel is used for input, the middle panel contains a map window that is used for developing an adaptation plan, and the right panel shows output parameters in real time. Each panel is summarized below.

The input panel consists of a *Setup* tab to specify properties of the project area, e.g. soil type, land use, scale of interest. Based on the entered properties, a list of adaptation measures is generated from a library and ranked by applicability. This list is shown in a second tab *Measures* (Voskamp and van de Ven, 2015). For each measure in the library – currently 72 – information and pictures are provided by selecting an *Info* button.

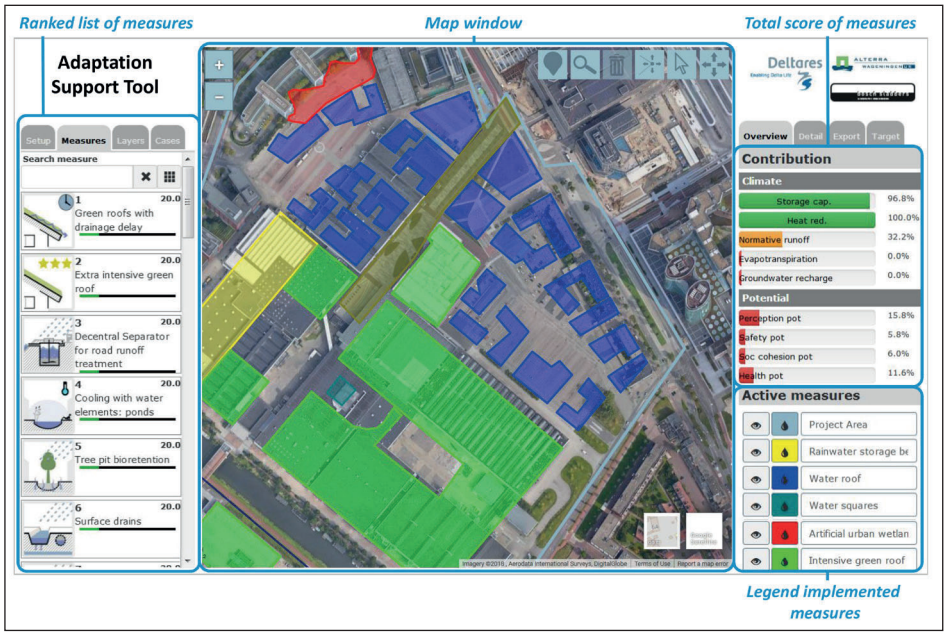

Figure 7. Interface of the Adaptation Support Tool and its three panels. The left panel includes the project set-up, the list of measures from the tool's library, and additional layers. The map window is where measures are implemented from the list. The right panel includes the quantitative indicators of the costs and effectiveness of the applied measures, detailed impacts per measure and the adaptation targets.

The map window contains base layers, like street and satellite view maps or aerial photographs, which are used for spatial reference. On top of these base layers, semi-transparent thematic maps can be displayed as overlays, like elevation, critical objects, and flood or heat maps. The layers help users understand the climate challenges in an area, and to choose effective locations for interventions. Selected measures can be applied in the map interface by drawing them as a polygon, line or point element. The estimated effectiveness and costs of the measure are then calculated, based on its dimensions, and the local properties and climate conditions. For more details on the models see Voskamp and van de Ven (2015) and van de Ven et al. (2016).

The output panel contains a legend of the measures that have been applied to the map and a list of key performance indicators: storage capacity, flood return period, heat stress reduction, drought reduction, water quality, and a first estimate of construction and maintenance costs. At the start of a workshop, targets are entered for each performance indicator and bar graphs are used to show the cumulative percentage of each target achieved. A second tab, *Details*, provides the quantified contribution of each measure that has been applied. Individual measures and combinations of measures can be quickly and easily compared for their effectiveness and costs.

Plans developed using the AST are intended as input for more detailed design efforts by water managers, urban planners and landscape architects. The added value of the AST lies in collaboratively developing ideas of possible measures and their locations, based on the dialogue of stakeholders, and informed by real-time, evidence-based feedback from the tool. AST sessions are meant to capture locally specific factors like acceptability, constraints and opportunities early in a planning process, and to create shared learning through dialogue and interaction with the tool (van de Ven et al., 2016).

3.3.2 Research methods

A case study approach provided an appropriate method for examining the role of a tool within a real planning process, where a holistic analysis promises the most useful insights (Yin, 2003). Accordingly, a single, exploratory, longitudinal case study was used to evaluate the role of the AST in the SSD-Moabit West sustainable urban water management design workshop and its longer term effects.

Evaluation factors

The evaluation factors are each operationalized by a number of indicators. These indicators were derived through a literature review and refined in the deductive and

inductive data analyses (Section 3.4.3). An extensive list of criteria provided by Thissen and Twaalfhoven (2001) served as a useful starting point for our choices. In this study we limit our selection to the indicators in Table 8. In choosing these indicators, we required that they be 1) general enough to be meaningful in most applications, 2) comprehensive enough to capture the elements germane to understanding the role of a tool, and 3) concise enough to support a pragmatic evaluation. Finally, our evaluation factors and indicators focus on the elements needed to understand the role of the tool within a workshop and planning process, as opposed to describing characteristics of a tool.

Table 8. The indicators used to operationalize each evaluation factor

Factors	Indicators
Context	Local setting; Institutional setting; Project structure and process
Input	Aim and role of activity; Organization of activity; Stakeholders and participants in activity
Process	Procedures of the activity; Communication during activity; Way of working during activity; Organization of the activity
Content	Quality and type of data and information used; Depth and breadth of the substantive content; Tool or methodology used in the activity
Results	Outcomes of the activity; Documentation of outcomes; Value and relevance of results for stakeholders
Use	Direct use of results; Indirect use of results; Unused activity results
Effects	Effects on learning; Effects on problem situation; Effects on planning process; Effects on decisions made; Intended effects

Data collection and types of data

In longitudinal case studies data is collected at more than one point in time to track changes in relevant factors (Yin, 2003). In this case study, the analysis was based on data collected over 18 months, in five phases:

1. Prior to the workshop (August –September 2016)
2. During the workshop (September 2016)
3. Immediately following the workshop (September 2016)
4. End of the project and final symposium event (December 2016 – January 2017)
5. One year following the end of the project (January – March 2018)

A table detailing the data collected in each phase is provided in Appendix B.2. A summary of the different types of data collected and how they were used is provided below:

- **Interviews.** 17 semi-structured interviews of one to three hours were carried out with the project management team and workshop participants. Audio recordings and written notes were transcribed for analysis.
- **Discussions.** In addition to the formal interviews, informal on-the-record discussions were used for confirming impressions and information, as well as asking for the views of a wider range of informants. Audio recordings and written notes were transcribed for analysis.
- **Documents.** A range of documents were reviewed, including planning documents, reports, websites, team emails, and work products.
- **Questionnaires.** A short questionnaire was taken by participants at the end of the design workshop. The questionnaire measured responses to the design workshop and the tool. The questionnaire included five-point Likert scale ratings and open questions (See Appendix B.3).
- **Observations.** Observations were made during the design workshop and at the project's final symposium event. Written notes were transcribed for analysis.

Data analysis

The data analysis comprised three steps, an inductive (thematic) analysis, a deductive analysis and a meta-analysis. Text analysis, using the software package Atlas.ti version 7.5.18 formed the primary method in the inductive and deductive analyses.

- **Inductive (thematic) analysis** was made first, to surface codes and themes that emerged from the case study. The codes were generic, as opposed to specific to the case. This choice reflects our intention to make the evaluation generalizable and therefore useful beyond this application.
- **Deductive analysis** was undertaken, using the pre-defined evaluation factors and a list of indicators from literature. The list of indicators (codes) was later refined to those listed in Table 8 (see Appendix B.4 for original list).
- **Meta-analysis** was used for two purposes. First, to compare the inductive and deductive analyses for differences and common findings. From this assessment a comprehensive list of themes and codes was created. Second, the meta-analysis was used to examine a number of indicators that were not well captured in text, yet were important for the evaluation, e.g. assessing the quality of work products.

The multiple data sources and three-part analysis were used to reduce bias in the evaluation and to strengthen the accuracy of the findings through triangulation (Creswell, 2003).

3.4 Results

The following section describes the findings for each evaluation factor and ends with a short reflection on the role of the tool, based on our analysis. We report results qualitatively and descriptively for two reasons. First, the small number of participants in our study and its inherently qualitative nature would make quantitative reporting unrepresentative and misleading. Second, most of our results are based on a combination of data sources, for instance questionnaires and interviews, which is not easily conveyed in graphical or quantitative formats.

3.4.1 Context

The indicators for evaluating context were surfaced primarily through the thematic analysis. The interviews and document reviews were particularly useful for evaluating context.

Local setting

The local setting is well described by earlier planning documents (See Green Moabit, 2013) and the district website (Quartiersmanagement Moabit West Beusselstraße, 2018). To summarize, industrial and commercial activity plays a central role in Moabit West and occupies much of the district's space. The area hosts roughly 400 companies and 10,000 workers, in manufacturing, logistics and services. Commercial properties are mostly leased and their surfaces are nearly completely sealed. Moabit West is also home to about 9,000 residents. This community has high rates of unemployment and poverty, and a large population of disadvantaged youth and immigrants. Cultural heterogeneity and spatial fragmentation of the area contribute to a low sense of community and local identity. Residential areas are densely built, with a high degree of surface sealing and limited public or private green spaces and recreational facilities. Like the commercial properties, the majority of residential properties are rented. Creating spaces for connection, recreation and improving the aesthetic quality and sense of place would be important social benefits for the district.

Berlin Wasserbetriebe (Berlin Water) provides the drinking, waste and storm water services to Berlin. While drinking and waste water fees are low, companies in Moabit West pay high drainage fees, due to surface sealing (Green Moabit, 2013). During heavy rainfall events, runoff leads to back-flow at inlets to the combined sewers, as well as overflows to the River Spree. Extreme heat and heavy rainfall events brought on by climate change are expected to exacerbate the current problems (Sieker et al., 2016).

Implementing blue-green measures in Moabit West is a promising approach to improve the physical and social conditions in the area. However, the next section lays out the challenges in realizing such projects in Berlin.

Institutional setting

The institutional context in Berlin played an important role in this project. The most critical elements were environmental permitting and commercial rental contracts. Environmental permitting in Berlin reportedly favours proven and traditional infrastructure, creating a significant barrier to installing the blue-green solutions that could benefit the area and are already used in cities around the world (Sieker et al., 2016). Furthermore, there is no streamlined process for implementing and monitoring pilot projects, which makes it difficult to introduce and test new measures. As one participant explained "To solve those problems [of climate change], we have to be quicker and install more individual solutions, and get permits to do the best for a specific place. We need more institutional flexibility."[1] Local stakeholders report that these barriers are exacerbated by layers of administration and the number of authorities that must approve a project. As one interviewee remarked "You really have this linear hierarchy and if you want to go outside of the usual process, you have to go up the hierarchy, to the side and then back down. During that process you lose a lot of information, and the innovative character [of the project] has to be transported through maybe five or six steps. This time kills projects."[1] These conditions make it a long and laborious process to introduce new measures.

A final institutional constraint for this project related to commercial properties. Since commercial property is privately owned, there are less permitting requirements for implementing adaptation measures, such as blue-green solutions. However, standard lease conditions and companies' business models, mean that return on investment for renters is required within two to three years (Sieker et al., 2016). The water group leaders noted that this was incompatible with the longer term benefits of the proposed adaptation measures, as well as the non-financial benefits for the area. Property owners are also not incentivized to invest in adaptation, as potential savings, on drainage fees for instance, benefit renters.

Project structure and process

The SSD-Moabit West project aimed at implementing climate adaptation solutions at the district scale, with the joint purpose of affecting changes to the physical and the institutional conditions, so that Berlin is better prepared for future challenges.

1 Follow-up interview with a workshop participant by lead author, February 15, 2018

The Climate KIC programme also brought its own ambitions and requirements. In particular, the focus on implementing solutions and the project's short timeline determined what could be done in the planning process. For example, a number of interesting measures and projects were proposed during the design workshop, but were not followed up, because, as one of the organizers said "I think it is really important to have this whole district approach to find new project areas, but the time frame for the project is so short that we can only follow our [original] ideas now."[2] Likewise, there was insufficient time for engaging the community in a meaningful way, so local project organizers focused on institutional stakeholders who could implement projects.

The SSD-Moabit West is part of a long chain of initiatives and projects that aim to nudge Berlin forward. Opportunities like SSD are picked up and used by local champions in their longer term effort for change. In particular, the SSD-Moabit West project helped its organizers realize an earlier development plan, Green Moabit. On a broader scale, SSD-Moabit West supported Berlin's Smart City Agenda. In this way, SSD-Moabit West was a vehicle for local organizers, particularly at CCC-TUB, to bring together and bring to life prior work, and to introduce new ways of working in the city.

Analysis: Relation of the tool to the context

In summary, the benefits of implementing blue-green adaptation measures in Moabit West are clear, but there exist institutional constraints to implementing them in both public and private spaces. While the project aimed at addressing both the physical and institutional problems, pragmatic constraints limited the focus of the workshop and its outcomes. The AST's aim to support co-design of spatial adaptation measures in urban areas, and its interactive nature fit the workshop's planning tasks. Previous research has highlighted the importance of task-technology fit in PSS usefulness (Pelzer et al., 2015a). In addition, the basic level of input required by the AST meant that the tool could be deployed within the limited timeline of the project. In these ways, the AST was an appropriate tool for the given contextual conditions.

3.4.2 Input

Input indicators were evaluated mostly through the thematic and deductive analyses of interviews, documents and observation.

Aim and role of the activity

The aim of the design workshop was to explore opportunities for sustainable urban water management measures on private and public space in Moabit West. The

2 Post-workshop interview with a workshop participant by lead author, September 21, 2016

workshop was designed to find pilot projects that could demonstrate new adaptation planning approaches in Berlin, such as blue-green measures and integrated solutions. The purpose of the pilot projects was twofold: to address the problems of "flooding during heavy rain, formation of urban heat islands, high surface sealing and overloaded combined sewers"(Sieker et al., 2016, p. 56), and to tackle local regulations that hinder new and innovative solutions in Berlin. A secondary aim of the workshop was to test collaborative planning workshops as a way to improve communication and interaction between stakeholders in Berlin.

Organization of the activity

The overall project workshop was organized by the managers at CCC-TUB. The water group leaders organized the design workshop as a three-hour session during the full-day event (Appendix B.1), with support from the European partners. The water group leaders selected the AST. They deemed the tool's collaborative design approach to urban adaptation a good fit with the workshop tasks. An abbreviated version of a normally full-day AST session was planned, due to the limited time available for the workshop. The water group leaders also requested a best practices document from the European partners, with examples of adaptation projects implemented in the Netherlands.

Stakeholders and participants in the activity

The local water group leaders identified and invited the relevant stakeholders to participate in the design workshop, based on their ability to be a partner in implementing pilot projects in the district. As the project aimed to introduce new ways of working and new types of projects, institutional stakeholders were considered key, as was keeping the working group small enough to be effective in the setting and time available. A list of invited stakeholders is provided in Appendix B.1.

The nine participants included representatives from Berlin Water departments of research and development and of sanitation, representatives from two local water consultancies, specialists from two Dutch knowledge institutes, and the evaluator. CCC-TUB organizers also played a supporting role. Stakeholders not invited included local industry representatives and property owners and renters, who could implement measures on private land. These stakeholders were approached separately by the project, before and after the workshop to identify project opportunities. Similarly, the local community were not invited to participate, due to the technical focus and small size of the design workshop.

Analysis: Role of the tool in the input

The local organizers selected the AST for its ability to support the primary aim of the workshop: exploring and designing blue-green measures in public and private spaces. The tool's focus on conceptual design also matched the level of the workshop. The local organizers hoped that providing a platform for stakeholders to work together on a design would not only result in solutions to the physical problems, but would also foster dialogue about the institutional barriers to implementing adaptation measures, thereby supporting their second objective. Finally, organizing the workshop around an interactive tool supported the broader aim of introducing new, more collaborative way of planning in Berlin. In these ways, the AST played a central role in the input to the workshop.

3.4.3 Process

Observations, interviews and questionnaires were used to evaluate the workshop process, using the inductive, deductive and meta analyses.

Procedures of the activity

The design workshop started with an introduction to the objectives of the session and the participants. The workshop proceeded with the following steps: an introduction of best practices in sustainable urban water management; an introduction to the tool and review of the adaptation measures in the library; creation of a short-list of the participants' preferred measures; and finally, implementation of the proposed measures in the tool. The design workshop ended at the prescribed time, although not all selected measures had yet been implemented. A detailed agenda is provided in Appendix B.1.

Communication

In questionnaires, all participants reported that the goals and structure of the workshop were clear and that they had communicated openly during the session. The tool was observed to play an important role in facilitating communication during the workshop. First, the AST library ensured a shared vocabulary for participants to communicate about measures. Second, the map provided a shared spatial language and focus for discussions. As one participant commented "It is easier to see with the sketches on the map, to interpret and to talk to each other. It is more open, you can ask 'why did you do that?' this is much quicker!"[3] In questionnaires, all participants reported that the tool helped them to communicate and understand others, giving a unanimous score of 5/5.

3 Follow-up interview with a workshop participant by lead author, February 15, 2018

Way of working

The touch table was placed in the centre of a table, around which participants sat or stood. The layout ensured that all participants could see each other and the information in the tool, and could interact with it easily (Figure 8).

Figure 8. Participants working with the Adaptation Support Tool in the design workshop for Moabit West, Berlin (used with permission from CHORA: Conscious City, TU Berlin)

Sitting around the tool and working collaboratively with it created a productive atmosphere and participants actively engaged with the activities and discussions. The map interface, the information in the tool, and the feedback from it, prompted responses and dialogue amongst participants, "Sitting together and having these new images is stimulating and innovative. It is not only a workshop, it's the animation, the *way* of working." The collaborative way of working was highly valued in the interviews and questionnaires.

Organization

The design workshop was organized around the AST; however, the time available was too limited for a full design to be realized in the tool. This was noted by the organizers, facilitators and participants in post-workshop interviews. Nevertheless, in the given time, the group managed to review a large number of measures using the tool's library, to identify preferred ones, and to explore their implementation in the project area. By providing content, the tool was central to realizing the workshop's achievements in a time-efficient manner, thereby improving the workshop process.

Analysis: Role of the tool in the process

The local organizers planned the design workshop around the AST. Our analysis indicates that the tool supported communication between participants and an interactive way of working, in large part through the map interface, the real-time feedback and the library of measures. Responding to the tool's content and working

around a common object, supported the dynamic and engaged process during the workshop. This highlights the interconnected nature of content and process in workshops, and a tool's role in supporting both. Finally, given the short time available for design, the tool offered a time-efficient way to realize a productive workshop.

3.4.4 Content

The observations, interviews, questionnaires and documents were most relevant for evaluating the content, using the inductive, deductive and meta analyses.

Quality and type of data and information used

The substantive content used in the design workshop had three sources. First, the AST, with its library and evaluative functionality, a digital satellite map of the district, and inundation and heat stress maps for the area, used as digital overlays to identify vulnerable areas (Appendix B.5). Second, a report of best practices for sustainable urban water management, which gave examples of adaptation measures implemented in the Netherlands. And third, the local and European partners, who brought their respective knowledge of adaptation and local conditions.

A version of the AST based on Dutch climate and cost data was used for time and budget reasons. Local organizers deemed the conditions in Berlin sufficiently comparable for the preliminary level of design in the session. The flood and heat maps were provided by the city of Berlin (Appendix B.5). The adaptation targets used in the workshop were estimates based on calculations by the water group leaders and the facilitators, with input from participants. The targets were 14,846m^3 added storage capacity (10mm over the project area), 0.5 °C heat reduction, and a 20 year flood return period (reducing the current period by a factor of 10). The remaining input conditions used to set up the AST are detailed in Appendix B.5.

Post-workshop questionnaires and interviews indicated that all participants found the data acceptable and suitable for the aims of the workshop, and that they were satisfied with the quality of the data and the results. However, the questionnaires and interviews also revealed that the use of Dutch data and the estimated adaptation targets made the indicators in the tool less relevant to participants. At least three participants reported wanting to know more about the models behind the tool's calculations. This appears important for the trustworthiness of the tool and its results.

Depth and breadth of the substantive content

A significant portion of the design workshop was spent reviewing adaptation measures and their local suitability, through the best practices report and the AST's library of measures. Following the workshop, one participant suggested that too much time was spent reviewing measures and discussing the challenges of implementation in Berlin, leaving insufficient time for design. However, our observations and other participants' feedback suggest that these discussions built capacity and a shared understanding about potential solutions. Moreover, reviewing measures surfaced constraints and preferences that were later used in the design, but were not present in the tool (e.g. which measures would be especially difficult to permit or finance). As the AST only accounts for technical criteria and input, there is no reliable shortcut to dialogue. The depth of discussion about measures meant that there was insufficient time to make a detailed design, to compare costs and effectiveness of different measures, and to make alternative plans in the tool. However, the unimplemented ideas were discussed so that the plan could be elaborated by the water group leaders.

The local participants introduced a wide breadth of topics during the session, not all of which could be fully addressed by the tool's technical focus. For example, when the group made a list of preferred measures, participants considered co-benefits not evaluated by the tool, like attractiveness and multiple-uses. Similarly, constraints, such as political ones, were introduced by local partners, to supplement the spatial constraints present in the tool. Still, the tool supported this dialogue and the design choices. The map, for instance, was particularly useful for eliciting discussions on a range of topics in the district.

Satisfaction with the depth and breadth of content was unanimously rated 4/5 in the questionnaires, with most participants noting the missing stakeholders and limited time as the only limitations in this regard. The tool's library was an efficient way of reviewing information on a large number of measures within a short time. This was useful for ensuring a shared knowledge base and vocabulary for designing, given the group's mixed familiarity with adaptation measures.

Tool or methodology used

The tool interface was central to communicating content from the tool to participants. The tool's interactive nature, library and maps served as catalysts for elaborating local conditions, sharing knowledge and discussing measures. The tool also creates an artefact of the workshop, as the choices for measures, their locations and rough dimensions are captured and saved, along with the adaptation targets and input

conditions. As one participant recalled in an interview "you install this [a measure in the tool] and immediately you have some feedback on what can be done… and by sitting together it is a creative atmosphere."[4]

In questionnaires and interviews, workshop participants consistently named the tool's library of measures and evaluative function as its most valued features. Despite the extensive library, new adaptation targets and measures cannot be added to the tool during a workshop, limiting the tool's ability to represent local objectives or solutions that may come up. This limitation was observed by the evaluator, but was not mentioned by participants, who simply supplemented the tool's content with dialogue.

Analysis: Role of the tool in the content

Our analysis indicates that the tool was a significant source of substantive content in the workshop and also elicited the communication of content held by the local and European partners. This included subjects not covered by the tool, such as social or institutional issues. The tool's most valued elements, its library of measures and real-time feedback, are its content.

Given the participants' mixed level of familiarity with adaptation measures, reviewing the tool's library created a common knowledge base for the design. Similarly, the map interface created a focal point for discussions and a shared spatial language. The interactive nature of the touch table was also valued for adding content in a more dynamic and creative way than traditional workshops.

3.4.5 Results

While the inductive, deductive and meta analyses were used to evaluate the results, the meta-analysis was particularly helpful.

Outcomes of the activity

The direct work product of the workshop was a plan made in the tool, with the selected adaptation measures and their rough dimensions located on public and private land in the district map (Figure 9), as well as the list of participants' preferred measures (Table 9). The plan developed in the workshop was later elaborated into two alternatives for the final report. One alternative included measures in public and private spaces, while the other included measures only on public spaces (Appendix B.5).

4 Follow-up interview with a workshop participant by lead author, February 15, 2018

Table 9. Summary of measures selected during the design session and their suitability for implementation on public or private land

Measures	Private land	Public land
Disconnect paved surfaces	X	X
Water square	X	X
Porous pavement	X	X
Bio swales/infiltration	X	X
Tree pit bio-retention	X	X
Wetting surface	X	
Urban agriculture	X	
Green roofs	X	
Rainwater retention pond	X	

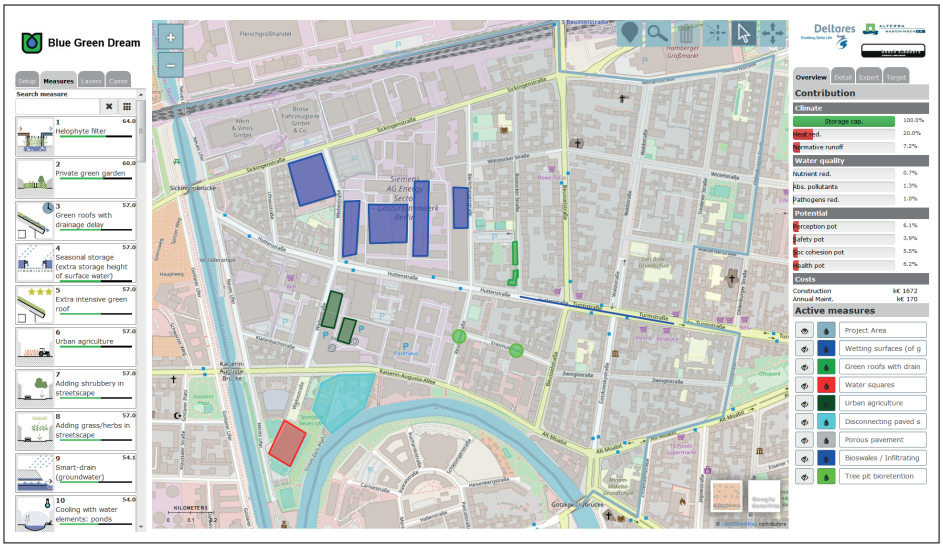

Figure 9. Initial plan developed in the Adaptation Support Tool, during the design session in Moabit West, Berlin

Less tangible results were also achieved during the workshop. These included discussions about which measures were possible, the barriers that existed to implementation, and the steps needed to realize pilots. The discussions resulted in agreed actions for the local partners. In follow-up interviews, some participants observed that working with the tool inspired them and strengthened their relationships with the other partners, which underpinned subsequent steps in realizing a pilot and spinoff projects. One participant noted that their experience using the tool and their desire to use it in other

applications had increased their engagement with the project. This had not resulted from the earlier dialogue-based workshop.

Documentation of the outcomes

The final plans and the process of the design workshop were comprehensively documented in the final report (see Kuhla von Bergman, 2017), and were presented at the project's final symposium. The presentation of the elaborated results included maps, adaptation targets, estimated co-benefits of selected measures, dimensions of the proposed measures and cost benefit analyses. The analyses and reporting were based on the plan created in the tool. Additionally, some process results were documented, such as planned meetings and the steps needed to achieve implementation. The report is available online and the project website includes descriptions and pictures of the workshop and symposium, as well as more project information.

Value and relevance of the results to the planning process and participants

The measures selected during the workshop (Table 9) address the stated problems of urban flooding, heat stress, surface sealing and improving the public space. Furthermore, local partners felt that the measures pushed local authorities beyond the status quo, while remaining plausible options. Practical considerations about permitting and financing were paramount in selecting these measures. Given the context and input conditions in Berlin, this shows a sound rationale for the design. The results were found acceptable by the water group partners and the project management, as reported in the questionnaires and post-workshop interviews.

Satisfaction with the work products was mixed. Most participants, the facilitators and organizers reported feeling that the design did not get as far as they had hoped during the workshop, due to the limited time, and the missing stakeholders' input. However, satisfaction was almost unanimously high regarding the less tangible results, such as the discussions and the opportunity to learn from the tool and from other participants. In questionnaires, "working together" and "new ideas and information" were the outcomes valued by the most participants. In interviews, the water group leaders and project managers valued the work products for project documentation, as input to the integration projects and as the basis of the analyses in the final report. Overall, the perceived value and relevance of the workshop's less tangible results was higher than that of the work products. This is consistent with the motivations of local partners, several of whom stated that achieving the political steps to implement a pilot project was more important than any particular measure.

Analysis: Role of the tool in the results

The tool was central to the results achieved in the design workshop. The main work product, the plan of measures on the map, was created in the tool and based on information provided by the tool's library and indicators. The plan was a useful artefact for project reporting and presenting, and also formed the basis of further analyses. Participants, however, found the less tangible results, like learning and collaboration, most valuable. It is, of course, more challenging to determine the tool's role in achieving these types of results, but evidence includes participants reporting that the tool made the workshop more effective and efficient than others they had attended, and significantly more so than local planning practice without workshops. The tool also supported dialogue and improved communication between participants, as discussed in earlier sections.

3.4.6 Use

The evaluation of use focused first on the use of results at two time frames, during the SSD-Moabit West project and after it. The meta-analysis was especially useful here for comparing planned or intended uses of results with actual uses over time.

Direct use of results

The direct use of results **during the project** began immediately following the design workshop, in the integration session. Here the plan developed in the tool (map and measures) were shared with the other working groups and used to find opportunities for integration projects. A street renewal concept combining a tree pit infiltration measure (water) with bike-share stations (mobility) and "smart" street lights (energy) was the most relevant proposal.

In the weeks following the design workshop, the results were used in several ways: water group leaders reported the plan and intended next steps to the project managers and used the plan in meetings with stakeholders, such as industry representatives whose properties were identified as pilot project sites. Additionally, water group partners used the work products to refine and elaborate the plan with more detailed design and analyses, and to make cost-benefit assessments for different measures. This elaboration also included collaborating with the other working groups to further develop the integration projects, like the proposed street renewal. Finally, the elaborated workshop results were used in the final project report and presented at the project's closing symposium. The symposium was attended by over 50 invited stakeholders from local government and non-government agencies, academia and industry.

After the project, the plan developed in the tool formed the basis of the street renewal pilot project, which was carried out in the year following the project. The plan was also used in dissemination activities for the project. Berlin Water also summarized the results and experience of the tool-based workshop in a memorandum for their management.

In summary, the plan developed in the tool was the central workshop result that was used during and after the project. The map, with measures located in the district, was used to communicate ideas and to develop plans.

Indirect use of results

During the project, new knowledge about measures from the tool, and their successful applications abroad, were reportedly used by partners as a "tool to convince"[5] local authorities to approve the tree pit pilot project. Water group leaders noted that there were around 30 meetings about implementing the tree pit, to determine which authorities would install, maintain and monitor it. Partners felt that this process benefitted from the strengthened relationships and commitments created in the workshop.

After the project, experiences from the workshop were used by several participants to inform future projects. First, the AST facilitators reported using their experience applying the tool in a shorter workshop and in addressing non-spatial issues to consider broader applications in the future[6]. Second, the tool's ability to produce a draft spatial plan with the input and agreement of multiple stakeholders in a short period of time inspired one local partner to propose the tool in a spinoff project, which is now under development[6,7].

Unused activity results

While the plan developed in the design workshop was the project's most used result, it was not used to select which measures were implemented, as would be expected. Participants and organizers attributed this to several reasons. First, the design workshop happened halfway through the already short project timeline, meaning that there were existing ideas about which measures to implement and insufficient time left to explore alternatives. Second, the water group leaders had invested time and money in the tree pit technology, so they were most interested in its implementation. Third,

5 Follow-up interview with a workshop participant by lead author, February 15, 2018
6 Follow-up interview with a workshop facilitator by lead author, January 30, 2018
7 Follow-up interview with a project manager by lead author, March 13, 2018

all pilots required an implementation partner and in the case of the tree pit, the partner was Berlin Water, which was part of the project and already committed to realizing the plan. Other measures would have required the partnership of stakeholders who did not participate in the workshop. Finally, the tree pit was identified as part of the street renewal integration pilot for which funding was already secured for implementation after the SSD-Moabit West project ended. In other words, the tree pit was the most likely project to be realized and the wisest measure on which to concentrate the limited time and resources of the project and its partners. The tool's role in the tree pit design was not selecting the measure, but identifying a suitable street for implementation. Here, the map interface encouraged participants to discuss and specify a promising location, based on local knowledge about upcoming projects and available space.

Analysis: Role of the tool in the use of results

Both the work products and the less tangible results from the tool were used directly and indirectly during and after the project. The plan developed in the tool was the most used result; however, it was not used to select measures. This was attributed to the pre-selection of a preferred measure and to contextual factors of the project, not to a shortcoming of the tool or workshop. Overall, the work products, namely the map and measures developed with the tool, were used for official purposes. The less tangible results, such as strengthened commitment, were used to motivate the actions of partners in this project and to inspire future initiatives. The use of work products is interesting in this regard, as the purpose of the AST is to create designs that inform planning processes, but contextual factors of the project appear to have limited this use, while making the designs useful in other important ways, and making the less tangible outcomes useful to the planning process.

3.4.7 Effects

The longitudinal study was particularly useful for capturing effects over time, using the inductive, deductive and meta analyses.

Effects on learning

The dominant effects from the workshop were direct effects on learning. Learning is considered an effect, as opposed to a result, because it was an objective of the project and workshop, and because it represents a change in the participants. However, learning was also used, like a result, to create other effects, as is elaborated below.

Learning was assessed from participants' responses in questionnaires and interviews, and through observations of exhibited learning during and after the workshop. The

topics of learning included learning about adaptation measures in the tool's library, about new ways of working in local adaptation planning, about the use of planning support tools, and about the experiences and interests of other participants. In questionnaires, all participants scored the workshop 5/5 for giving "new insights into the problem and solutions". Additionally, the questionnaires showed that the most valued aspects of the workshop were learning about and from the tool and other participants. The collaboration between local and European partners during the workshop was also highly valued as a learning opportunity. One participant later questioned whether the tool was needed or whether "sitting together and talking"[8] could have achieved the same ends. The tool's most direct contribution to learning was offering an efficient way to review different measures and their implementation in other places, which was important, given the limited local experience. One participant later recounted using their learning about successful implementation projects as a "tool to change minds"[9] with authorities in Berlin. In a less direct way, the tool improved communication and interaction between stakeholders (Section 3.4.3), factors which contribute to learning (Pelzer and Geertman, 2014). For these reasons, the tool does seem to have played an important role in achieving learning effects in the workshop.

Effects on the problem situation

The most important effect on the problem situation is that authorities were convinced to change the rules prohibiting infiltration measures, such as tree pits. This was achieved through the year-long process of meetings between local partners and authorities. Two tree pit pilots are expected to be implemented in 2019. This is an indirect effect of the workshop. Learning about measures and their successful implementation abroad, as well as strengthened commitment to the project seem to have contributed to this effect and were reported to be at least in part due to using the tool.

As the tree pit pilots have yet to be implemented, there is no effect on the physical problem situation (overloaded sewers, urban heat, etc.). The industry stakeholders whose properties were identified as possible project sites did not move forward after meeting with water group partners. This is reportedly due to their rental contracts and business models. Without the participation of property owners and renters, no changes on private property have been realized. However, project leaders indicated in follow-up interviews that proposed adaptation measures are being considered for upcoming renovations on a school and at a vintage car depot in the area[10].

8 Follow-up interview with a project coordinator by lead author, February 16, 2018
9 Follow-up interview with a workshop participant by lead author, February 15, 2018
10 Follow-up interview with a local partner by lead author, February 16, 2018

Effects on the planning process

The design workshop had a limited effect on the remainder of the planning process for the project. For instance, during the workshop, participants agreed that holding an additional session with the missing stakeholders would be valuable, but this was not pursued, due to the project's limited remaining time.

While the plan developed in the tool was used in the project in multiple ways, it did not affect the steps taken in the project, or the measures that were pursued. Indirect contributory effects of the tool came through some participants' use of their learning and strengthened commitment to convince authorities to permit the pilot project. Taking a longer view of planning in Berlin, local partners report that the workshop informed the planning process of a spinoff project that is under development and will employ similar workshops, while applying the lessons from the design session; namely, holding earlier and more workshops, and ensuring the participation of all stakeholders.

Effects on the decision or policy

As explained in previous sections, the plan made with the tool did not influence the choice of measures that were pursued for implementation in the project. However, this was due to several contextual conditions and not to the workshop or tool. The location for the tree pit pilot was identified using the map interface of the tool during the workshop and this became the location of the integrated street renewal project that received implementation funding.

Intended effects

Owing to the institutional context in Berlin, implementing a pilot project was the primary objective of the water group and the project managers. The role of the pilot was to overcome negative views of adaptation measures, like tree pits, and to push city authorities to start thinking in terms of opportunities in planning. Similarly, the tool-based workshop was a form of pilot itself, to demonstrate a new way of working on planning projects in a collaborative and integrated fashion. These intentions were largely achieved, as has been documented in the previous sections. As one local partner stated "if you go to Moabit, you cannot see that this project happened yet, but the seed is in the earth and in the minds."[11]

Analysis: Role of the tool in the effects

The tool's strongest effect during the project was on learning. Here, the collaborative workshop and the tool's library of measures and interactive character appear to have

11 Follow-up interview with a workshop participant by lead author, February 15, 2018

contributed to learning through the provision of content and improved communication and interaction. The tool supported the intended effects of the project by providing a successful pilot of collaborative tool-based planning workshops, as evidenced by the proposed use of the tool for other projects in the city. The learning and strengthened commitment credited to the tool also played a role in achieving approval for the tree pit pilot, however, these effects are too indirect and enigmatic for strong claims.

The tool did not have a discernible effect on the rest of the planning process, on the decisions made, or on the physical problem situation. This appears to be largely due to contextual factors of the project, like its timeline being too short to consider new ideas.

3.5 Discussion

We conceptualized the use of planning support tools as nested within a workshop that occurs during a planning process, which itself takes place within a larger context. In the previous section we described our findings from applying the evaluation framework to the SSD-Moabit West design workshop for sustainable urban water management, which made use of the Adaptation Support Tool (AST). In the discussion we reflect on the use of the tool in the workshop, the connections to the planning process and its context, and finally, on our research methods.

3.5.1 Reflections on the use of the tool in the workshop

Our results have shown that the design workshop was perceived positively and that participants enjoyed working with the one another and the tool in collaborative adaptation planning. In our experience, these positive responses are a standard result for collaborative workshops, with or without a tool. Similarly, developing a common understanding of the local problems and sharing experiences can be achieved without a tool. Beyond outcomes that could reasonably be expected from dialogue alone, we ascribe the following attributes to the use of the tool:

- Providing information about the many adaptation measures in the tool's library, which created a common knowledge base and vocabulary for the design.
- Supporting dynamic communication by serving as a focal point of discussion and group work, through a shared spatial language in the map, and interaction with the tool.
- Ranking suitable measures for the local physical conditions, adaptation targets and input criteria.

- Producing a mutually-supported spatial plan of preferred measures, with their basic dimensions and locations specified.
- Improving learning among participants through substantive content, enriched communication and interaction with the tool.

While some of these outcomes could arguably be achieved with paper maps and more traditional forms of a workshop, the tool provided time efficiency to achieve these results within three hours. In this way, the tool's unique contribution was to combine the analysis, design and dialogue aspects of conceptual planning in a time efficient and informed manner. These findings are consistent with the main added values of PSS identified by Pelzer et al. (2014), namely, learning, communication, collaboration, consensus, efficiency and more informed products.

Facilitation of the tool was important to the process of the design workshop. Skilled facilitation structured the session, helped to maintain the group's focus, integrated a variety of topics that came up in discussion, and provided expert knowledge about adaptation measures. The facilitators were also important for easing participants' interactions with an unfamiliar tool. As evidenced by their comfortable use of the AST, participants did not find the tool overwhelming or difficult to understand, which can be a problem with planning support tools (Arciniegas et al., 2013; Eikelboom and Janssen, 2015) . The importance of facilitation to the successful use of the tool is consistent with earlier experiences with AST workshops (McEvoy et al., 2018; van de Ven et al., 2016), and other tools (Eikelboom and Janssen, 2017; Mayer et al., 2005; Pelzer et al., 2015b).

When reflecting on the value of the tool in the workshop, most participants remarked that the *way* of working was more efficient, creative, interactive, or inspirational than traditional planning. This is an interesting result, because in a series of earlier experiments carried out using the AST, some student participants felt that the tool's technical focus hindered creativity (McEvoy et al., 2018). The difference seems to be that in Berlin, the focus of creativity was on the collaborative way of working with others, while the students focused on the creative quality of the designs and the physical way of working (e.g. entering measures in the tool, versus sketching). The difference in these views is likely influenced by the backgrounds of the workshop participants. In Berlin, all participants had engineering backgrounds, while the student groups included urban planners and designers, policy analysts, and engineers. Previous PSS research has shown that some types of users, such as planners and community members, may find an analytical map-based tool disruptive to their manner of working

(Pelzer et al., 2013). In Berlin, the match between the AST's engineering frame and the participants' backgrounds probably contributed to their demonstrated comfort with the tool.

The design workshop participants have significance for our results. First, the shared engineering background means that we did not evaluate the tool for different types of users, who may have found the tool more difficult to operate and understand or the tool's technical focus on measures too limited to address their concerns. Indeed, in light of the fact that the problems driving the project were as much institutional as they were physical, it was surprising that participants did not find the technical indicators, measures and approach of the tool to be limiting. Second, the workshop participants were all partners in the SSD-Moabit West project and shared a common interest in the project's aims and similar views of the problems and solutions. As such, we did not evaluate the tool's ability to support finding common ground on problems or solutions.

3.5.2 Reflections on connections with the planning process and context

The most relevant effects of the tool on the planning process were contributory and less tangible in nature, such as learning and improved communication. This is not surprising, given the preliminary level of design in the workshop and the focus on overcoming barriers to implementing pilots. The lack of more causal and concrete effects, however, is in part a function of the context. Most critically, the project structure defined, to a large extent, the role that the tool could play in the planning process. A better alignment between the workshop aims and project schedule seems like it would provide a better opportunity for the tool to affect the planning process in a material way. Future research should look more closely at the influence of context on the role of a tool.

Learning plays an important role in adaptation (Anguelovski et al., 2014; Birkmann et al., 2014; Mayer et al., 2005; Tyler and Moench, 2012) and forms a common aim of planning support tools, and PSS more specifically (Pelzer et al., 2014). Therefore, the learning effects created through using the AST in the design workshop are important outcomes. In many ways, the most impactful effect of using the tool would be if participants used their experiences and learning to change planning practices in Berlin. This has yet to be seen.

3.5.3 Reflections on the research methods

Case study

A longitudinal case study proved a useful approach for examining the role of a tool in a workshop and planning process, particularly in that this approach allowed us to evaluate the use of results and the effects over the life of the project and beyond. As expected, the complexity of real world planning made it challenging to tease out the mostly contributory and less tangible effects that were realized. Here, the richness of context was important for understanding the "how" and "why" of what was observed.

The SSD-Moabit West design workshop was a representative case of adaptation planning. Evaluating "real" workshops, as opposed to those designed for academic research, offers obvious benefits for the representativeness of results. However, real workshops are imperfect research objects. In our particular case, there was insufficient time for using the tool to its full capacity in the workshop, which limited the extent of the design; local data was not used in the tool, limiting the value of its indicators; and some stakeholders were missing from the workshop, whose perspectives were absent from the dialogue. Evaluating a real workshop, however, revealed the critical importance of context in determining the role a tool is able to play.

While case studies are meant to offer in-depth insights rather than broadly generalizable results, it is useful to compare our findings to other research on planning support tool and PSS use in workshops. In doing so, we see a number of consistent themes emerge. For instance, Pelzer et al. (2014), found that users' valued the MapTable planning support tool more for collaboration and communication support than for outcomes. Similarly, Pelzer et al. (2013) found that the same tool's shared map interface stimulated knowledge sharing and dynamic interactions in workshops, which contributed to learning. Meanwhile, Arciniegas and Janssen (2012) found that another map-based touch table tool supported improved communication and new insights into land use planning. Mirroring our own findings, Pelzer (2017) noted the need for alignment between a tool's functionality and the stage of planning in order to promote effective tool use. Finally, a number of researchers (e.g. Geertman, 2006; Pelzer et al., 2016; Russo et al., 2018; te Brömmelstroet, 2015) have highlighted context as a determining factor in the role, and even the meaning, of a PSS and its outcomes. While many of these findings were based on simulated workshops and different tools, our corroboratory results are based on a real planning workshop using the AST. More importantly, while prior research has focused on the workshops, we have evaluated the effects of PSS use over the overall planning process, a novel approach in this field.

Evaluation framework

We required a framework that recognized the nested nature of tools within workshops, planning processes, and context. The framework we developed for this purpose is based on Thissen and Twaalfhoven (2001), as well as other examples in literature. Our framework was useful for structuring the evaluation and for ensuring that it was systematic and comprehensive. The framework, however, is descriptive in nature; it simply structures the data so that it is addressed, regardless of whether it fits with expectations or preconceptions. It is up to the evaluator to make sense of the data and to draw causal links. The framework was used as the basis of the deductive analysis, while the inductive and meta-analyses proved invaluable for surfacing explanatory threads, major themes and components missing from the original framework. This combination allows the locally specific and relevant themes to emerge, while ensuring the evaluation is still thorough and produces reliable and comparable results.

Our choice for a framework that does not focus on characteristics of the tool, but on the factors that help to understand the role of the tool in a broader setting, provided a holistic and rich picture of what worked (and not), how it worked and why. A challenge in using and reporting on the framework is overlap, which comes from the interconnectedness of factors. For instance, the tool's content, such as the map interface, also played an important role in the process of the workshop. We chose to report the results in the structure of the framework to illustrate its application, as well as the results of this particular case.

The challenges of evaluation revisited

We started this article by laying out several challenges in evaluating the use of tools in adaptation planning workshops and processes. Reflecting on our framework and evaluation, we found:

- The framework structure to be generic and comprehensive enough to produce comparable results and useful insights.
- The evaluation factors and indicators general enough to be applied to a variety of tools and workshops.
- The combination of the framework and the analysis method complete enough to capture emergent themes and to minimize the omission of data that do not fit pre-conceptions.
- The framework and the analysis method to be flexible enough to reflect local conditions and produce more broadly meaningful results.
- The longitudinal evaluation indispensable in capturing the effects of the tool on the planning process and participants, and in revealing the importance of context.

- The nested view of tools helpful for understanding the use of the tool, its results and effects.
- The descriptive nature of the framework to be a strength in its broad applicability, but likely a weakness in its reliability.

The results of our evaluation of the AST used in the design workshop for SSD-Moabit West are, of course, specific to the tool and the application studied. The use of tools, the tools themselves, and the conditions in which they are used, are too varied to make claims about the generalizability or transferability of our results. Nevertheless, by using a systematic and structured approach to the evaluation, the outcomes should be comparable and useful in other cases. The reliability of the framework can only be confirmed through testing in more applications. However, the skill of the evaluator is an important and less predictable variable in the quality of results. Validity is a more interesting question, and a common challenge in qualitative studies (Creswell, 2003; Yin, 2003), such as ours. We found several strategies useful for limiting bias:

- Using many sources and types of data for triangulation.
- Basing the evaluation on a structured framework for ensuring a systematic review of all the data.
- Using different approaches in the data analysis for capturing a comprehensive view of the data.
- Using a longitudinal study for the consistency of our findings over time.
- Checking our themes, hypotheses, explanations and findings with key informants over time.
- Using an evaluator who is independent of the tool, the workshop and the project.
- Engaging an external reviewer to check the evaluation design, analysis and results.

Finally, we recognize that the access, time and resources to carry out a comprehensive and longitudinal evaluation are luxuries not readily available to most projects. While our analysis was time consuming, the framework could also be used in a "light" evaluation. Workshop organizers or evaluators could fill in most of the framework based on their knowledge, soliciting input and feedback from key participants, as needed. Care should be taken to think critically about the evaluator's biases or preconceptions, as they will not have the benefit of thorough data collection and analysis.

3.6 Conclusions

We set out to understand what role a planning support tool, like the AST, plays in collaborative planning workshops, and what effects such tools have on these activities, the participants, and the planning processes in which they are used. We also wanted to test how such evaluations could be carried out effectively. There are a number of challenges in evaluating the role of tools in a way that the results are both meaningful to a specific case, and more broadly useful and comparable. Such evaluations must be flexible yet structured, and detailed yet broad. In this article, we have presented a framework for making evaluations, along with our results and experiences in applying it to a longitudinal case study of the AST, used in a design workshop for sustainable urban water management, in Moabit-West, Berlin. Our findings showed that the tool's role was mostly contributory and less tangible in nature (e.g. supporting learning and communication) as opposed to directly causal and concrete (e.g. affecting the planning process, decisions or problem situation). Perhaps most importantly for illustrating our assertion that the effect of tools should be studied within the wider arena of the planning process and context, our results showed that the effects of the tool were largely a function of contextual conditions, such as project structure and timing.

While one case study is a modest contribution to understanding the role of tools in collaborative planning workshops, the longitudinal case study approach allowed us to evaluate the effects of a tool over time, and to test a framework for evaluation. We found our framework and research approach addressed the challenges of evaluations and provided useful and usable results. Naturally, more applications are needed to test the reliability of the framework, while additional evaluations of tools in real applications are needed to continue improving the quality of PSS and of adaptation planning practice and theory. Finally, evaluations that account for the nested nature of tools within workshops, planning processes and context, can help to capture effects beyond the workshop.

4

Influence of context on the use and added value of planning support tools: a case study from Guayaquil, Ecuador

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Supplementary material for this chapter is provided in Appendix C.

Chapter 3 showed that a planning support tool's lasting effects on a planning process were largely indirect in nature and a function of context. Research has long recognized the importance of context for a planning support tool's performance. However, until now, there has not been a dedicated study on the influence of context on the use and added value of tools. This gap is addressed here, through a case study of the Adaptation Support Tool (AST), used in a planning workshop in Guayaquil, Ecuador.

The purpose of this chapter is to present the results of the case study and to contribute to addressing the fourth research question in particular. Section 4.1 offers a brief introduction to the chapter. The relevance of context for planning support tools and the contextual factors that form the focus of the case study are presented in Section 4.2. Next, the research design and case study are presented in Section 4.3. In Section 4.4 the findings for each contextual factor are presented in two parts. First, the results for the contextual factor are summarized, and then an analysis is made of the contextual factor's influence on tool **use** *and on each level* **of added value**. *Finally, conclusions are drawn in 4.5.*

Abstract

Planning Support Systems (PSS) are a promising tool for involving stakeholders in urban adaptation planning workshops. Past research has acknowledged the importance of context in determining the effectiveness of PSS. However, there has been no dedicated study of the influence of context on the use and added value of the tool. To address this gap, we made an in-depth case study of a PSS, called the Adaptation Support Tool (AST), used in an adaptation planning workshop in Guayaquil, Ecuador. Interviews, questionnaires, observations and document review were used to investigate the influence of three contextual factors (the style of tool use, the phase of planning and the local project setting) on the use and added value of the AST. Our findings indicate that the style of tool use and the local project setting were the most important contextual factors in determining the use and added value of the AST in the workshop. Meanwhile, the phase of planning appears most critical for achieving impacts over the overall planning process. This case study is a modest first contribution to understanding the influence of context on the use and added value of PSS in practice.

4.1 Introduction

As cities face the need to adapt to climate change, collaborative planning workshops are increasingly used to engage stakeholders in planning, design and decision making activities. A plethora of tools and methods have been developed to improve the process and content of such workshops, and to otherwise support their aims.

Planning Support Systems (PSS) are a particular type of tool, defined as "geo-information based tools intended to support planners in planning tasks such as information handling, communication and analysis in planning processes" (Vonk and Geertman, 2008). A growing body of research on PSS has provided valuable insights into their use, usability and usefulness (Pelzer et al., 2016; Russo et al., 2018b; te Brömmelstroet, 2016; Vonk, 2006). Among this research, Pelzer et al. (2014) defined three inter-dependent levels of perceived added value: individual, group and outcome. At the individual level, added value comes from learning about the object of planning and about the other stakeholders. At the group level, added value relates to collaboration, communication, consensus-building, and efficiency. At the outcome level, the added value is in better informed plans and decisions.

The added value of a PSS does not depend only on characteristics and capabilities of the tool itself, but is influenced by the context in which it is used. What can be achieved with a PSS and the meaning of those achievements, depend on factors like the users' backgrounds, the aim of a workshop and the planning issue at hand (Geertman, 2006; Pelzer et al., 2014). Yet, PSS research has focused more on instrumental aspects of the tools than on understanding the interactions between tools and the contexts in which they are used. This shortcoming is well recognized in the field of PSS, where calls for tools to be studied in the "real world, context-rich environment" (te Brömmelstroet, 2013, p.306) are ubiquitous in the literature (e.g. Eikelboom and Janssen, 2015; Goodspeed, 2015; Pelzer, 2017; Pelzer et al., 2016; te Brömmelstroet, 2013). And yet, we are unaware of studies concerned explicitly with context and PSS.

The goal of this research is to explore the influence of context on the use and added value of PSS. To this end, we carried out an in-depth case study of a collaborative planning workshop in Guayaquil, Ecuador, which made use of the Adaptation Support Tool (AST). This single exploratory case study is a modest first step toward understanding the role of context in the use and added value of PSS.

4.2 Context and Planning Support Systems

This section offers a brief overview of how context is represented in PSS literature and introduces the three contextual factors used in this research.

Geertman's (2006) conceptual framework of factors that influence the potential roles of PSS in planning practice highlighted variety of important contextual factors. Since then, PSS researchers have increasingly drawn attention to the influence of context in achieving desired outcomes (te Brömmelstroet, 2013), in determining the added value of tools (Pelzer et al., 2016), and in the suitability of tools under different conditions (Janssen et al., 2014). The most common contextual factors recognized in PSS research are users' (workshop participants) backgrounds (e.g. Arciniegas et al., 2013; Goodspeed, 2015; Russo et al., 2018a), the quality of facilitation (e.g. Pelzer et al., 2015; te Brömmelstroet, 2016), the phase of planning in which the tool is used (Chapter 3; Pelzer, 2017), and the political, cultural and economic settings of applications (Mayer et al., 2005; Pelzer, 2017; Russo et al., 2018a).

4.2.1 Contextual factors used in this study

For this study, three contextual factors we explored:

- The style of tool use,
- The phase of planning when a tool is used, and
- The local setting of the planning process.

We focused on these factors based first on their presence in the PSS literature, so that the findings would be relevant and useful beyond our specific case, and second, on the conditions present in the case itself. We did not focus on individuals' backgrounds, because all participants had studied and currently worked in science and engineering. For the purposes of this research, there was insufficient diversity in participants' professional backgrounds (e.g. professional planners, general public) to focus limited resources on this factor. Personal differences, such as gender and age, were outside the scope of this study. The three selected contextual factors are elaborated below.

Style of tool use

There are two common claims in PSS literature, related to the style of tool use in collaborative workshop settings. The first is that facilitation is necessary to ensure that tools are used effectively and do not "take over the workshop" (Pelzer et al., 2015, p. 363) (see also Eikelboom and Janssen, 2017; Pelzer and Geertman, 2014; van de Ven et al., 2016). The second claim is that the interactive nature of the touch tables on which PSS many are used, and the physical act of participants working around a common tool, create a dynamic and collaborative atmosphere (Arciniegas and Janssen, 2012; Hopkins et al., 2004; Pelzer et al., 2015b). In other words, the physical nature of touch table based PSS plays an intrinsic role in their added value (Pelzer et al., 2014). We wished to explore both of these claims. Accordingly, we used **facilitation** and **the physical manner of tool use** to examine the style of tool use. The individual (non-collaborative) use of PSS in professional planning practice is considered a different style of tool use, which is not addressed in this study.

Phase of planning

PSS are meant to improve a workshop in which they are used, and subsequently, to benefit the next stages of planning and decision making (te Brömmelstroet, 2013). Using a tool too late in a planning process has been found to hinder a tool's ability to effect learning (Pelzer and Geertman, 2014) and planning decisions (Chapter 3). Given the apparent importance of the phase of planning for a tool's effectiveness, we wished to explore tool use in the earliest conceptual phase, when the problem is being

explored, the solution space is still open and the process is not yet fully defined. The case offered the opportunity to examine whether **early tool use** would influence the planning process or the added value of the tool.

Local project setting

PSS are developed and studied almost exclusively in countries like the Netherlands and the United States. Meanwhile, cities in Latin America, Africa and Asia face similar planning challenges, such as adapting to climate change, under different conditions. We wished to explore how a PSS would support planning in such a setting. We used four characteristics of setting that are particularly relevant to the use and usefulness of PSS, and were possible to study in our case: **data availability**, the capacity of local stakeholders, culture, and the level of social-economic development. **Data availability** is an important consideration for PSS applications, as most tools rely on geo-information and other data for their input (Russo et al., 2018a). The **capacity of local stakeholders** has implications for the added value and usability of a PSS (Geertman, 2006; Pelzer et al., 2016; Russo et al., 2018a). The **level of social-economic development** is an intentionally general characteristic, as we were curious what implications this may have for the role of PSS.

Finally, **culture** was particularly interesting, as many of the positive results from using PSS have been based in the Netherlands, a country famous for its consensus-based decision making (Janssen et al., 2014) and low value of hierarchy (Hofstede, 1984). In other words, a culture that is well-suited to collaborative planning. Meanwhile, researchers have acknowledged the importance of culture in determining what is achieved and the appropriateness of particular tools (Geertman, 2006; Janssen et al., 2014; Russo et al., 2018a). Ecuadorian culture offered an interesting comparison with its high respect for hierarchy, deeply collectivist orientation, and relatively high discomfort with uncertainty (Hofstede, 1984). These characteristics have important implications for collaborative planning practice. For instance, collectivist orientation leads to face-saving behaviour, which is an obstacle to openness. Similarly, strong vertical hierarchies are problematic for equal participation between individuals of different social or professional status. Likewise, uncertainty avoidance discourages deviation from existing ways of thinking, which is a barrier to innovation (Hofstede, 2011, 1984).

To summarize, we used four characteristics to examine the influence of the local setting on the use and added value of the PSS: **data availability, stakeholder capacity, culture,** and **level of social-economic development.**

4.3 Research design

In this section, we introduce the case study, the workshop and the PSS that form the focus of this research. Next, we review the research method, including how we studied each contextual factor, and our data collection and analysis.

4.3.1 Case study

To explore the influence of context on the use and added value of PSS, we used a single in-depth case study. This approach was appropriate for evaluating tool use in a way that accounted for the complexities of a real world application, and because a holistic and rich analysis promised the most useful insights (Yin, 2003). While single case studies can be limited in their generalizability, their focus on tangible, practical knowledge is a powerful tool for learning (Flyvbjerg, 2006), consistent with the aims of this research. We selected our particular case because the workshop employed the Adaptation Support Tool, a PSS we have used and evaluated in other cases (McEvoy et al., 2018; van de Ven et al., 2016), and because the workshop, planning process and local setting provided the opportunity to study three contextual factors of interest.

Case description

The case study focuses on a workshop for designing sustainable urban water management solutions in Urdesa, a central district of Guayaquil, Ecuador. Guayaquil is a delta city of three million people, and one of the world's most vulnerable to climate change effects, especially flooding (Hallegatte et al., 2013). The district of Urdesa is representative of the larger city, in terms of physical characteristics and flooding problems. For the purposes of the workshop, Urdesa was divided into two parts: Lower Urdesa, a middle-income, low-lying neighbourhood built at the confluence of estuary branches, and Upper Urdesa, a neighbourhood with a combination of informal settlements and new, gated communities, built on the hillside above Lower Urdesa. As a whole, the district is mixed commercial and residential, and is characterized by a high portion of paved and sealed surfaces in public and private spaces. Lower Urdesa experiences extreme inundations several times a year, when high tides inhibit drainage to the estuary and intense rainfall creates runoff from Upper Urdesa.

The workshop was held in July 2017, in central Guayaquil. It was organized by the city's department for risk management (here forth risk department) and Deltares, a Dutch institute for applied research in water and subsurface. The workshop was carried out in the earliest conceptual phase of a larger flood-risk management project, for which the problems and terms of reference had been roughly defined, but the

details of the planning process were not yet finalized. The aims of the workshop were for participants to learn about adaptation measures for urban flooding at the district scale, and to engage stakeholders in the earliest phase of the planning process. The full-day workshop included:

- A plenary introduction to the workshop and Urdesa's flooding problems, followed by a review of adaptation measures.
- A breakout session where two groups were formed to design adaptation plans for Upper and Lower Urdesa, using the AST.
- A plenary session where each group presented and discussed their plan. See Appendix C.1 for workshop agenda.

Thirteen expert stakeholders participated in the workshop, eleven representing city and national level agencies and two representing universities. Two of the expert stakeholders were also residents of Urdesa. One community member arrived at the end of the breakout sessions and so did not participate in the design activity, but observed the remainder of the workshop. Two facilitators, a tool operator and designated observer were also present.

Adaptation Support Tool

The Adaptation Support Tool (AST) was developed to support collaborative design of spatial adaptation plans in urban areas. The tool contains a library of blue-green and grey adaptation measures[12], which can be implemented in the tool's map interface. Using simple input conditions, like the predominant soil type, and adaptation targets, like storage volume, the tool calculates the cost and effectiveness of implemented measures. This feedback is given as "Indicators". The indicators show the percentage of each adaptation target that has been achieved by the combination of measures implemented in the plan. A "Details" tab provides the quantified contributions of each measure toward each target (van de Ven et al., 2016; Voskamp and van de Ven, 2015) (Figure 10).

4.3.2. Research methods

In the Urdesa workshop, the AST was set up for two groups. For the first group, one tool was set up with the input conditions and adaptation targets for Lower Urdesa. For the second group, a second tool was set up with the input conditions and adaptation

12 'Blue-green' infrastructure, such as green roofs and urban ponds, makes use of water (blue) and vegetation (green) to provide services, such as rainwater management and urban heat mitigation, as well as co-benefits, like aesthetic quality and biodiversity. By contrast 'grey' measures represent traditional solutions, often based on concrete (grey), like storm drains and cisterns.

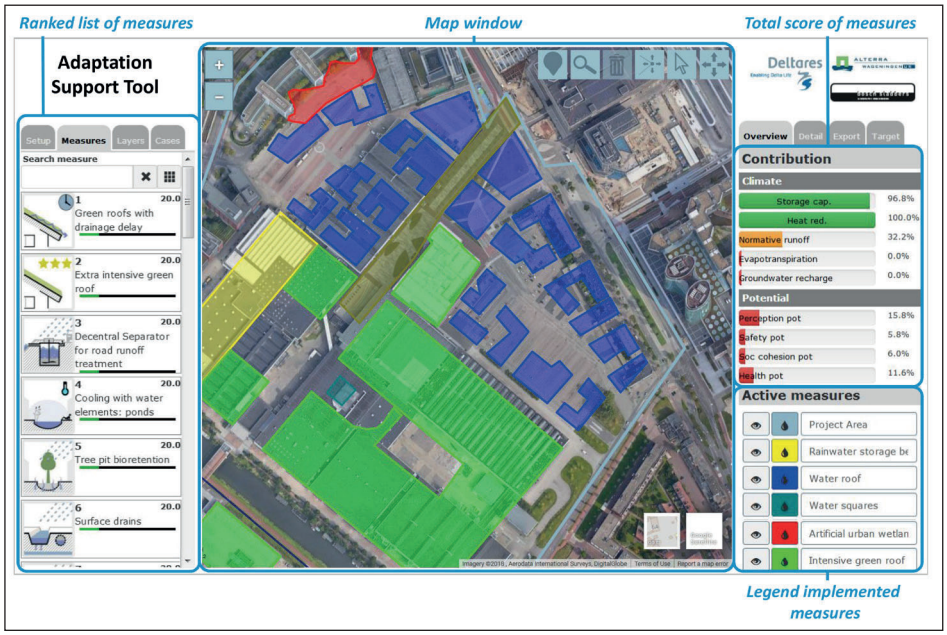

Figure 10. Adaptation Support Tool interface with three panels. The left panel includes the project set-up, the list of measures from the tool's library, and additional layers. The map window is where measures are implemented from the list. The right panel includes the quantitative indicators of the costs and effectiveness of the applied measures, detailed impacts per measure and the adaptation targets.

targets for Upper Urdesa. The adaptation targets were based on calculations from reported flooding and community interviews. Due to issues with data availability, the AST's models could not be prepared with local data. An existing version of the tool based on similar meteorological conditions and the same currency was used to calculate the indicators in the workshop.

The remainder of this section includes an overview of how each contextual factor was studied, followed by an explanation of the data and data analysis methods.

The workshop process and outcomes

PSS applications aim to improve workshop processes and their outcomes. As such, examining the workshop's process and outcomes was central to understanding how context influenced the AST's use and added value. We have therefore included descriptions of the workshop process and outcomes in our findings. We considered two types of outcomes: the plans developed during the breakout session and learning.

Learning is widely considered the most important added value of PSS applications (Eikelboom and Janssen, 2017; Goodspeed, 2013; Pelzer et al., 2016, 2013). It has also been suggested that this is common across different PSS applications and planning contexts (Pelzer et al., 2016). For the individual level of PSS added value, Pelzer et al. (2014) identifies two types of learning: learning about the planning object and learning about the other stakeholders (Figure 11).

Studying the style of tool use

The formation of two groups in the breakout session allowed us to use different styles of facilitation and physical manner of tool use with each group. As both groups had participated in the plenary session and used the same tool in the breakout, this offered desirable conditions for studying the style of tool use. The setup is summarized in Table 10. Both groups received the same assignment, to develop a plan of measures that addressed the adaptation targets for their portion of the district. In studying the style of tool use, we focused on each group's working process, on the plans they produced and on their learning outcomes.

Studying the phase of planning

The workshop was held in the earliest conceptual phase of the project. This provided the opportunity to study a PSS used at the very start of a planning process. Furthermore, the AST was designed to support conceptual planning (van de Ven et al., 2016), suggesting task-technology fit. These conditions offered a useful comparison with previous experience (Chapter 3) and reports in literature, which suggest that a PSS' effectiveness can be hindered by using it late in a planning processes or by a mismatch between the aim of a workshop, the stage of the project and the focus of a particular tool (Geertman, 2006; Pelzer and Geertman, 2014). In studying the phase

Table 10. Style of tool use (facilitation and physical manner of tool use) for Groups 1 and 2

Group	Group facilitation	Physical manner of tool use
1	A facilitator led the workshop, while an assistant operated the tool. The facilitation was structured around identifying adaptation measures and locating them in **Lower Urdesa**.	The tool interface was projected onto a vertical screen in front of the group, which was seated at a shared table. Group members could easily stand up and touch the image on the screen, but the tool was operated only by the assistant.
2	A facilitator demonstrated how to operate the tool and was available for technical support and questions. The group worked independently on an adaptation plan for **Upper Urdesa**.	The tool was used on a large touch table, around which the group stood to see and operate the tool through its touch-enabled interface.

of planning, we focused on the tool's ability to meet the aims of the workshop and any effects on the next phase of the project.

Studying the local setting

The project's location in Ecuador allowed us to study the influence of local setting on the added value of the PSS. First, we were aware that data availability was a concern for the project. Second, Hofstede's cultural dimensions (1984) suggest a number of barriers to collaborative planning in Ecuador, and, on most dimensions, Ecuador differs significantly from the Netherlands, where much of the PSS research is carried out. This offered an interesting comparison. Third, as a "developing economy" (International Monetary Fund, 2017), Ecuador faces challenges in adaptation planning that are likely familiar to many parts of the world. In studying the local project setting, we focused on how the use and added value of the PSS were influenced by the data availability, the stakeholder capacity, the culture and the level of social-economic development.

4.3.3 Data and data analysis

Interviews, questionnaires, observations and documents were used in our analysis. Thirteen semi-structured interviews of one to two hours were carried out with expert stakeholders and workshop organizers, before and after the workshop. These interviews covered four areas: first, perspectives and information on local flooding problems and climate change; second, planning practices in Guayaquil; third, expectations of the workshop; and fourth experiences of the workshop and the AST. One year after the workshop, four follow-up interviews were carried out with project managers, to discuss the use and lasting effects of any workshop outcomes. In addition to the stakeholder interviews, twenty shorter interviews (ten to twenty minutes) were carried out with local residents, business owners and workers in Urdesa, before the workshop. These interviews provided community perspectives on local flooding and formed the basis of the adaptation targets used in the workshop. A full list of data sources is provided in Appendix C.3

Questionnaires were used at the start of the workshop and after the design session. The questionnaires covered topics such as reasons for attending the workshop and individual perspectives on what was achieved and the value of the workshop and the tool (see Appendix C.5). A designated observer was present throughout the workshop (see Appendix D.4) and the facilitators of both groups were debriefed for their impressions. Field notes before, during and after the workshop were taken, using a prepared protocol. Workshop documents and documentation were collected,

including all materials provided or presented to participants and group materials. Finally, background documents, including planning documents, earlier project reports, follow-up project proposals and project documents and communication were analysed.

Interviews and questionnaires were translated from Spanish to English and transcribed. All data was coded using Atlas.ti, version 7.5.18. The text analysis comprised three steps. The first step was to structure the data as: input to the workshop, process of the workshop, content of the workshop, results (outcomes) of the workshop, use of results following the workshop, and effects (impacts) from the workshop. The reasons for applying this framework are elaborated in Chapters 2 and 3. The second step was to analyse the workshop's process and outcomes for the three contextual factors. The third and final step was to reflect on how these contextual factors influenced the added value of the PSS for this case (Figure 11). A list of steps and codes is provided in Appendix C.4. The questionnaire results were analysed in the text analysis. A quantitative analysis is not reported due to the small N.

4.4 Findings

The following section comprises five parts addressing the influence of context on the use and added value of the AST. First, the workshop process is summarized, followed by an overview of the workshop outcomes. This provides important information

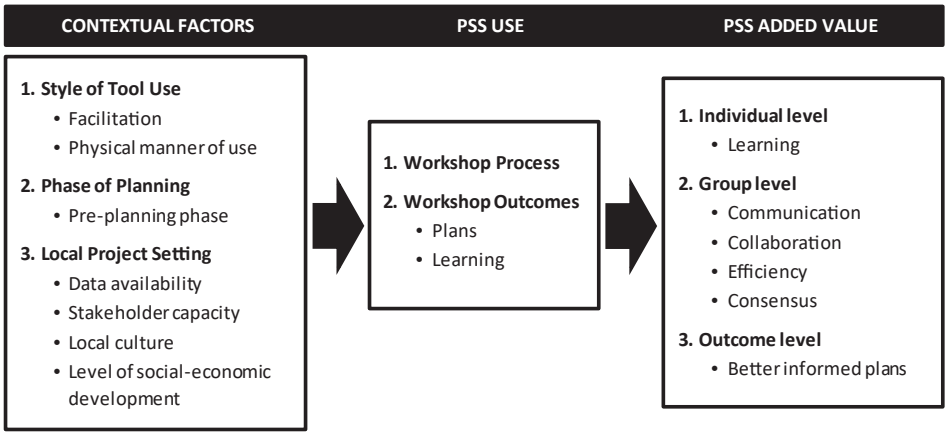

Figure 11. Conceptual structure of the contextual factors, Planning Support System use and added value evaluated

for understanding the influence of each contextual factor. The remaining three parts report the findings for each contextual factor, including a short analysis of the contextual factor's influence on PSS use and on each level of added value.

4.4.1 Workshop process

Following a one hour plenary presentation on flooding in Urdesa and a review of adaptation measures from the AST's library, the participants were divided into two groups of six participants, with roughly equal national, local and academic representation, as well as gender balance. Group 1 was assigned to design a plan for Lower Urdesa and Group 2 was assigned to design a plan for Upper Urdesa. The facilitation and physical use of the AST differed for the groups (Table 10). Each group was given the same assignment and roughly three hours to develop an adaptation plan that achieved the pre-determined adaptation targets for their area. Based on observations and the questionnaires, the group working processes are summarized below.

With the direction of their facilitator, **Group 1** started by creating a list of preferred measures for implementation. Next, the facilitator guided the group in discussing each measure and where it could be located in Lower Urdesa. The selected measures were implemented in the tool by the tool operator. Once the plan was complete, the facilitator led the group in a reflection on future climate scenarios and enabling measures for implementation. Asking, for instance, "What would have to happen for these measures to be implemented?" "Under what conditions do you think that these measures would no longer serve?" These discussions were documented by the facilitator on flip charts. Group 1 started with rather formal communication and took time and active facilitation to engage openly.

Group 2 worked without a facilitator and did not appoint a leader or develop a strategy for their work. This group began immediately exploring measures by directly implementing them in the tool and discussing the feedback from both the indicators and the detailed contributions of each measure. Through this process of experimentation and discussion, Group 2 designed a plan for Upper Urdesa. This group discussed the appropriateness of specific measures for different areas in Upper Urdesa and different strategies for implementation. They did not consider future climate scenarios. This group started playing with the tool almost immediately and communicated openly from the beginning.

Following the design sessions, all participants completed the post-workshop questionnaires. Finally, each group presented and discussed their results in a plenary session.

4.4.2 Workshop outcomes

The workshop produced two types of outcomes: adaptation plans and learning, summarized below.

The adaptation plans

Group 1 produced a detailed adaptation plan for Lower Urdesa. This plan included a number of measures on public space, focused on increasing the storage and retention in the area. This part of Urdesa is where flooding is concentrated and the design achieved 25,500 m^3 of additional storage (30% of the target). Group 1's plan was thorough, with each measure placed and dimensioned realistically, given current conditions in the area (Figure 12).

Group 2 produced an adaptation plan for Upper Urdesa. This plan included a number of measures on public and private space for increasing the storage and retention, and decreasing runoff. The runoff in this part of Urdesa is a major contributor to flooding in Lower Urdesa. The design achieved 115,000 m^3 of additional storage (58% of the target) and reduced the normative runoff from two to fifty years (100% of the target). Group 2's plan was rough and conceptual in nature. It was not detailed in terms of locations or dimensions of measures. The plan also included extreme options, like replacing current built areas with green space (Figure 13). The reason the group took this approach was "to see what is possible".

Learning

Based on the interviews and questionnaires, we found several instances of the types of learning identified by Pelzer et al. (2014): learning about the planning object and learning about the other stakeholders. However, we also found a number of instances of learning that did not fit these types, which we have characterized as three new types: learning about planning practice, learning about measures or interventions, and learning about workshops (details provided in Appendix C.2). It is worthwhile noting that learning about measures is not the same as learning about the planning object. As defined by Pelzer et al. (2014), we understand learning about the planning object to include learning about *impacts* of measures, for which the AST's performance indicators were found to be most useful. However, the AST's library of measures leads to learning *information* about different measures, such as their existence, how they work and look, and what functionalities and co-benefits they have.

Learning about the measures and about the other stakeholders were the most valued outcomes of the workshop, according to the questionnaires of both groups. However, during the workshop and in post-workshop interviews, a number of participants reflected on learning about the planning object. A dominant theme was learning how conditions at the street level determine the effectiveness of particular measures.

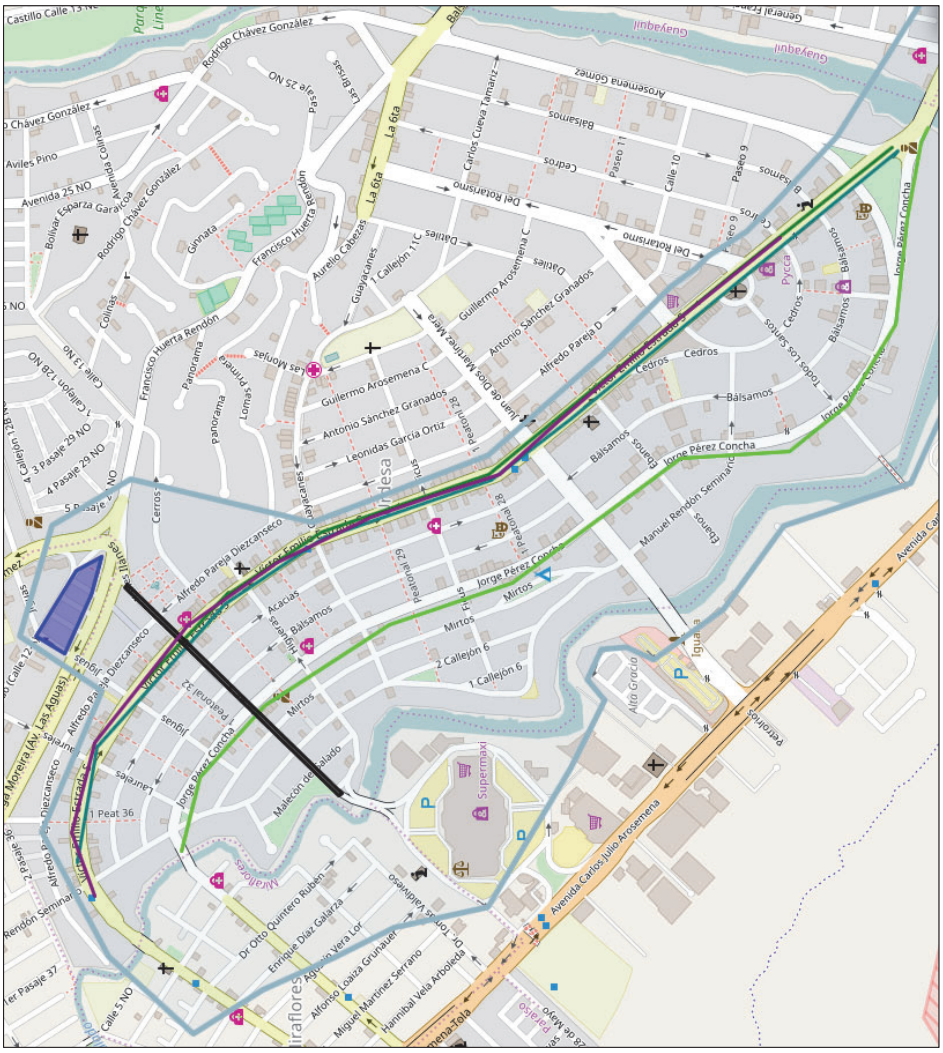

Figure 12. Group 1's adaptation plan for Lower Urdesa. Measures include adding trees, bioswales, grassed swales, a water square and pervious pavement, and replacing leaking storm drains. This plan is notable for its detail and realism.

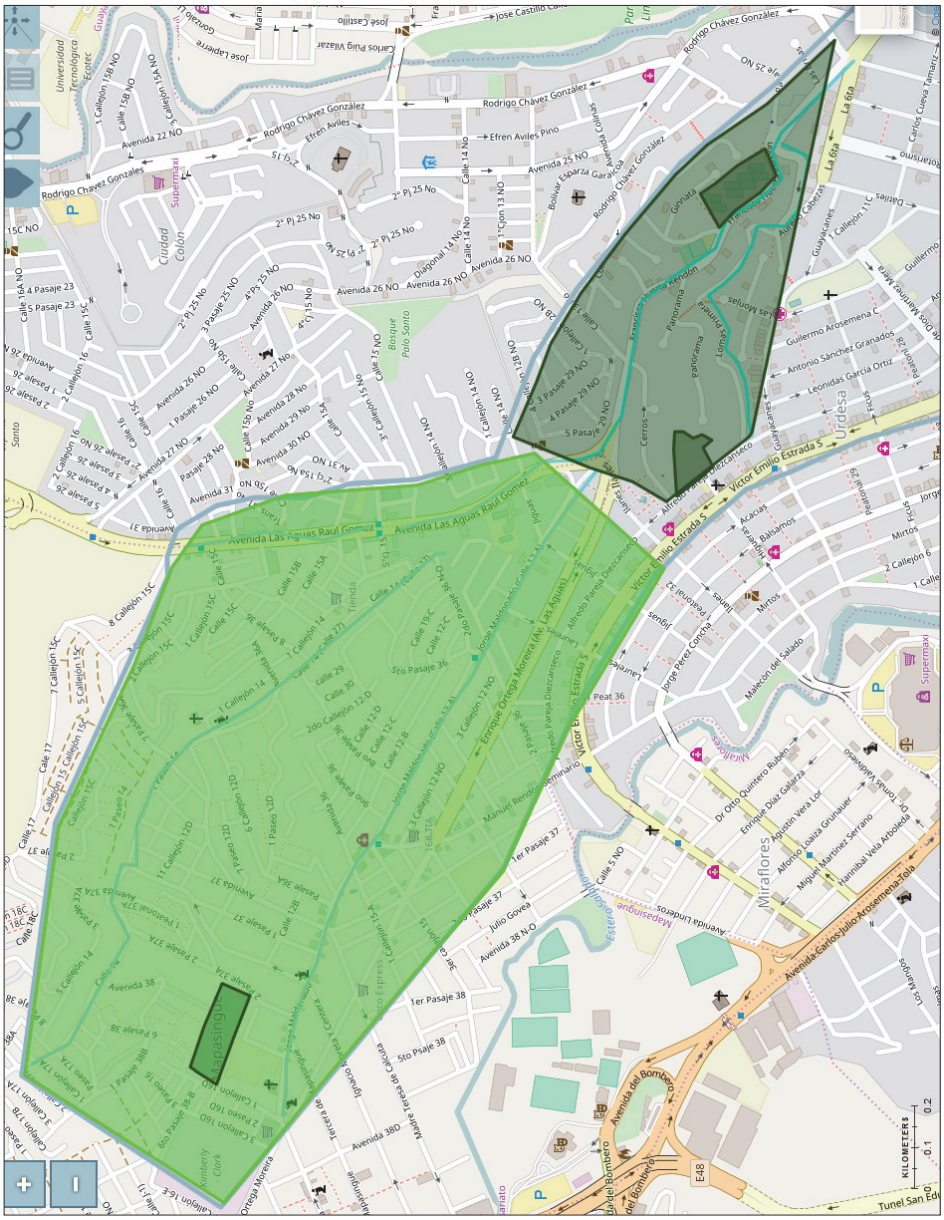

Figure 13. Group 2's adaptation plan for Upper Urdesa. Measures include adding turf grass in the street, pervious pavements, cisterns and green roofs. This plan is notable for its conceptual nature and lack of detail.

4.4.3 Style of tool use

The style of tool use affected the role that the tool played in each group, as summarized below.

In **Group 1** the tool played a supporting role to group discussions led by the facilitator. The tool was used to implement measures, to provide feedback via the indicators, and to document design choices. This group did not use the tool to compare the cost and effectiveness of specific measures in the AST's *Details* tab. Similarly, the adaptation targets did not seem to motivate this group's design. Instead, they focused on developing a pragmatic, implementable plan for reducing flooding in Lower Urdesa. For example, when a measure was implemented in the tool, the group would check the indicators, but the feedback did not influence their choice for a particular measure or spark a reflection on the choice that had been made. This group relied on dialogue to select measures and once a measure and its location had been decided, group members often looked away from the screen to begin discussing the next measure, while the operator implemented their design in the tool. Throughout the workshop, participants focused on one another and the facilitator more than on the screen projected in front of them (Figure 14). To summarize, for Group 1, the tool played a supporting role to the facilitator-led dialogue. This group used the tool to design and document their ideas.

Figure 14. Illustration of Group 1 working, based on a photograph. Group is focused on dialogue and facilitator, tool is in the background.

Illustration by Pascale Karthaus.

In **Group 2**, which worked without facilitation, the tool played the central role in discussions and was used to learn about adaptation measures and to compare the cost and effectiveness of different options. Feedback from the tool, both the indicators and

the detailed contributions of each measure, formed the dominant rationale for design choices. This group was motivated to achieve the adaptation targets. The map interface and the information about measures provided in the AST's library sparked discussions about spatial differences in Upper Urdesa, such as social-economic disparities and the structural quality of formally and informally constructed buildings. This led to further discussions about the implications of these differences for implementing specific measures. From here, the group explored "what if" scenarios, as in "what if these structures were strong enough to implement green roofs?" This group also proposed different implementation strategies for the poorer, informal areas and the wealthier ones. While working, participants in Group 2 focused on the tool around which they stood (Figure 15). The tool's interactive character helped participants to almost immediately begin working together in a comfortable, animated and collaborative manner. To summarize, in Group 2 the tool played the central role in prompting and supporting dialogue with information and the shared spatial language in the map. This group used the tool to explore, learn and play in the area.

Figure 15. Illustration of Group 2 working, based on a photograph. Tool forms the focus of group and dialogue .

Illustration by Pascale Karthaus.

Interestingly, despite differences in the style of tool use, participants in both groups reported equal levels of satisfaction with the workshop and tool, found learning the most important outcome of the workshop and listed the tool's indicators and library as its most valuable features.

Analysis: Influence of the style of tool use

PSS use

Our findings suggest that the style of use affects the tool's role in collaborative planning workshops, and has implications for a workshop's process and the types of plans produced. It is our impression that both the facilitation and the physical manner of tool use contributed to the differences observed. However, as we did not isolate each factor, we cannot apportion their contributions. We can say that for the aims of this workshop, namely learning about adaptation measures for the local setting and engaging stakeholders in a collaborative planning process, both styles of use were successful in different ways.

Our findings do not support Pelzer et al.'s (2015) claims that tools should not be allowed to take over a workshop and that facilitation is necessary for successful collaboration. Group 2 demonstrates a successful application of an un-facilitated PSS taking centre stage. We ascribe, at least in part, the explorative approach of Group 2 to the lack of direction from a facilitator. Nevertheless, we recognize that the success of un-facilitated groups depends on factors like the aim of the workshop, the usability of the tool and the abilities of the users.

PSS added value: Individual level

Participants in both groups reported that learning and "knowledge exchange" were the most valued workshop outcome. It is particularly interesting that participants reported consistent topics of learning from substantially different design sessions. For instance, a participant from Group 1 reflected that "I learned that knowing the area is important for finding measures. You really need to know the place and its relevant characteristics". Meanwhile, a participant in Group 2 made a similar comment that "We discovered that the differences in social [-economic] level in the area mean that some measures are suitable on one block, but not on another. [Adaptation] is a very local question." In two different ways of working, participants learned about the importance of local conditions for adaptation planning.

PSS added value: Group level

The AST facilitated collaboration and communication in both groups; however, it was more central to Group 2. Our findings support the claim that working around a touch table creates an open and collaborative atmosphere, particularly when compared to working with a vertical projection of the tool. In particular, the map played a more central role when working with the touch table. This corroborates earlier research (Arciniegas and Janssen, 2012; Hopkins et al., 2004; Pelzer et al., 2014).

For collaboration, direct interaction with the tool seemed more important than facilitation, but this is a function of the workshop and the participants. Without a facilitator structuring their process, Group 2 focused on experimenting with different measures, which emphasized collaboration and communication. By contrast, Group 1's facilitator-led process realized efficiency benefits, in terms of achieving a fairly detailed and realistic plan within a few hours. In Group 1, the facilitator, rather than the tool, played the central role in achieving open communication.

PSS added value: Outcome level

When looking at the two different plans developed, it is clear that the style of tool use led to different plans, in terms of their relationship with current conditions and their level of detail. In post-workshop questionnaires, Group 1 valued the tool more for developing a plan, while Group 2 valued the tool more for exploring opportunities. In both cases, the tool produced better informed plans, but in different ways. For Group 1, the tool's role in informing the plans was mostly through the library of measures, while decisions were dialogue-based. For Group 2, the tool played the same informing role, but the tool's feedback was also used in decision-making. As such, the tool played a larger role in informing the plans of Group 2, which is attributed to direct interaction with the tool.

4.4.4 Phase of planning

The planning workshop aimed to create learning about adaptation measures and to involve stakeholders in a collaborative planning process, both of which were important components of the project. Due to project delays, the next phase of planning began one year after the workshop and is ongoing. A review of the planning activities and documents in this phase, as well as interviews with project managers, have revealed that the plans and learning from the workshop have not been explicitly used in the project or planning decisions. Lack of continuity in the project schedule and in the individuals involved (roughly half of the current project team represent stakeholders who were not part of the workshop, or are different individuals from those who did participate in the workshop) appears to have limited the influence of the workshop on the remainder of the planning process. For instance, project documents make no reference to the workshop, the AST or the plans developed. Project managers report that the workshop and tool have only been referred to in meetings once or twice. There is, however, evidence of internalized learning from the workshop. While participants were unfamiliar with specific adaptation measures before the AST workshop, a facilitator still involved in the project reported that the individuals who had used the tool were able to easily identify and discuss adaptation measures during later project

meetings. Those individuals also suggested to the team that similar workshops would be helpful in the project's current phase.

Analysis: Influence of the phase of planning

PSS use

Our findings suggest that continuity in the project and in the individuals involved is important for an early-phase planning workshop to affect the remainder of the process. Embeddedness of a workshop within a planning process seems necessary (though we cannot say sufficient) for workshop results to be used. These findings are, of course, limited by the fact that the case study was not ideal for studying the effects of PSS use on the longer term planning process. Furthermore, these findings are based only on the first phase of the project. It is conceivable, but unlikely, that effects would be seen later. Also, we did not follow up with the individual participants, which could reveal indirect impacts of PSS use, such as participants using their learning to inform other projects or decisions. Finally, we could not compare the early-phase use with a later-phase AST workshop. Nevertheless, the early phase of planning did appear to have implications for PSS use within the workshop itself, as described below.

PSS added value: Individual level

Holding a workshop in the earliest conceptual phase seemed to free participants to think creatively, without concerns for having to implement their ideas. This was particularly observed in Group 2, where the design included unrealistic solutions like converting large built-up areas to green space. However, this freedom was also felt in Group 1, where one participant commented "I did not have to think 'who is going to pay for that?' I could just think 'that is a good idea, it is more effective than I thought!'" Being free from project constraints appears to have allowed participants to engage more freely with new information and ideas, encouraging learning.

PSS added value: Group level

Because the workshop occurred in the earliest conceptual phase of planning, before detailed planning decisions are needed, there was little conflict between participants and the need for consensus was not relevant. This was observed in the workshop and reported in interviews. It is also the case that there is general agreement about the problems and the need for action. The question of efficiency was also less important for project managers, because the pressures of the project were not yet present. Nevertheless, the tool was a time-efficient way to 1) learn about different measures, their effectiveness and local suitability, and 2) foster open communication between participants, via their responses to content in the tool.

PSS added value: Outcome level

The initiative phase of planning allowed creativity in the designs of both groups, as observed in their working process and the plans produced. However, the plans have not affected the larger project in any discernible way. In follow-up interviews, project managers attributed this to the lack of continuity in project activities and some of the individuals involved. For this case, the tool's added value to project-level outcomes (as opposed to workshop products) seems to rely more on the workshop's (lack of) embeddedness within the planning process, than on being used in the earliest phase of planning. However, lack of continuity in this case means that it was not ideal for measuring effects on planning processes. Although we could not compare the effects of a later AST workshop in this project, the findings are consistent with earlier experiences with AST workshops (McEvoy et al., n.d.; van de Ven et al., 2016).

4.4.5 Local setting

Data availability is a serious problem in Guayaquil because not enough data is collected and because agencies do not share data. As the AST's models could not be prepared with local data, an existing version of the tool based on similar meteorological conditions and the same currency was used. The district-level information required by the tool to set up a project and rank measures in the library is intentionally simple and easily known (e.g. predominant soil type). Together, these conditions meant that the tool's indicators were still relevant and that the tool was useful in the data scarce setting, particularly for the conceptual level design. Post-workshop questionnaires and interviews indicated that all participants found the data acceptable and were satisfied with the extent to which data were used. Elaboration in interviews showed that this acceptance is based on the preliminary phase of planning and the emphasis placed on learning about measures.

Local stakeholder capacity was high in terms of education, but less so on the topic of adaptation. Workshop participants had backgrounds in engineering and the sciences, and held senior positions in their institutions. Most participants reported that they were familiar with the concept of blue-green infrastructure, but had little knowledge of specific measures and their effectiveness. Furthermore, only two participants reported having thought of opportunities for implementing such measures in Guayaquil and several acknowledged that they had a negative impression of such measures. This reflects a local preference for traditional infrastructure. The tool was used to provide information and learning about blue-green measures and their effectiveness in the limited time of the workshop. In the post-workshop questionnaires and interviews, participants valued most highly the library and the quantitative indicators for

learning. As one participant reflected "The discussions were valuable because the tool combined and compared the measures." In terms of familiarity with PSS, all workshop participants were comfortable and competent using digital maps and computer technology, but were unfamiliar with PSS. It is unknown whether participants use Geographic Information Systems or similar technologies in their work, but the lack of professional planners present, makes it unlikely.

Local culture played out in several ways during the workshop. First, a culture of saving face means that stakeholders in Guayaquil are reluctant to seek help, or admit to errors or shortcomings. At the start of the workshop, participants' most listed reason for attending was to share their knowledge and to show support for adaptation. Learning was the least listed reason for attending. In other words, participants felt that they were there to help others learn, but that they did not need to learn themselves. In the post-workshop questionnaires, however, participants listed learning as the most valued outcome, which they attributed to the tool's content. Second, face saving was also observed in communication during the workshop. In the opening plenary, participants used formal language when speaking to the group and were defensive of their own agencies. Once using the tool, participants were observed to be notably more comfortable asking questions and often interrupted one another. This came more quickly for Group 2, interacting directly with the tool, than for Group 1. While participants' comfort was also likely affected by the smaller group sizes, by settling in, and by the more interactive nature of group work, the speed and level of comfort achieved in Group 2 implies that working directly with the tool played a role in overcoming some barriers to collaborative and communicative work. This was confirmed in interviews. The openness continued in the closing plenary.

In addition to direct interaction with the tool and the map's spatial language, the neutral character of the tool's information seemed to ease communication in Group 2 by limiting confrontation between individuals, i.e. allowing face saving. In this group, for instance, information in the (neutral) tool was used to resolve questions about the costliness and effectiveness of two measures. Participants could focus on the tool instead of each other. By contrast, Group 1 participants took longer to warm up, as the vertical projection of the tool did not provide a shared focus in the same way as the touch table. The tool still offered neutral information, but this played only a supporting role to dialogue. This set-up meant that Group 1 participants had to disagree more directly with one another.

The **level of social-economic development** showed up in two interesting ways. First, Group 2 identified that the spatial distribution of wealth in Upper Urdesa means there are differences in the quality of structures, which has implications for the measures that may be implemented. For instance, when discussing placing water tanks on roofs, Group 2 used the map to identify areas where buildings would be able to support additional loads. Second, the recognition of spatial wealth disparities sparked a discussion on options for financing implementation. The group suggested that tax incentives could be used to encourage wealthier businesses and residents to invest in roof tanks or greening measures on private property, while the city could invest development funds in blue-green measures in public spaces in poorer areas, to improve the living environment while reducing flooding. The juxtaposition of rich and poor within Upper Urdesa became a major topic for Group 2. The tool's map interface was particularly helpful for recognizing and communicating spatial differences. The social-economic context did not play a role in Group 1's work, likely due to the less prominent role of the map, and the lower diversity of wealth in Lower Urdesa.

Analysis: Influence of the local setting

PSS use

On all counts, the local setting influenced the use of the AST. Perhaps the most novel finding is that the tool's provision of neutral information and an interactive platform helped overcome cultural barriers to collaborative planning for Group 2. Prior to the workshop, the local project managers warned that institutional stakeholders in Ecuador would not engage with the design session. After the workshop, the managers expressed surprise at the enthusiasm and level of participation, suggesting that the tool's content involved participants.

When considering stakeholder capacity, the tool appeared a particularly good match for the workshop participants, whose technical backgrounds supported learning about adaptation measures, and using the AST technology. Furthermore, the type of content provided by the tool (the library and the indicators) matched the knowledge that participants lacked. The absence of more diverse types of participants, such as local residents, or non-technical professionals, is a limitation of these results.

With respect to the level of social-economic development, the tool's use in Group 2 was particularly interesting. Here, the map interface and library of measures not only provided content but elicited local knowledge from the stakeholders. When confronted with the map and the measures that could be applied, participants naturally drew

upon their knowledge of spatial disparities and began discussing the implications for planning. It is unclear whether Group 1's lack of consideration for social-economic factors was a result of the facilitator not addressing this question, the lower economic disparity in Lower Urdesa, or the less prominent role of the map in this group's work. It is worth noting that while official maps may not always include informal settlements, the tool's use of satellite images and open street maps allowed participants to recognize the area and draw upon their embedded knowledge of social and technical systems, at the city-block scale.

PSS added value: Individual level

Our analysis shows that local stakeholder capacity likely influenced which topics of learning were most valued by participants. Learning about adaptation measures reflects a match between the tool's content and the participants' backgrounds and prior knowledge. Meanwhile, learning about the other stakeholders and the tool reflects the novelty of collaborative planning and PSS in Guayaquil.

Ecuadorian culture was also important to the added value of learning. Here, the neutral information and feedback from the tool created openness to learning that is normally difficult to achieve. The tool was found to contribute to this in two ways: by providing content (library and indicators) and through its elicitation of knowledge sharing between participants. Learning through knowledge sharing was particularly evident in Group 2's exploration of spatial wealth distribution and the implications for implementing adaptation measures. Finally, as previously discussed, the AST's flexibility in data requirements allowed it to provide useful content for learning, despite limited local data availability.

PSS added value: Group level

We found that the AST supported communication and efficiency, given the local stakeholder capacity and data availability. First, by reviewing the adaptation measures in the tool's library and by using the map interface to implement measures, participants with limited prior adaptation knowledge could communicate easily on the topic. This was a time-efficient way of ensuring that individuals with different levels of familiarity with the measures could participate more equally. Second, given issues with local data availability, the AST's ability to use data based on similar meteorological conditions and the same currency, as well as its basic input requirements were efficiency gains that also helped ensure informed communication during the workshop.

The AST also seemed to help overcome cultural barriers to collaborative and communicative work. The tool's neutral information and common spatial language helped participants work together, without having to contradict, correct or confront one another directly. This allowed face saving and seemed to reduce hierarchy barriers between participants. Focusing on the shared tool and communicating by interacting with it, seemed to allow open dialogue. This effect was stronger for Group 2, working directly with the AST than for Group 1. For instance, the most junior member of Group 2 tried implementing a measure in the tool, while more senior members discussed another alternative. The group then discussed the added measure, without the junior member having to "speak up" or the more senior members being challenged about their idea. These findings suggest that in a local setting very different from the Netherlands, the suitability of PSS was not limited, as has been a concern of other researchers (see Janssen et al., 2014; Pelzer, 2017; Pelzer et al., 2016). Instead, the AST had additional value.

PSS added value: Outcome level

Two elements of the local setting are relevant for the outcomes. The first relates to the level of social-economic development. The presence of informal settlements in a city is unique to developing countries. The tool's map interface allowed users to identify the spatial distribution of wealth in Upper Urdesa, and to use this information in selecting and locating suitable adaptation measures. Second, the collaborative design process of working with the tool created more integrated plans than are typical for the city, due to the siloed administration and authorities. For instance, public green spaces are the domain of one municipal department, while flood risk is the domain of another, and water infrastructure is managed jointly by a service provider and a local authority. In the plans developed by both groups, blue-green infrastructure was used to combine functions and also to consider co-benefits like aesthetic quality. Our analysis shows that the tool facilitated this integration through its focus on blue-green measures, the spatial orientation of the map interface, and the collaborative, interactive approach.

4.5 Conclusions

In this final section, we start with the limitations of this study, followed by a synthesis of our findings on the influence of each contextual factor and the three levels of added value of PSS.

4.5.1 Limitations

There are several limitations to this study. First, our findings are based on a single case study of one PSS workshop, with a relatively small number of participants. These findings are more exploratory and indicative in nature, than generalizable and conclusive. A second limitation is that while the style of tool use was studied by comparing two groups during the workshop, the phase of planning and the local project setting could not be compared to parallel planning processes or locations, for obvious reasons. To enrich and broaden the meaning of our findings, we have drawn comparisons with previous experiences of the AST and from literature. Third, while we found the style of tool use to be an important contextual factor for the added value of the AST in a workshop setting, we could not isolate the effects of facilitation from the physical manner of use. This was a result of practical circumstances during the workshop. Similarly, we did not evaluate the individual participants' backgrounds and how this may have influenced the groups and their use of the tool. The findings on the style of tool use are further limited to PSS use in collaborative workshop settings. The use and added value of PSS in professional planning practice (i.e. non-collaborative settings) remains an important question (Russo et al., 2018a). Finally, a longitudinal study, or one that focused on the level of individual participants, may have uncovered indirect effects of tool use that were not captured in our evaluation.

4.5.2 Synthesis of findings

Considering the limitations of this study, our findings suggest that the style of tool use and the local setting were important contextual factors in determining the use and added value of the AST in the workshop. The phase of planning seems more important for achieving impacts on the overall project and planning process.

The style of tool use proved an important contextual factor for all three levels of added value. Contrary to the accepted view that facilitation is necessary for successful PSS use, our findings, although based only on two groups, suggest that facilitation was not as important as the physical manner of tool use. This finding is likely limited to tools that are relatively easy to understand and operate, like the AST, and to certain types of participants, like the technically trained institutional stakeholders in our workshop. If local residents had participated or individuals in either group had clashed, a facilitator may have been necessary to help ease interactions between different parties. The un-facilitated group using the touch table (Group 2) demonstrated more creativity in their thinking, in their design approach and in their plan, than the facilitated group using the vertical projection of the tool (Group 1). It is unclear to what extent this effect is due to the difference in facilitation versus the physical manner of tool use,

but it is our impression that both factors contributed. Our findings do suggest that standing around the touch table created a more dynamic and collaborative way of working than sitting in a facilitator-led group using a vertical projection of the AST. In this way, the tool's hardware played a role in its added value at the group level. This corroborates earlier findings (Pelzer et al., 2014) and our own experiences using the AST in similar workshops. Our findings also support Russo et. al's (2018b) suggestion that dynamic visualization and the relatability of a PSS' content is central to a tool's value for stakeholder communication.

The phase of planning seems most important in terms of creating an impact on the project, but also plays a role in tool use in the workshop. Pelzer et al. (2016) hypothesized that alignment between the phase of planning and the focus of a workshop affects the added value of a PSS. In our case the tool was well-aligned with the phase of planning and the aims of the workshop, but continuity was missing between the workshop and the next step of the planning process. This meant that the tool's added value was mostly seen at the workshop level and not at the project level. Important aspects for increasing the chance of influencing plans and decisions seem to be (1) continuity in the process and the individuals involved, and (2) embeddedness of a workshop within a process, so that there is a clear place for outcomes to be used.

The local setting of the project was most interesting for the culture and social-economic development. In both cases, we found that the tool added value in ways that were not anticipated and have not been seen in previous applications. First, the tool helped overcome cultural barriers to collaborative planning approaches by providing neutral information and feedback, a shared spatial language and a common point of focus. This was most evident in Group 2, apparently due to the direct interaction with the tool. Second, the tool's map interface was used to stimulate knowledge sharing and creation about the implications of social-economic conditions for planning decisions. Together, these findings suggest that while some researchers have considered different application contexts potentially limiting for PSS (Arciniegas and Janssen, 2012; Pelzer, 2017), the tools may be even more useful in settings like Guayaquil. For instance, while the value of interactive and dynamic content has been highlighted before (Arciniegas and Janssen, 2012; Pelzer et al., 2014; Russo et al., 2018b), we found that the neutral character of the content was equally important in Ecuador's cultural context.

With regard to **the three levels of added value**, we found the individual and group levels were more important to participants than the outcome level. This is consistent with findings from other PSS applications in different contexts (Arciniegas and

Janssen, 2012; Goodspeed, 2013; Pelzer et al., 2016, 2014; te Brömmelstroet, 2010). Like Pelzer et al.(2014), we too found that at the group level, participants particularly valued communication and collaboration. Efficiency and consensus were not mentioned by participants. These findings likely also reflect the early planning phase of the workshop. There is, however, one difference in our findings at the individual level. While others have specified learning about the planning object and the other stakeholders, we found three additional topics of learning. One of the most valued topics of learning in our case was learning about adaptation measures from the tool's library. We have argued that this is distinct from learning about the planning object (cf. Pelzer et al., 2014).

This brings us to the final contribution of this article, the new topics of learning: about planning practice, about measures, and about planning workshops. We suggest that these topics are not unique to this case and should be considered in future PSS studies. This would complement Pelzer et al.'s (2014) framework of added value, which we otherwise found to be useful, complete and robust. Furthermore, as others have suggested that learning is a, or *the*, central added value of PSS, (Goodspeed, 2013; Pelzer et al., 2016; te Brömmelstroet, 2010), broadening our view on learning would benefit future research.

5

Returning to the research questions

The research questions and motivation for this research were introduced in Chapter 1. Chapters 2, 3 and 4 presented the results of a series of experiments (simulated workshops) and case studies (real workshops and planning processes) that examined different aspects of planning support tools in use. Each chapter focused on one or two of the research questions in particular. However, something can be taken from every chapter when answering each question.

The broad scope of the research questions and the qualitative nature of the research do not lend themselves to definite and objective conclusions, therefore the aim of this chapter is to return to the research questions and to discuss what has been learned from the work as a whole. In addition to providing a synthesis of earlier results directed at each research question, this chapter also offers several new insights. A discussion of the contributions and limitations of this research is left to Chapter 6.

The research questions and approach are briefly reviewed in Section 5.1. Research Questions 1, 2, 3 and 4 are then answered in Sections 5.2, 5.3, 5.4 and 5.5, respectively.

5.1 Introduction

This research was motivated by a desire to better understand planning support tools in practice. The starting point was a curiosity about what roles tools play in collaborative planning workshops and how their use influences planning decisions and outcomes. To this end, four research questions were posed in Chapter 1:

RQ 1 . How should collaborative planning support tools be evaluated?

RQ 2. How do planning support tools influence the workshops in which they are used?

RQ 3. How does a planning support tool used in a workshop influence the overall planning process?

RQ 4. How do contextual factors influence a planning support tool's role in a workshop and the overall planning process?

As introduced in Chapter 1, this research is informed by the ideas and theories of policy analysis. Most centrally, this research adopts a view of adaptation planning as a complex decision making process involving many stakeholders, with their individual knowledge, values, abilities and perspectives (e.g. Thissen and Walker, 2013). This study also relied on the fields of participatory and collaborative planning, adaptation and resilience planning, and planning support tool and Planning Support System (PSS) research. These fields provided discipline-specific ideas about planning workshops and processes. Integrating these fields resulted in an interdisciplinary approach to studying planning support tools in use.

A practice orientation is inherent in the research questions and motivation for this study. As such, the research approach was designed to explore tools in use, employing empirical methods of observing and analysing tools in use in the real world. As a first step, a literature review was made, followed by testing different tools in a series of simulated workshops. Next two case studies were carried out to evaluate a specific tool, the Adaptation Support Tool (AST), in real collaborative planning workshops. While each of the research activities was focused on answering one or two of the research questions, all activities contributed to the answers (Table 11).

The remainder of this chapter comprises four sections, each addressing one of the four research questions. Each section presents what has been learned on the given question by drawing together earlier results and providing new insights that arose over the course of this research.

Table 11. Summary of research activities and their contributions to each research question in this dissertation

	RQ 1	RQ 2	RQ 3	RQ 4
Primary research activity	Literature	Experiments	Berlin case	Guayaquil case
Supporting research activity	Cases, Experiments	Case studies	Guayaquil case	Berlin case
Primarily addressed in	Chapters 2, 3	Chapter 2	Chapter 3	Chapter 4
Supporting material in	Chapter 4	Chapters 3, 4	Chapter 4	Chapter 3

5.2 RQ1: Evaluating collaborative planning support tools

The first step in answering RQ1 was a literature review to identify what an evaluation must include to produce meaningful results for planning support tools in use, and which evaluation frameworks already exist. This review resulted in a number of findings:

1. Planning support tools aim to structure and support a workshop's process and content, and to improve its results, be they plans, learning, or other products. A framework should reflect these aims;
2. Planning support tools are often used and valued for "soft" support, such as facilitating communication and learning. A framework should therefore account for this role;
3. Planning is a complex adaptive process that displays emergent behaviour. Therefore, a framework should be flexible to capture delayed, unexpected, indirect and unintended results, and their use and effects;
4. By improving workshops, tools are meant to lead to improvements in the subsequent steps of a planning process and its eventual outcomes. To evaluate this, a framework should include the longer term planning process, not only the workshop;
5. A number of frameworks exist to evaluate participatory planning processes, but these do not capture the level of detail of individual workshops. A framework must capture both the overarching planning process, as well as the details of what happens in an individual workshop and its results;
6. A number of frameworks exist to evaluate activities like workshops, but these do not focus on the tool used or include longer term effects on the planning process. A framework must relate the tool, the workshop and the planning process; and
7. There is a dearth of structured and systematic tool evaluations from real workshops. The framework should be flexible enough to be applied to different tools and settings, but structured enough to provide reliable and comparable results.

The existing frameworks and practice reviewed in literature were found to be inadequate on most of the identified requirements. On this basis, a new framework was designed to address the research objectives. The resulting framework, which has been presented in Chapters 2 and 3, is characterized by two features: its nested view of tool use and its broad, flexible structure. Furthermore, it is more comprehensive than existing frameworks, as it satisfies all seven points above.

First, the framework's nested structure is based on four interdependent levels: a **tool** embedded within a **workshop**, which takes place in a **planning process**, carried out in a wider **context** (Figure 16). This structure seems intuitive from real-life observations, but tool use has not previously been conceptualized in this way. Doing so allows the framework to address point 4, above. This structure also bridges the gap between the frameworks that evaluate workshops and those focused on planning processes (points 5 and 6). The framework's nested structure makes explicit the interconnections between the four levels and allows a tool to be understood within the real-world setting of interest in this research. It was from the perspective of this nested view of tools that the choice was made to focus the framework on the tool in relation to the workshop, planning process and context. As such, the framework does not detail the characteristics or functionalities of an individual tool, as separate from its contributions to the workshop's process, content and results.

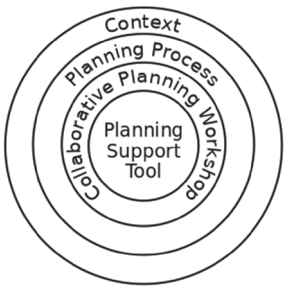

Figure 16. Schematic of the nested nature of planning support tool use within a workshop, planning process and its context

Second, the framework's broad and flexible nature ensures that it is usable for any tool application, while maintaining a common structure and set of criteria. The framework consists of seven factors: **context**, **input**, **process** of the activity, **content** in the activity, **results** of the activity, **use** of results, and **effects**, either directly from the activity or through the use of results (Figure 17). This structure is based on earlier work by Thissen and Twaalfhoven (2001) and was modified for the purposes of this research. The necessary changes were: adding context to the existing framework; using the structure to evaluate a planning support tool, as opposed to only the workshop; and operationalizing the framework for evaluating planning support tools more specifically. These changes transformed the framework's focus on workshops to encompass the nested view of tool use within workshops, planning processes and context.

The evaluation factors in the framework reflect the idea that tools form part of a workshop's process and content, and that these will influence an activity's results (addressing point 1). By making the factors broad and generic in nature, any tool used within a workshop can be evaluated on these seven factors. This makes the framework useful for a variety of applications, while ensuring that data are collected and structured systematically, regardless of preconceived notions and expectations. Reporting evaluations based on this framework also allows results of different tools and applications to be compared (point 7). By extension, the framework's flexibility resolves points 2 and 3, as the factor "results", for instance, can capture both concrete planning products and less tangible achievements, like learning.

Once the framework structure was established, it had to be operationalized and tested. This process has been detailed in Chapters 2, 3 and 4 of this dissertation. In its application, the framework's nested view of tool use and its broad, flexible structure proved valuable for making holistic evaluations that captured the specific details of the individual cases, while producing comprehensive and comparable results. However, the framework is not causal. It produces descriptive information about how tool use transpires within a workshop, planning process, and context. As such, it is up to the evaluator to interpret the results and to propose relations between the findings. This requires a skilled and critical analysis, even more so as the evidence is most often qualitative in nature (or not statistically significant), contextually rich and multi-faceted.

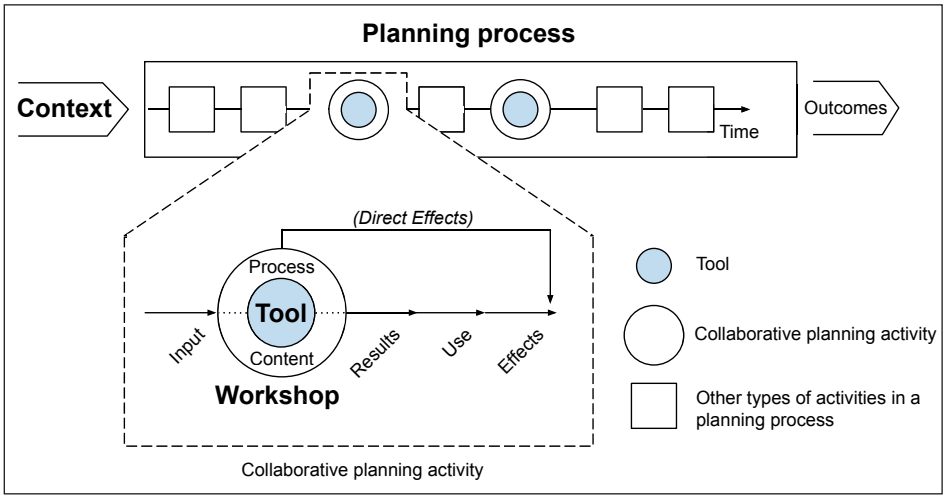

Figure 17. Schematic of the evaluation framework's broad and flexible structure, accounting for the nested nature of tool use within a workhops, planning process and context (in bold)

In summary, existing evaluations of planning support tools fall short on a number of requirements for producing structured and systematic results to science and practice. To address these shortcomings, a framework was developed and operationalized for evaluating planning support tools in use. This framework is characterized by two features. First, the framework's nested structure reflects tool use within workshops, planning processes and context. This allows tools to be evaluated in practice. Second, the framework's broad and flexible nature makes it widely applicable and capable of producing comprehensive and comparable results of different tools in different settings.

5.3 RQ2: Effects of planning support tools in workshops

Answering RQ2 was, in some ways, the central activity of this research, as understanding the role of planning support tools in workshops was the foundation for answering the remaining questions. Addressing RQ2 comprised two parts. First, evaluating three different planning support tools and a tool-free approach in a series of simulated workshops, and then making two in-depth case studies of the AST in real planning workshops. The simulated workshops were designed to explore whether different tools led to differences in the workshops and their results. The case studies were used to test findings in the real world, by focusing on one of the tools, the AST. In total, four simulated workshop groups and three real workshop groups (one in Berlin, two in Guayaquil) were studied using the AST. Additionally, in the simulated workshops, four groups used Group Model Building and three groups each used the Stress Test Guideline and Tool-free Approach.

The simulated workshops showed that different tools led to differences in the ways of working and in the results (in terms of plans, learning and the development of shared understanding). These differences seemed to reflect characteristics of the tool that was used. For instance, the plans developed using the AST reflected its spatial focus and design orientation, producing pragmatic collections of technical solutions. By contrast, outcomes from using Group Model Building reflected the systems-thinking approach, producing strategic plans and shared understanding. For the AST, this finding was corroborated in the case studies, where the workshops in Berlin and Guayaquil produced spatial adaptation plans focused at the district scale represented in the map and consisting of measures in the tool's library. However, there were also a number of noteworthy differences between the real and simulated workshops. First,

the way learning was measured in the simulated workshops did not capture learning about adaptation measures, which was an important outcome of AST use in the real cases. Second, while students working with the AST did not work as collaboratively as those using Group Model Building, for instance, working together was one of the most valued aspects of using the AST in real workshops. This discrepancy does not appear to be attributable to the minimal facilitation in the simulated workshops, as the un-facilitated group in Guayaquil worked in a collaborative manner comparable to the facilitated groups in Berlin and Guayaquil. Third, in Guayaquil, one group did expand their solutions beyond the tool's content, by considering the spatial distribution of social-economic disparity and its implications for implementing measures. This discussion was triggered by the map interface, which elicited local knowledge about the area that was not displayed in the tool. By contrast, students in the simulated workshops did not have local knowledge and so the tool's role was limited to information provider.

In studying the AST's effect on workshops, a number of the tool's characteristics proved central to its role and value. The AST's most important features are that it is map-based, that it is interactive and that it contains substantive content, in the form of the library of measures and the feedback from the quantitative indicators. These are each elaborated below.

The **map interface** not only provided content for the dialogue, but provided a shared spatial language and evoked knowledge sharing, which enriched discussions and led to individual learning and to the co-creation of knowledge in the real workshops. The value of the map, however, depends on the local knowledge of the users. In the simulated workshops, the map served only as a background for locating measures in the plans and as a source of basic spatial information. As there was no local knowledge "at the table", more nuanced and embodied information could not be connected to the map.

The AST's **interactive nature**, particularly users' physical interaction with the tool, proved important for its added value at the group level, namely in collaboration and communication. This was highlighted in Guayaquil, where one group's physical interaction with the tool in touch table format reduced barriers to collaborative work, when compared to another group that used the tool on a vertical projection that was not directly interactive. In Berlin, co-designing a plan in the tool was also seen by users as a significant advantage for communication and time efficiency, when compared to the typical (non-collaborative) planning practices there. Physical interaction with the AST also played a role in the simulated workshops, in a different way. Here, urban

design students found that the tool constrained their preferred ways of working, such as sketching. This finding could not be verified in the case studies, as, by chance, no participants had design backgrounds. However, Pelzer et al. (2013) found that a similar planning support tool infringed on the working styles of urban designers and landscape architects, which suggests that the simulated workshop results for the AST could also be true in real workshop settings. Nevertheless, focusing on, standing around, and working with the common object of the AST appears to affect the way users interact with one another and to create a dynamic and engaged way of working that is especially valued by participants.

The AST's **substantive content** was valued by users in the simulated and case study workshops. While users in all applications found the quantitative indicators beneficial, the library of measures was by far the most valued content. This finding is based on questionnaire responses and also the demonstrated learning about adaptation measures in the cases. Tool users (workshop participants) found the library most useful for learning, as it provides information on different measures in an accessible and efficient way. This learning represents added value at the individual level. However, the library was also found to add value to the group level. When individuals in a group have different degrees of knowledge about adaptation measures, the library supports more equal participation by providing a basic shared vocabulary and knowledge base. This allows all users to join the discussion in a meaningful way and also to represent their own interests in the adaptation planning arena. This added value at the group level was not recognized explicitly by participants or intended by the tool's developers, but was inferred from participants' comments in interviews and questionnaires, as well as from observations.

When the simulated and real workshops are taken together, the influence of the tool seems to stem from three sources: 1) the focus or aim of the tool (e.g. problem exploration, solution design), 2) the working process it engenders (e.g. interaction, way of working as a group), and 3) the content the tool provides or elicits (e.g. objective information, participant perspectives and values, spatial focus). These three sources are distinct but clearly not independent of each other.

In summary, the results from the simulated and real workshops indicate that a planning support tool influences how a workshop plays out and its direct results. In the simulated workshops, different tools were found to result in consistent differences in learning, in the development of shared understanding within groups, in the types of plans that were produced, and in a group's way of working. Moreover, a workshop's

process and results appear to reflect characteristics of the tool that is used. Results of the case study workshops using the AST supported this finding.

5.4 RQ3: Effects of planning support tools on planning processes

RQ3 addresses a core assumption of planning support tool use: that improvement in a planning workshop will affect the subsequent steps in the planning process. Evaluating the effects of planning support tools on planning processes is more challenging than evaluating the tools in workshops, as it requires tracking myriad factors over time, and teasing out which effects are attributable to the tool. This task is further complicated by the importance of less tangible and hard-to-measure effects, like learning. An in-depth longitudinal case study was the approach chosen to address RQ3. This was carried out over 18 months and allowed the AST to be evaluated in the context-rich setting of a real planning process.

In the Berlin case study, the impacts of AST use on the planning process were found to be contributory, indirect and emergent in nature. The Berlin case study also revealed the central role of context in determining the effect a tool has on the planning process. These findings seemed to be supported by the Guayaquil project, although the longer term effects were studied less rigorously there. In evaluating the effects of the AST on planning processes, the framework's broad and flexible structure was instrumental in capturing unexpected and emergent effects over time.

When taking the case studies together, it appears that for the tool to influence the planning process two conditions had to be satisfied: 1) a local champion needed to take up the lessons learned or the ideas developed from using the planning support tool, and 2) there needed to be an opening or a gap that the tool fills. To illustrate this, in Berlin, the AST did not meaningfully influence the choice of measures, because the solution space was not open. Nevertheless, the tool *did* influence the permitting process for the tree-pit measure, because permitting was an open problem to which the tool provided some useful information. Still, this relied on the initiative of workshop participants operationalizing the information to achieve a positive outcome. By contrast, in Guayaquil, there was no clear gap for the tool to fill and there was no champion who directly promoted new ideas inspired by using the tool, even though the solutions space was ostensibly open.

When considering the levels of added value of planning support tools (individual, group, outcome), it is useful to consider where each value is likely to play out in the nested view of tools (e.g. workshop or planning process). When considering workshops in the conceptual phase of design, the most important added value of the planning support tool was improved communication and collaboration. Here, a tool can lead to better workshop process and content, as was observed in the AST workshops in both cases. When considering effects on the overall planning process, however, learning seems to be the most important added value of a planning support tool. As the Berlin case study illustrated, learning can impact individuals' actions and decisions in subsequent steps of the planning process. Better informed plans, or the outcome level of added value, do not seem important to users in the conceptual phase of planning, and do not seem to directly influence the final plans. The results of AST workshops suggest that the plans produced may be more accurately viewed as consequences of a workshop, than as direct input to a planning process. Instead, individual learning appears to be more influential on final plans. These findings, based on both case studies, suggest that for planning support tools used in the conceptual phase, it is more important for tools to generate learning and to support communication and collaboration, than to produce detailed work products.

To summarize, when planning support tools are used in the conceptual phase of planning, their effects on the remainder of the planning process are unlikely to be concrete and directly causal. Instead, effects are characterized by their less tangible, contributory and indirect nature. Furthermore, the effects of tool use on planning processes are influenced by context, exhibit emergent behaviour, and seem more likely to result from "soft" outcomes like learning, than from work products, like plans. Not only were "soft" outcomes more effectual, they were also more valued by participants.

5.5 RQ4: The influence of context on planning support tools

To address RQ4, two steps were required. First, the concept of context needed to be operationalized, and second, a planning workshop needed to be evaluated to study the influence of context.

Operationalizing something as ambiguous and boundless as context is challenging. The case study in Berlin offered a starting point, as it showed that contextual factors relating to the project and to the local setting shaped the AST's use and added value.

A complementary literature review found a number of contextual factors that had been identified or suggested by different researchers, mostly working with PSS. These contextual factors were categorized into four types (Table 12).

Table 12. Types of contextual factors identified in literature as relevant for Planning Support System performance, including examples and references for each factor

Type of contextual factor	Examples of factor	References for relevant articles
1. The individuals in the workshop	Disciplinary background, personal views on the planning issue, etc.	Arciniegas and Janssen, 2012; Goodspeed, 2015; Russo et al., 2018
2. The tool and the way it is used in the workshop	Facilitation, tool hardware (e.g. touch table, computers, etc.)	Pelzer et al., 2015; te Brömmelstroet, 2016
3. The planning process in which the workshop takes place	Phase of planning, nature of the planning problem, etc.	Chapter 3; Pelzer, 2017
4. The local setting of the planning process	Culture, dominant planning style, political environment, etc.	Mayer et al., 2005; Pelzer, 2017; Russo et al., 2018

The specific contextual factors that influence a tool's use and effects are unique and a function of the place, project, workshop, tool and individuals involved. Therefore, like evaluating planning support tools more generally, assessing the influence of context should make use of broad contextual factors that capture what is locally relevant, while remaining widely applicable to different tools and settings. Categorizing the many different elements of context into four types is helpful in this regard.

In addition to informing which aspects of context were important to study, the Berlin case also informed ideas of *what* should be studied. In Berlin, the AST did not influence the plans themselves, but the tool still added value to the planning process in unanticipated ways, like providing information that was useful to permitting the pre-selected measures and demonstrating collaborative planning as an alternative to the city's current practices. For this reason, when studying the influence of context, it was decided to focus on the tool's **use** and **added value**, as opposed to narrower ideas about work products.

The case study in Guayaquil was used to study the influence of context on the tool's use and added value. In order to benefit from the earlier findings in Berlin, it was important that the two cases share some characteristics, yet differ in other areas. It was most important that the AST was the tool used and that the workshops were

comparable in their aims, size, types of participants and duration. The conditions in Guayaquil offered the chance to study the **style of tool use**, the **phase of planning** and the **local project setting**, or contextual factor types 2, 3 and 4, respectively (Table 12).

The findings from this case study indicate that all three contextual factors determined the AST's use and value in Guayaquil. Berlin offers corroborating evidence for the influence of the phase of planning and the local project setting. The style of tool use was not evaluated there. From the simulated workshops and literature, it also seems that *who* uses the tool is an important factor. This could not be confirmed in the real workshops, due to the relatively uniform type and background of participants in both Berlin and Guayaquil.

The importance of context to the use and added value of a planning support tool may seem to imply that ensuring the "right fit" between a tool and the context is a necessary condition for successful tool use. However, when taken together, the results of all the workshops do not support this restricted view. Instead, it seems that the workshops made use of what was useful or relevant in the given setting, while ill-fitting aspects of the tool seemed more often ineffectual than detrimental. This is, of course, impossible to prove, as alternative workshops cannot be carried out to test the effects of different tools. However, given the social and adaptive nature of planning, and accepting that planning processes exhibit emergent behaviour (Innes and Booher, 1999), it is arguably unknowable what will be useful to different individuals as a given workshop and planning process unfold. Effort should still be made to align the basic characteristics of a tool with a workshop's aim and setting. A useful way to think of tool use comes from earlier work characterizing maps in policy processes, which identified four modes of functionality: 1) functional as planned, 2) emergent functionality, 3) non-effective, or 4) dysfunctional (Carton, 2007). This characterization does not reflect a static characteristic of an individual tool, but a tool's functionality in relation to the specific application and the individual users (workshop participants). That is to say, the map interface of a tool may be functional as planned in one workshop and for some of its participants, while in another case, or for different participants in the same workshop, the map may have an unforeseen emergent functionality, or even be dysfunctional.

To summarize, while planning support tools do affect the collaborative planning workshops in which they are used, contextual factors influence, or even determine the tool's use and added value in the workshop, and whether or how the overall

planning process and outcomes are impacted. Categorizing contextual factors into four types, relating to the individuals in the workshop, the tool use in the workshop, the planning process and the local setting, is a helpful way of generalizing the myriad unique aspects of context in different applications. In the case of Guayaquil, the way the tool was used and the local project setting proved the most important contextual factors in determining the use and added value of the AST in the workshop. In both Berlin and Guayaquil, contextual factors relating to the planning process and the local setting were most important for achieving impacts on the overall project and planning outcomes.

6

Reflections on the research and suggestions for future inquiry

The final chapter of this dissertation reflects on the contributions and limitations of this research, and suggests directions for future inquiry into planning support tools in practice.

Section 6.1 summarizes the contributions of this research, followed by a reflection on the findings and the overall research approach, including the limitations, in Section 6.2. Key lessons for tool researchers, developers and practitioners are summarized in Section 6.3 and directions for future research are suggested in 6.4.

6.1 Contributions of this research

This research contributes to the understanding of planning support tools in practice. First, it proposes a new way to view planning support tool use, as embedded within workshops, planning processes and context. Second, this research provides a framework for evaluating tools in use, in a way that links tools to the workshops, planning processes and context in which they are used. The framework's broad and flexible structure makes it useful for evaluating any tool in real planning setting, while ensuring that evaluations are systematic and comparable. The framework's widespread use would allow for meaningful comparative studies in the future. Third, the simulated and case study workshops are unique in planning support tool research for a number of reasons. The simulated workshops are the largest and most rigorous known study comparing a Planning Support System (PSS) to different types of planning support tools. In turn, the two case studies were the first known studies dedicated to evaluating the effects of a tool on a planning process, and the influence of context on the use and added value of a planning support tool. Carrying out evaluations on real planning workshops alone contributed much needed ground-truthing to planning support tool and PSS research. Fourth, this work has brought a new perspective to evaluating planning support tools, combining multi-actor policy analysis theory with the fields of adaptation, resilience and collaborative planning. Together, these contributions enrich the understanding of tools, address current gaps in literature, and offer a stepping stone in the ongoing work of planning support tool research.

When the results of the simulated and case study evaluations are taken as a whole, several new insights arise. First, the results suggest that a tool's influence on a workshop stems from three tool characteristics (its focus, the working process it engenders, and the content it provides or elicits). Second, for a tool to affect the overall planning process, two necessary conditions were identified (a local champion and a need or gap that the tool fills). Third, based on a literature review of context in planning support tools and PSS, more specifically, a characterization of contextual factors was developed (Table 12). Fourth, the experiences of the simulated and real workshops suggest that a tool's functionality, or effectiveness, within a given context, can be represented by four modes of functionality (functional as planned, emergent functionality, non-effective and dysfunctional). The complex adaptive nature of planning processes means that the effectiveness of a tool in a given context is not entirely predictable. These contributions should be explored and tested in future research.

In a number of instances, this research has also found corroborating evidence for the claims of earlier PSS studies. For instance, that learning, collaboration and communication are more important than outcomes to PSS users, and that maps improve communication through the provision of a shared spatial language. At the same time, this research has brought new information to bear on several accepted tenets in the field:

- The Guayaquil case demonstrated that, for the Adaptation Support Tool (AST) used in conceptual design, both facilitated and un-facilitated groups used the tool successfully and that facilitation appears to influence the use of the tool. This finding challenges the broadly held view that facilitation is essential for a successful tool-based workshop (Eikelboom and Janssen, 2017; Pelzer et al., 2015b; van de Ven et al., 2016).
- The AST achieved new topics of learning compared to those included in Pelzer et al.'s (2014) framework of added value. In addition to learning about the planning object and the other participants, AST groups demonstrated learning about planning practice, about adaptation measures, and about planning workshops. Elaborating the existing framework with these new topics of learning was proposed in Chapter 4.
- The AST offered unexpected added value when used in a new cultural context, hopefully broadening ideas about how PSS work and where they can be used effectively.

6.2 Reflections on the results and the research approach

This research is based on a series of simulated workshops and two in-depth case studies. Naturally, the choice for this approach has implications for the findings. Here, the representativeness of the findings is discussed, followed by a reflection on the limitations of the case studies. Next, the usefulness of simulated workshops for testing planning support tools is considered. Finally, the issue of bias is addressed.

6.2.1 Representativeness of the findings

Studying the AST in real and simulated workshops offered new perspectives on planning support tools in use. However, the representativeness of the findings is an important question due to three features of this research approach: 1) the real workshops focus on a single tool; 2) only a single case study focused explicitly on the tool's effects on the overall planning process; and 3) only a single case study focused explicitly on the influence of context.

The choice to focus on detailed studies of one tool in different settings provided deeper understanding of the AST. The question inherent in this approach is how broadly the findings can be interpreted. When considering how representative the findings are for different applications of the AST, the case study results show a number of common themes in terms of the tool's use, added value and effects. For instance, the importance of the library of measures and the map interface, compared to the plans produced. This consistency supports the internal validity of claims made about the AST.

While each of the case studies focused on a particular research question, both cases contributed to answering all four research questions (Table 11). For instance, while the Berlin case study focused on the effects of tool use on a planning process, it also offered insights into the influence of context and informed the dedicated study on this topic in Guayaquil. Likewise, in Guayaquil, follow-up interviews were used to check for any effects from the workshop on the planning process. While two case studies is a limited number on which to base findings, consistency between the results strengthens the answers to the research questions.

A more complicated question is how representative the findings are of *other* tools or PSS. While the results of this research are specific to the AST and the applications studied, the AST shares characteristics with other tools, which suggests that some lessons from this research may be more broadly applicable. For instance, the importance of physical interaction with the touch table in supporting collaboration, and the role of the library of measures in fostering communication and learning, have wider potential meaning than the AST. Furthermore, some of the findings, such as the role of the map interface in facilitating communication and knowledge exchange, corroborate earlier PSS research.

In terms of the representativeness of the individual cases that were studied, both were typical examples of collaborative planning workshops supported by a tool. For the aim of studying planning support tools in practice, it was important that the workshops were not exceptional. Nevertheless, the involvement of a researcher inherently interferes with the in-situ conditions. For instance, by asking participants to reflect on their expectations of the workshop beforehand, and their experiences of the workshop afterwards, interviews and questionnaires could enhance learning.

A final limitation of the case study findings relates to the lack of comparison with other tools or tool-free workshops in practice. In other words, the null hypothesis cannot be tested in the type of case study research undertaken here. The reported

results are based on the observations and analysis of the workshops that took place. The claims made in this dissertation about the effect of the AST are based on these observations and analyses carried out independently and carefully, using best practices for case study research. Of course real case study workshops are not reproducible, but making the same rigorous evaluations of alternative tools would strengthen claims about the AST and offer valuable insights via comparison of the results.

6.2.2 Limitations of the case studies

While this research employed in-depth studies of the AST, there are limitations to the particular cases that were evaluated. First, the case studies both included only expert stakeholders with technical engineering and science backgrounds. This was a coincidence resulting from the use of real workshops instead of ones designed for research purposes. However, the fact that all participants had technical backgrounds in line with the tool's own framing likely influenced the results relating to the use and added value of the AST. It would be worthwhile to evaluate the AST with more diverse users, such as urban designers and citizens. A second limitation stemming from the particular conditions of the case studies is that there was little conflict between workshop participants. In both cases, participants had basically shared ideas about the problems at hand and were open to exploring solutions. This was likely influenced by the early stage in planning, when meaningful trade-offs are not yet mandated. However, the results from both case studies suggest that the AST may be useful in more contentious conditions. In Guayaquil, for instance, the tool helped to overcome cultural barriers to collaboration through improved communication. This may also help ameliorate conflict, where it exists. A more compelling argument, however, comes from the field of process management, which rests on the idea that groups with different problems and problem definitions can work together toward a common idea of a shared solution (de Bruijn et al., 2010). By facilitating the collaborative design of plans in the map interface, the AST seems to bring to life opportunities within a social process. It would be worthwhile to evaluate the role and added value that planning support tools, and the AST more specifically, could take in contentious planning processes.

Finally, this research focused on the conceptual phase of planning, for which the AST was designed. Of course planning support tools can be used in other phases of planning, like decision making and implementation. When it comes to the findings of this research, the conceptual phase of planning may explain the limited influence of tool use on decisions and planning processes. That is to say, many additional ideas and influences will shape the planning process after a conceptual planning workshop.

The early phase of planning may also be the reason that learning, communication and collaboration were emphasized as the most valuable contributions of tool use. In later stages of planning, when decisions have greater consequences, the work products could become most important. For now, the claims made in this research are limited to the conceptual phase of planning.

6.2.3 The use of simulated workshops to test planning support tools

This research used simulated workshops with students to compare different planning support tools and to serve as a pilot for the case studies. It is common practice to use simulated workshops to test planning support tools. Simulated workshops can involve students, or practitioners from planning and other disciplines, but the workshops are designed by researchers or tool developers to test a tool, as opposed to observe its use in practice. There are obvious reasons for using the more controlled set-ups of simulated workshops, not to mention the practical difficulties of arranging and carrying out studies in real planning processes. Authors reporting simulated workshop results typically acknowledge that the environment was an imperfect simulation of real applications, but that the specific implications of simulation are unclear. Given that this research followed simulated workshops using the AST with real ones, it is useful to reflect on how well the simulated workshops served to test this tool.

The first comparison to draw relates to what was valued by tool users. The simulated workshops showed that for a tool user's experience, the working process was more important than a tool's content. For instance, students using tools with clearly defined steps and guidance (Group Model Building and the Stress Test Guideline) were more satisfied with the workshop than students using the content-centred AST. Although only the AST was tested in case studies, the results of real workshops did not support this finding. The library of measures was valued in both the simulated and real workshops; however it was more valued in the latter. The quantified indicators were also more valued in the real workshops, than in the simulated ones. This is particularly interesting, as the local data used to calculate the indicators was only correct in the simulated workshops. This finding appears to support the suggestion made following the simulated workshops that content would be more valued by real stakeholders than by students.

A second comparison relates to the content of planning support tools and the AST's ability to elicit knowledge from users. Following the simulated workshops, it was posited that in real workshops, stakeholders would introduce and share their own local or discipline-specific knowledge. However, the extent to which the tool itself

would elicit that knowledge was not fully anticipated. Designing solutions in the map interface was particularly effective at drawing out users' knowledge of local conditions. In other words, the effect of knowledge sharing came not only from the users having knowledge, but tool characteristics that elicited that knowledge.

A third comparison between the student workshops and case studies relates to the tool's framing effect. In the simulated workshops the AST was found to focus the spatial scale and the type of solutions, based on what was presented in the tool. In the real workshops we found consistent effects. In both the simulated and real workshops, groups discussed issues not directly present in the tool; however, these topics were not developed in the plans, like the tool's spatial adaptation measures were. Only in one group in Guayaquil were such discussions developed as part of the planning. It seems that without a place to "put" such issues, or a way to connect spatial and non-spatial solutions in the tool, groups concentrate on the spatial aspects. This could also be influenced by the engineering backgrounds of workshop participants. With regard to framing the spatial scale of plans, the case study workshops were consistent with the simulated workshops. While there were some instances of street and household level solutions, the plans focused almost entirely on the district scale. There were no instances of plans connecting to larger scales. This is interesting, because the digital map is adjustable. Users can easily change the spatial scale by zooming in and out, or even change the location by panning. These functions were used in all three real workshop groups, but this did not seem to influence the district-scale focus of plans. It is also interesting that the framing effect cannot be attributed to the users' themselves, as every workshop participant worked at a higher level than the district in question, such as city, regional or even national, in the case of Guayaquil. The participants did not connect the district level planning in the workshop to the problems or solutions in their larger jurisdiction.

A fourth and final comparison between the simulated workshops and the case studies relates to the role of facilitation. During the simulated workshops, there was minimal facilitation of the AST. It was suggested that with full facilitation, as the tool is meant to be used, the AST's results would improve. For instance, facilitation could provide the process guidance that the simulated workshop groups lacked. In the Berlin case study, the tool was fully facilitated and the positive outcomes seemed to support the earlier suggestion. This indicated that facilitation is central to the success of a tool-based workshop. A tenet widely held in the field. However, in Guayaquil, we tested this finding with one facilitated group and one un-facilitated group. The results showed more creative use of the AST in the un-facilitated group, while the facilitated group

produced more realistic and detailed plans. These contradictory findings have not been resolved, though it seems clear that facilitation is not strictly necessary for a successful workshop. This begs the question of how the Berlin workshop and the other group in Guayaquil would have performed without active facilitation. Although it is not clear from this research, it seems likely that the need for, or importance of, facilitation is a function of a tool's usability (e.g. can it be operated and understood easily by a novice user), the workshop participants' capacities (e.g. their comfort with the technology and information), and the aims of the workshop (e.g. exploration, detailed analysis).

The findings from comparing the results of the simulated and case study workshops indicate that simulated tests of planning support tools are most useful for developing a researcher's ideas about tools, testing evaluation instruments and possibly examining specific questions about tool usability or design features. However, simulated workshops do not seem a reliable substitute for using tools in practice and the findings of laboratory tests should be validated in real workshops. The experience of real stakeholders engaged in planning activities is necessary to understand the real use and value of a tool.

6.2.4 Bias in the research

Bias is a challenge of any qualitative research, especially when the investigator is involved with the activities and individuals that form the object of study. Identifying potential biases, reflecting on how they may influence the investigator or findings, and devising strategies to counter act biases, are an important step in research such as this. To address bias in the individual workshops, traditional techniques were used (see Creswell, 2003; Yin, 2003), including:

- Using many sources and types of data for triangulation. This included using a range of informants (see Sections 2.3.2, 3.4.2, 4.3 and Appendices A.3, B.2, B.3 and D).
- Basing the evaluations on a structured framework to ensure a systematic review of all the data (Figure 17).
- Using different approaches in the data analysis for capturing a comprehensive view of the data (see Sections 2.3.3, 3.4.3, and 4.3.2).
- Collecting data at different points in time to check for consistency in the findings and the expectations (of the investigator and of study participants) (See Sections 2.3.2, 3.4.2, 4.3.2, and Appendices A.1 and B.2).
- Checking themes, hypotheses, explanations and findings with key informants over time.
- Evaluating the tool without having an active role or involvement in the workshops, the projects or the tool studied.

- Engaging an external reviewer, who remained fully removed from the cases, to check the research design, analyses methods and results.

On a more detailed level, care was taken to frame questions in the questionnaires and interviews so as not to lead participants (see Appendix D). Audio recordings of interviews were also checked for leading or verbal cues from the interviewer.

At the project level, this research is unique in that the evaluations were not carried out by a tool developer or an organizer or facilitator of the workshops. This independence helps limit bias in the results. It is also noteworthy that the starting point of this research was not a positive view of the AST. This critical stance stemmed from policy analysis theory, which claims that defining the problem is the first step in solving complex problems, like adaptation planning. The AST, by contrast, starts with designing solutions, regardless of whether the problem or criteria are well defined. This approach is based on the idea that the problem definition will surface and be refined and enriched through the design process. Policy analysis also argues for opening the solution space in early phases of decision making, like conceptual design. From this perspective, the AST's library of measures seems to offer a finite set of solutions to problems that have not yet been fully formulated or analysed. These initial reservations about the AST were reinforced by the results of the simulated workshops, which indicated that the AST did not offer advantages over the other tools, in terms of learning, shared understanding, the way or working or the quality of the designs. Moreover, some users felt that the AST restricted creativity. Nevertheless, despite this starting point, the AST was studied further because the promise of PSS to support the substantive content and working process of planning workshops warranted further investigation and because Deltares offered access to the tool and to real planning workshops, as part of the European project, GRACeFUL.

6.3 Lessons for tool researchers, developers and practitioners

The findings presented in this dissertation contribute to the body of research on planning support tools, and PSS, more specifically. Moreover, with the focus on tool use in practice, the results of this research are also meant to be useful for improving collaborative planning workshops and planning support tools in practice. As such, key findings are offered here for tool researchers, developers and practitioners.

Lessons for tool researchers and developers

The results of this study illustrate the emergent behaviour that characterizes collaborative planning workshops and processes that makes it impossible to predict outcomes from tool use, especially in the conceptual phase of planning. As such, tool developers should focus on building flexible tools that support learning, communication and collaboration within workshops. This may conflict with developers' proclivity for more data, more information and more sophisticated work products. However, these were found less valuable by workshop participants in this study, as well as others (Arciniegas et al., 2013). Producing plans is still worthwhile, if for no other reason than because the process of doing so leads to learning, collaboration and communication. However, the results of AST workshops suggest that the plans produced may be more accurately viewed as consequences of a workshop, than as direct input to a planning process.

For researchers, the findings of this work should encourage more and better evaluations of planning support tools. First, using a framework, like the one used in this research (e.g. comprehensive and flexible), is imperative for ensuring structured and systematic evaluations. This is necessary for the quality of the individual evaluations, and for improving planning support tool research more broadly. Without comparable cases, researchers will continue to rely on simulated workshops and will be unable to make meaningful comparisons between tools and their application contexts. This leads to the second suggestion: that planning support tools should be evaluated in real workshops. Comparing the results of the simulated and case study workshops suggest that caution should be used when relying on simulated workshops as stand-ins for real stakeholders engaged in real planning activities.

Lessons for practitioners

For those organizing collaborative planning workshops, the take home message from this research is that the AST can add value to collaboration, communication and learning in workshops. The tool has also proved an efficient way of developing a shared understanding of adaptation options and potential solutions in a given place. The more generalizable lessons are:

- Physical interaction with a tool supports communication between group members;
- Maps provide valuable content, elicit knowledge sharing and offer a shared spatial language. However, maps also frame the problem and solution at a particular spatial scale;
- A library of measures, or similar informational features, build individual and group capacity, which facilitates more equal participation and provides valuable content to mixed groups of users;

- Tools may support a workshop as planned, but tools may also display emergent functionality;
- Contextual factors, relating to a workshop, the participants, the project and the local setting influence a tool's use and added value. Ensuring that the tool is sufficiently aligned with the context will improve the likelihood that it is effectual.
- In the conceptual phase of design, it is more reasonable to aim for communication, collaboration and learning from workshops than to expect measurable effects on the planning process and outcomes.
- For a tool to influence a planning process, it must fit some "gap" for the participants and planning problem, and individuals must take the initiative to make use of workshop results.

6.4 Outlook and future research

This study has contributed to a growing body of research on planning support tools, and PSS, more specifically. Nevertheless, there remain many areas that would benefit from future research. Beyond the obvious need for more and better evaluations of planning support tools in use, and the need for further investigation into many of the findings reported in this study, three new topics are suggested for future inquiry.

- Research on PSS usability and adoption, has called for more user-involvement in tool development (e.g. Pettit et al., 2018; Russo et al., 2018). This is based on sound arguments that involving users will create a sense of ownership, ensure that tools better reflect the planning problem and values at hand, and lead to greater PSS adoption. However, the reality of urban adaptation planning, particularly in the conceptual phase, is different from theory. There is rarely enough time and budget for workshops, never mind for tool development. Not to mention that workshops often happen without sufficient lead time for tool development. Contrary to calls for more tailored tools, research and development of generic tools that can be easily adapted and rolled out for a particular workshop seems a promising approach to wider use of planning support tools. For starters, such tools would lower the barrier to carrying out tool-based workshops. Two caveats to this suggestion are that such tools must also be easy to use and understand without too much training and familiarization, and that such tools are likely less valuable for more detailed design stages, or when a tool will be used repeatedly in the same place. In these instances, more tailored tools seem worthwhile and more likely to receive the time, budget and effort of users.

- The AST is designed to use local meteorological and cost data for calculating the Indicators and the detailed contributions of each measure. In both the Guayaquil and Berlin workshops, however, it was not possible to populate the tool with local data. This has been the case in other applications of the AST as well. The problems stem from a lack of time and resources to collect and format the data – as well as a fundamental lack of data. In Berlin, a version of the tool using Dutch data was used, and in Guayaquil, a version using New Orleans data was used. In both cases, the conditions were similar to the stand-in data set, and the currency matched the local one, though the value did not. Nevertheless, knowing that the data was not local from the start, workshop participants and local organizers in both cases found it acceptable for the purposes of the activity. This suggests that it is worthwhile to explore the option of using data types, in place of local data, for workshops in conceptual planning. This would lower the barrier to using the AST (or other tools), as workshop organizers could simply select a climate type from a list of options, a currency, and a basic cost bracket for their currency's value. This would allow the indicators to provide feedback that is accurate enough to compare measures' effectiveness and costs, without the burdensome data demands. In observing how the AST is used in practice, this is the level of information that is used in the workshops, as participants are typically focused on learning, on exploring solutions, and on discussing trade-offs. Preferences for certain measures and their locations are not born of data-driven optimizations, but of negotiation about different stakeholder values. Research into developing data-light, quick and flexible tools seems a promising way to make them more accessible in the reality of planning practice.
- In the simulated workshops and in both case studies, it was noted that the AST's map interface appeared to focus the spatial scale of solutions. This is curious, as the map can easily be zoomed in or out and re-centred. In all three cases, it can be argued that the focus of the workshops was on planning at the district scale, however, in the simulated workshops, groups using the Group Model Building tool connected the district plan to larger and smaller scale interventions. Since other planning support tools are also map-based, it would be useful to research how the spatial scale bias can be counteracted.

As cities increasingly face the need to adapt the urban environment and to involve different stakeholders in the planning process, planning support tools, like the AST, can play an important role in collaborative planning workshops. This research has shown that tools can support both the process and content of workshops and improve the learning, communication and collaboration of workshops in conceptual phases of planning.

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Appendices

Appendix A: Supplementary material for Chapter 2

Contents

A.1 Workshop agenda

9:00-9:15	Plenary	Group formation and startup
9:15-9:45	Plenary	Introduction to the workshop • Structure and objectives of the day (10 min; Frans) • Introduction to the Stadspolders, Dordrecht case and information (15 min; Berry) • Explanation of questionnaires and consent forms (5 min; Sadie) • Groups move to assigned work spaces (Facilitator)
9:45-10:15	Groups	Hand out group instructions (Facilitator) Explanation of work assignments (Facilitator) Complete consent forms and Questionnaire 1 (Individual participants)
10:15		Collect questionnaires and consent forms
10:15-10:30	Groups	Tutorial on tool assigned to group (Facilitator)
10:15-15:00	Groups	Design session • STG: 10:30-15:00 Design (Groups) • GMB: 10:30-13:00 Modeling (Groups) 13:00-13:05 Extra questionnaire (Individual participants) 13:05-15:00 Design (Groups) • AST: 10:30-15:00 Design (Groups) • TA: 10:30-15:00 Design (Groups)
13:35		Collect GMB extra questionnaires (Facilitator)
15:00-15:15	Groups	Select spokesperson and prepare presentation (Groups)
15:15-15:30	Groups	Complete Questionnaire 2 + Reflection forms (Individual participants)
15:30		Collect Questionnaire 2, Reflections, recorder notes (Facilitator)
15:30-16:40	Plenary	Group presentations of results and questions (Group spokesperson)
16:40-16:50		Judges confer on group presentations and select top design (Judges)
16:50-17:00	Plenary	Award presented to winning group and closing remarks (Frans)

A.2 Example of group schedule

Workshop Climate Resilient Urban Design Stadspolders, Dordrecht

GROUP 1

Group result/output:

Drawing(s) (**maps**) showing where each adaptation measure is taken and briefly explains **why**.

- which problems are solved by your plan?
- which additional value(s) is/are created?
- which stakeholders benefit?
- which stakeholders suffer from negative impacts; who pays?
- who will maintain these new facilities?

Tell us: **Why is your plan the winning plan?** Consider the criteria presented this morning.

[It is NOT about the artistic quality of the drawing; it's about creating resilience + added values!]

Agenda:

09:45-10:15	Start of group assignment: 1. Introduce yourselves and which master program you are in 2. Distribute the following roles and corresponding participant number. Role 1 must be taken by an urbanism student. Role 2 must be taken by a water management student. Please take roles you are familiar with or in which you are interested. Consider the information provided in this morning's presentation about each stakeholder's interests. 1. City of Dordrecht – spatial planning & development 2. City of Dordrecht – water 3. Local residents representative 4. Local businesses representative 5. Environmentalist 6. Recorder For the **recorder** - The recorder will be responsible for recording processes and actions during the group work (how they organize themselves, key decisions, why and how they were made). They will be an observer of the process and will also be called upon to reflect on the group process. They will **type** their observations and send results to Sadie McEvoy by the end of the day. 3. Complete consent forms 4. Complete surveys **ALL participants (incl. recorder) must complete surveys and consent forms**
10:15-10:30	Introduction to the Adaptation Support Tool: A touch table with the AST has been set up for your group. Your facilitator will demonstrate how to use it to complete the design challenge.
10:15-14:00	Group work: Your facilitator will support you in using the AST to plan your adaptation measures.
14:00- 15:00	Finalize your design
15:00-15:15	Select a presenter and prepare presentation. Evaluate your final solution from the perspective of each stakeholder ; share the evaluations and evaluate fair distribution of costs & benefits
15:15-15:30	Complete survey Complete reflection **ALL participants (incl. recorder) must complete all surveys and reflections**
15:30-17:00	Group presentations of results and questions

A.3 Pre- and Post-workshop questionnaire and reflection forms

Questionnaire: Workshop Climate Resilient Urban Design Stadspolders

Group: 1

Participant: 1

Role: City of Dordrecht, Spatial Planning Department Time: _____

Considering the real and current case of the Stadspolders district in Dordrecht that was presented this morning, please list the three issues you think are most important for improving its climate resilience:

1. _____
2. _____
3. _____

Note: The same questionnaire was taken by each participant before and after the design workshop.

Reflection: Workshop Climate Resilient Urban Design Stadspolders

GROUP NUMBER: 1 PARTICPANT NUMBER: 1 STAKEHOLDER ROLE: Spatial Planning Dept.

Based on the climate resilient design you helped to develop for Stadspolders, in Dordrecht, please reflect upon the following:

A. From the **perspective of your stakeholder role**, write a few lines on each of the following:

Describe the design your group proposes and its most important features:

Describe your role in the design process of your group:

Explain how the design meets the interests of your stakeholder role:

Explain how the design fails to meet your stakeholder interests:

B. From your **perspective as a technical expert** in your field of study (please circle one):
water management / urban planning / architecture / policy analysis /
other: _____, write a few lines on the following:

Your view of the design:

The technical quality of the design:

What did you like most and least about the method/tool that your group was assigned for the design process?

Most:

Least:

C. Reflecting on your experience with your group and today's workshop, please respond to the following:

Did your view of the district's **problems** change during the workshop? Yes ☐ / No ☐ / Unsure ☐

> What led to the change in your view?

Did your view of possible **solutions** change during the workshop? Yes ☐ / No ☐ / Unsure ☐

> What led to the change in your view?

What is the most significant thing you learned from your experience in this workshop?

What was the most significant learning moment for you today?

Thank you for completing this reflection form and the questionnaires today!
If you have additional comments, please feel free to leave them below:

A.4 Protocol for analysing student workshop results

The following steps were taken in the analysis of the data per group:

1. Surveys and reflections organized by participant and group.
2. Preliminary reading of surveys, reflections and plans. Note topics and impressions that surface.
3. Enter surveys and reflections into excel by group.
4. Code surveys, reflections and plans – read first by participant per group, then by Questionnaire 1, Questionnaire 2 and Reflection. Note topics and impressions that surface.
5. Cluster codes and identify themes per survey per group. Strength of each theme represented by number of participants that identified each theme, out of total number of participants in the group.
6. Quantify number of survey responses that change per survey per group, to get rough idea of learning (change in understanding) for each group.
7. Re-read the reflections and surveys together to identify convergence in language and topics. Quantify common descriptions of the design by group participants, repeated words and ideas, satisfaction with the design and its technical quality. Note interesting responses and group impressions.
8. Use text analysis to identify thematic words or phrases and counting how many times they were used, per group, per survey and which participant used them. This was done to 'trace' the formation of themes in the group and to try to identify participants that were influential or outliers. Convergence was measured here in the strength of theme development and amount of outliers.
9. Review notes from recorder, observers and facilitators to compare with own understanding of each group process and outcomes.
10. Code notes from recorder, observers and facilitators.
11. Review and summarize all analysis and notes made per group.
12. Reflect on weaknesses in data and procedures. Possible implications for results.
13. Develop hypotheses and claims from analyses and reflection.

The following steps were taken in the analysis of each stakeholder role:

1. Reorganize surveys and reflections by stakeholder role in each group (i.e. all water surveys and reflections together) in excel.
2. Code surveys and reflections. Note topics and ideas that surface. Look especially at satisfaction with the design and its technical quality. Consider the participant's role as a leader/follower/outlier within their group. Note interesting responses and role impressions.
3. Count number of questionnaire responses that changed per questionnaire per role, to get a rough idea of learning for each role.
4. Code the notes from recorder, observers and facilitators with special attention to each role.
5. Review and summarize all analysis and notes made per role.
6. Develop hypotheses and claims from analyses and reflection.

Appendix B: Supplementary material for Chapter 3

Contents

B.1 Workshop agenda and invited stakeholders

Grey cells are plenary workshop; white cells are the design session evaluated in this research

Time	Activity	Material	Outcome
9:30	*Coffee & reception*		
10:00-10:30	Workshop introductions & overview	Presentations	
10:30-11:00	Working group updates - water, energy, mobility	Presentations	
11:00-11:15	**Introductions** Self-introductions in the group Review of session aims & agenda Explanation of the evaluation research & consent forms	 Consent forms	 Group familiarity Communicate aims & agenda Inform & consent
11:15-11:30	**Presentation of best-practices document by TNO**	Report detailing best practices for sustainable urban water management measures in the Netherlands	Learning about best practices & several examples of sustainable urban water management in the Netherlands
11:30-12:15	**AST introduction & start-up** Explanation of AST content, operation Review of the measures in the tool's library of measures – including discussion about implementation experience Review of the site map, with flood inundation & heat maps to identify critical locations for measures Entering adaptation targets & local conditions into AST Formation of short-list of group's preferred measures	 AST on touch table AST library of measures AST set-up tab White board	 Learning about the tool Learning about 67 adaptation measures, sharing experiences & local challenges Focusing on spatial aspect of problems Agreed set-up conditions in tool Short list of preferred measures
12:15-13:15	**Designing adaptation plan in the AST**[1] Discussion of measures, possible locations for implementation & applying them in the AST	AST on touch table with tool operator/ facilitator	A plan developed in the AST with measures implemented, giving basic dimensions & indicators of effectiveness
13:15-13:30	**Design session wrap-up** Discussion of what should be elaborated in final plan Agreement on next steps		Agreed elaboration of plan Agreed next steps for project
13:30-13:40	**Questionnaires** Completion post-workshop surveys	Hardcopy surveys	Completed surveys

13:30-14:30	*Lunch*		Informal discussions & agreements for actions
14:30- 15:00	Working group presentations of design session results – water, energy, mobility	Presentations	Communicating results to other working groups
15:00-16:00	Integration session – looking for opportunities to integrate water, energy, mobility pilot projects	Discussion	Integrated project proposals
16:00-16:15	Coffee break		
16:15-17:00	Funding session for workgroup leaders	Discussion	

Local stakeholders from Berlin	
IPS	Local urban water consultancy. Led the sustainable urban water management group.
Nolde & Partner	Local design-build-operate consultancy, specializing in urban water solutions. Could design and build blue-green measures.
Berlin Wasserbetriebe	Berlin water company. Would be responsible for implementing measures related to urban drainage and retention. Three departments were invited: research and development, sanitation, and drainage.
Bezirksamt Mitte von Berlin	District authority, tasked with approving, operating and maintaining any measures in public streets or green areas in Moabit West. The offices of streets and green spaces, and of nature conservation were invited.
Senatsverwaltung für Stadtentwicklung und Umwelt	City department for urban development and environment. The departments of water resources and ground water were invited.
European partners from the Climate-KIC consortium	
Deltares	Dutch institute for applied research in the field of water and subsurface. Facilitated the Adaptation Support Tool design session.
TNO	Dutch institute for applied sciences. Developed the best practices document.

B.2 Data collection

Data collected by phase	
1: PRIOR TO WORKSHOP *August-September 2016*	
Documents	Website of preceding project that initiated SSD project
	Report from preceding project that initiated SSD project
	Internal team emails about organization and planning the design session
Interviews	5 interviewees – interviews were recorded and transcribed
	1 design session organizer
	1 design session participant
	1 design session facilitator and participant
	1 workshop organizer
	1 project manager
2: DURING WORKSHOP *September 2016*	
Observations	Observations of design session and larger workshop, based on observation protocol. Written notes were used to record observations.
Surveys	Post-session surveys from all participants
Discussions	During breaks, short discussions with most participants, organizers and facilitators to check information and ask for impressions. Written records were made of discussions.
Documents	Presentations made in plenary and working group sessions
	Workshop records (agenda, invitees, participants, etc.)
	List of measures selected by water group for application
	Photographs of design session participants working with tool
	Inspiration document prepared for session
3: IMMEDIATELY FOLLOWING WORKSHOP *September 2016*	
Documents	Plans developed in design session
Agreements, plans for next steps	From interviews and discussion in sessions, the planned next steps were recorded, as well as agreed actions of different actors. These were also reported by session organizers to the project management team.
Interviews	5 interviewees – interviews were recorded and transcribed.
	1 design session organizer
	1 design session participant
	1 design session facilitator and participant
	1 workshop organizer
	1 project manager

4: PROJECT END – FINAL SYMPOSIUM EVENT *December 2016 – January 2017*	
Documents	Final project report
	Symposium records (agenda, invitees, participants)
	Symposium handouts
	Presentations made at end symposium events
Observations	Observations of end symposium event with stakeholders and partners, based on observation protocol and with use of German interpreter. Written notes and audio memos were used to record observations.
Interviews	3 interviewees – interviews were recorded and transcribed.
	1 design session organizer and participant
	1 design session participant
	1 design session facilitator and participant
	1 project manager
Discussions	During breaks and after symposium, short discussions several partners, participants, organizers and managers, to check information and ask for impressions. Written records and audio memos were used to record discussions.
5: ONE YEAR POST-PROJECT END *January-February 2018*	
Interviews	4 interviewees – interviews were recorded and transcribed.
	1 design session organizer and participant
	1 design session participant
	1 design session facilitator and participant
	1 project manager
Documents	Project website (SSD Moabit)
	Project status updates and reporting shared during interviews

B.3 Post-workshop questionnaire

Post-workshop questionnaire

Moabit – Deep Dive Workshop

14 September 2016

Name:

Organization/group/interest you are representing:

In your opinion, what are the three most important challenges for making Moabit more resilient to climate change?

1. _____
2. _____
3. _____

In your own words, please describe the work products and other outcomes of today's workshop:

Based on your experience in this workshop, please answer the following:	Absolutely	Somewhat	Unsure	Not really	Not at all
1. Did you gain new insights into the problem or possible solutions?	◯	◯	◯	◯	◯
2. How openly did you communicate your views or knowledge?	◯	◯	◯	◯	◯
3. How committed do you feel to the next steps in the project?	◯	◯	◯	◯	◯
4. How satisfied are you with the extent to which data and information were used in the workshop?	◯	◯	◯	◯	◯
5. Did you find the data, information and assumptions acceptable?	◯	◯	◯	◯	◯
6. Was the workshop objective clear and relevant to you?	◯	◯	◯	◯	◯
7. Did you find discussions of the problems, solutions and impacts sufficiently broad?	◯	◯	◯	◯	◯
8. How valuable was the workshop for your understanding and work?	◯	◯	◯	◯	◯
9. Do you find the *outcomes* of the workshop relevant and useful?	◯	◯	◯	◯	◯
10. Did the touch table tool help you think of the problems in new ways?	◯	◯	◯	◯	◯
11. Did the touch table tool help you to think of climate adaptation solutions in new ways?	◯	◯	◯	◯	◯
12. Did the touch table tool help you to communicate or understand others?	◯	◯	◯	◯	◯
13. Did the touch table tool support a better outcome (innovation, added value, performance, representativeness, other_____)?	◯	◯	◯	◯	◯

Post-workshop questionnaire

Moabit – Deep Dive Workshop

14 September 2016

Please describe briefly:

What aspects of the **workshop** were ***most*** helpful to you? Why?

What aspects of the **workshop** were ***least*** helpful to you? Why?

What aspects of the **touch table tool** did you find ***most*** helpful in this workshop? Why?

What aspects of the **touch table tool** did you find ***least*** helpful in this workshop? Why?

B.4 Codes and themes used in analysis

EVALUATION FACTOR	INDICATOR	CODES USED IN DEVELOPING INDICATOR
CONTEXT		
	Local setting	*CONTEXT - Setting information* *CONTEXT - Prior elements*
	Institutional setting	*CONTEXT - Institutional* *CONTEXT - Challenges Institutional*
	Project structure and process	*CONTEXT - Process structure* *CONTEXT - Challenges Structural*
INPUT		
	Aim and role of activity	*INPUT - Aim of Activity*
	Organization	INPUT - Resource Availability INPUT - Organization of Activity
	Stakeholders and participants	INPUT - Actors INPUT - Participants
CONTENT		
	Depth and breadth	CONTENT - Depth and Breadth
	Data and information	CONTENT - Validity and Credibility
	Tool and methodology	CONTENT - Methodology
PROCESS		
	Procedures	*PROCESS - Procedures*
	Communication	PROCESS - Communication
	Way of working	PROCESS - Participants PROCESS - Working Method
	Organization	PROCESS - Organization PROCESS - Resource Use
RESULTS		
	Outcomes	RESULTS - Work Products RESULTS - Non-product Results
	Documentation	RESULTS - Presentation RESULTS - Availability
	Value and relevance	RESULTS - Acceptance RESULTS - Relevance RESULTS - Solution quality RESULTS - Verifiability and Validity
USE		
	Direct use	USE - Direct
	Indirect use	*USE - Indirect*
	Unused	*USE - Unused*
EFFECTS		
	Learning effects	EFFECTS - Actors EFFECTS - Learning
	Problem situation effects	EFFECTS - Problem Situation
	Planning process effects	EFFECTS – Planning Process
	Decision effects	EFFECTS - Decisions/Policy Quality
	Intended effects	*EFFECTS - Intended*

Italicized items from inductive analysis; otherwise, based on deductive analysis using Thissen and Twaalfhoven (2001) framework.

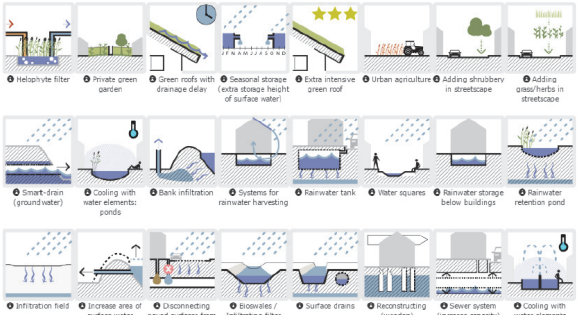
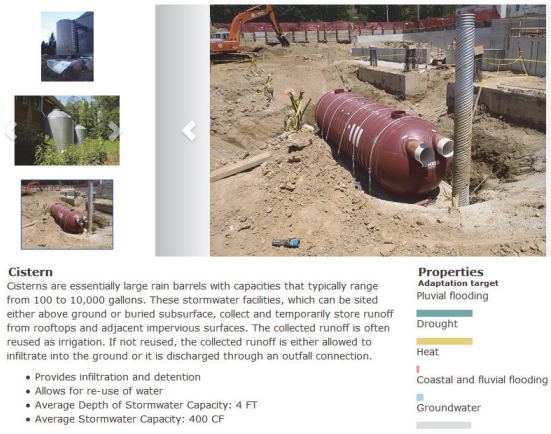
In addition to the codes and themes that were developed and summarized above, there are also two other ways codes and themes were used in the analysis.

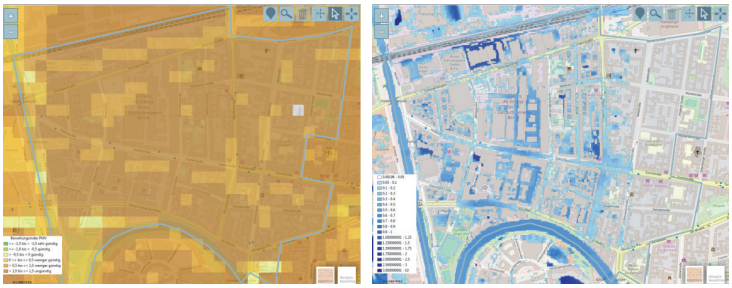
1. 'Tracking codes': Codes that were used to keep track of narratives in the data that did not contribute to a specific theme, but were useful for the meta-analysis. For example, a code 'Planned use' was helpful for tracking intended use of results, which could later be compared to the actual use.
2. 'Prompting codes': Factors that were used in the meta-analysis, but were not conducive to text coding. These codes were used as prompts for the meta-analysis. For example, factors such as 'sensible results'.

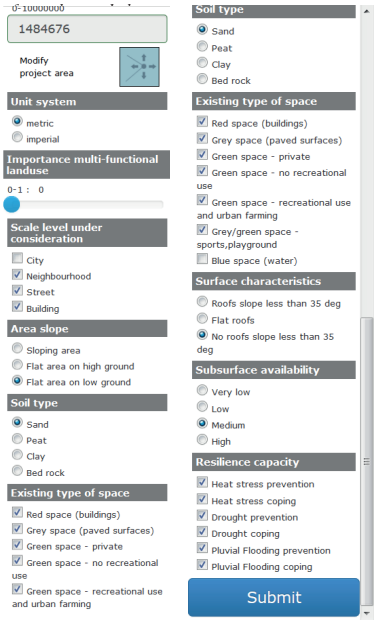
TRACKING CODE	**USE**
CONTEXT - Challenges General	To identify the role of these challenges as they reinforced/ counteracted the role of the design session and tool
PROCESS - Changes	To identify if the process of the design session strayed from plans
PROCESS - Ending	To identify how the design session ended
RESULTS - Planned Actions	A type of result that is a plan to take action by a participant. Later compared to actual actions taken following design session.
USE - Planned Use	Track intended use of results for different time periods for comparison with actual use. Identified realized, unrealized and realized but unforeseen uses of results and their time frames
EFFECTS - Types	Track different types of effects over time
Needed actions	Track actions that were identified as necessary to reach certain aims, like implementation. Later checked which actions were taken and the results.
Next steps/expectations	Track the plans and expectations of different actors to compare with the actual process and what transpired.
Participation	Identify role of participation and views on participation
Perspectives/views	Track different perspectives of actors in the project over time to identify changes, contradictions, shared views, etc.

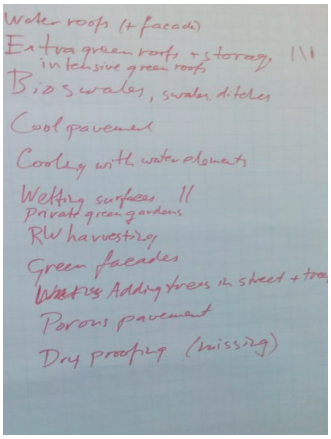
PROMPTING CODE	**USE**
RESULTS - Consistency	Assessing the consistency of the results with the input conditions, actors, process and content of the design session and project
RESULTS - Documentation	Assessing the quality of the documentation, different from the theme documentation
RESULTS - Sensible	Assessing whether results seemed reasonable for the project and actors
USE - Timeframe of Use	Examining when results were used in the process
USE - Used Elements	Examining which results or elements were used
USE - Used For	Examining in what capacity or for what purpose results were used
USE - Who Used	Examining who used which results following the design session
EFFECTS - Implementation	Assessing implementation or realization with a broad view, not only of 'built project' but 'soft changes'

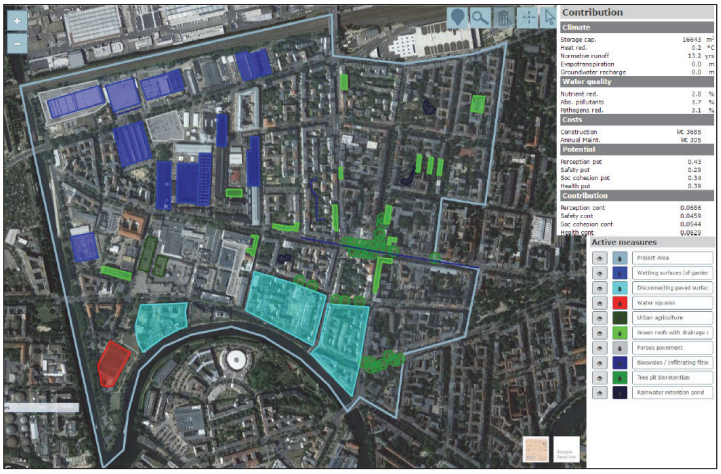
B.5 Summary of workshop contents and products

AST INTRODUCTION AND STARTUP (11:30-12:15)	
Activity:	**Explanation of AST content, operation**
Materials:	AST touch table
Outcome:	Learning about the tool
AST role in outcome:	AST is focus of activity, as participants learn about each panel in the tool, how the tool operates and calculates the indicators.
Activity:	**Review of the measures in the tool's library of measures** – including discussion about implementation experience. The facilitator led the group through a review of AST's 67 adaptation measures, by selecting the icons for each measure to open the information page with photographs and descriptions. Workshop participants contributed their own experiences and asked questions about the different measures. A central theme of the discussions was how each measure could be permitted in Berlin and what challenges would come with the different options.
Materials:	AST library of measures *Screenshot from AST library of measures*  *Screenshot information screen for an example measure, Cistern* 

Outcome:	**Learning about adaptation measures, sharing experiences & local challenges.**
AST role in outcome:	The AST is central to the learning, as it provides a concise library with the information that was reviewed. In addition to its role as information provider, the library also elicited questions and knowledge sharing among participants, which enriched the learning outcomes.
Activity:	**Review of the site map, with flood inundation & heat maps to identify critical locations for measures** The facilitator turned on the flood inundation overlay and then the heat overlay to facilitate discussions on where flood and heat vulnerability were highest and interventions would be most effective. Workshop participants shared information that was not shown in the map.
Materials:	AST touch table with map interface and overlays of flood inundation and heat stress. *Screenshots of the area map in the AST with heat overlay and flood inundation overlays. Overlays could be turned on and off during the spatial analysis.* 
Outcome:	Spatial analysis of the area and problems, identifying vulnerable areas, as well as spatial opportunities and constraints for implementing measures.
AST role in outcome:	The AST is central to the spatial analysis as it provides the map and shows the overlays that are used to understand vulnerable areas, potential locations for measures. This information also triggers knowledge sharing among participants, about spatial opportunities and constraints that are not included in the map.

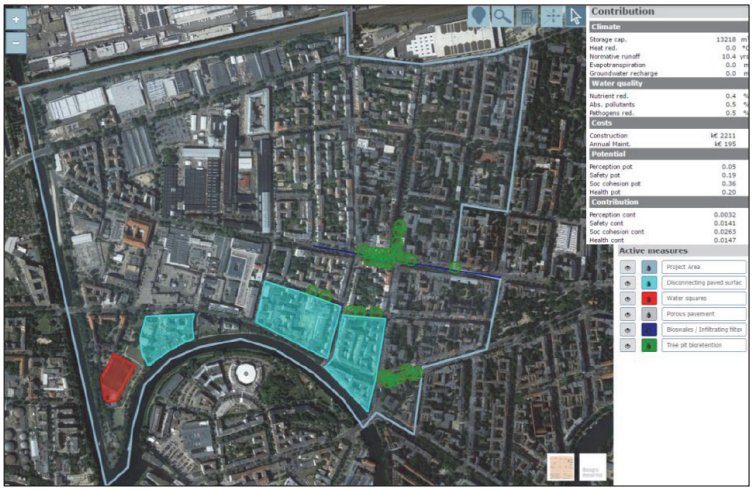
Activity:	**Entering adaptation targets and local input conditions into AST**
Materials:	AST Setup and Targets tab As there were no existing concrete adaptation targets, values were estimated with the advice of the AST facilitators and project managers and with input from participants. The storage capacity was calculated as 10mm over the entire project area, 14846 m^3, the flood return period was reduced by a factor of 10, to 20 years, and heat reduction was set at 0.5°C. The input conditions were selected by the group, without any disagreements. *Screenshot of the input conditions* 
Outcome:	Agreed Targets and Setup conditions for the AST
AST role in outcome:	The AST takes the adaptation targets and local conditions defined by the group as input

Activity:	**Formation of short-list of group's preferred measures** After reviewing the measures and the local conditions, and setting adaptation targets, the group were asked to each list ~3 adaptation measures they thought were suitable for the plan. A group list was created from these measures, with the number of 'votes' marked for each suggestion.
Materials:	Flip chart *Photograph of the flip chart with list of participants' preferred measures.* 
Outcome:	A list of participants' preferred measures to be used in prioritizing the design, with number of votes in parentheses: • Water roofs & facades (1) • Extra/intensive green roofs (3) • Bioswales/swales/ditches (1) • Cool paving (1) • Cooling with water features (1) • Wetting surfaces (2) • Private green gardens (1) • Rainwater harvesting (1) • Green facades (1) • Trees in the street/tree-pit (1) • Porous pavement (1) • Dry proofing (not in tool) (1)
AST role in outcome:	The AST provides the list of measures and supports the spatial analysis, which are both used by participants to identify promising measures for the plan. In this way the AST is central to the outcome, although the list is made on a flip chart. Without the AST, this list would likely be less informed, because participants would not have a common knowledge of measures or a shared understanding of the local problem areas.

DESIGNING THE ADAPTATION PLAN IN THE AST (12:15-13:15)	
Activity:	**Discussion of measures, possible locations for implementation & applying them in the AST.** Using the short list of measures and starting with the most voted ones, the facilitator led the dialogue of where each of the measures should and could be implemented in the district, connecting each measure's value to the areas where it is needed (e.g. measures for flooding, in flood hot-spots). The local partners selected the locations for measures, considering whether land was public or private, and possibilities for new projects, such as planned street improvements.
Materials:	AST touch table with tool facilitator During the design, participants integrated their knowledge of different measures, from the library review, the information from the map and the flood and heat overlays, with local knowledge in the area to identify suitable locations for preferred measures. As measures were added, the indicators gave feedback on the contribution to the adaptation targets. The participants did not focus on the indicators or use them to inform their design. Instead, they used local knowledge about which spaces were public and private, the co-benefits of certain measures for the community (e.g. greening areas adds aesthetic quality to an unpleasant street, as well as cooling) to make their design.
Outcome:	A plan developed in the AST with measures implemented, giving basic dimensions, locations & indicators of effectiveness. This was later elaborated based on the agreements in the workshop. The elaborated designs were used in the proceedings steps of the project and are included here. *Elaborated design with measures implemented in the AST on public and private land.* 

B

Elaborated design with measures implemented in the AST on public land only. Elaboration



Summary of effectiveness of elaborated designs from tool's calculations

INDICATOR	TARGET	PUBLIC SPACE	PRIVATE+PUBLIC SPACE
Storage Capacity, m^3	14846	13218 (89% of target)	16643 (112% of target)
Heat Reduction, °C	0.5	0.03 (6% of target)	0.16 (32% of target)
Normative Runoff, yr	20	10.4 (52% of target)	13.2 (66% of target)

AST role in outcome:

The design is created in the AST map interface and the indicators are calculated by the tool. A plan with quantified impact could not be developed within one hour, without support from a tool, like the AST.

Appendix C: Supplementary material for Chapter 4

Contents

C.1 Workshop agenda

Workshop Agenda

Time	Activity
09h00	Welcome
09h15	Consent forms Pre-workshop questionnaires
09h20	Introductions to the case • Background and current climate risks in Guayaquil • Explanation of the Urdesa case – area of flooding and acceptability thresholds • Aims of the workshop
09h45	Review of adaptation measures, using tool's library
10h15	Break into two groups Coffee break
10h30	Group planning sessions using the Adaptation Support Tool
13h00	Post-workshop questionnaires
13h15	Lunch
14h00	Presentation of group plans, discussion and conclusions from workshop
14h30	Closing words

C.2 Types of learning found

Types of learning identified by Pelzer et al. (2014) with examples and quotes from case study

Learning type	Specific learning examples	Illustrative quotes
About the planning object	Local opportunities for adaptation measures	"I knew of these kinds of measures, but thinking more specifically about where and how to implement them here was new and valuable"
	How local conditions affect the suitability of specific measures	"[I] realized from the tool that it is important to know the area that you are working in… you need to know the specific characteristics to know which type of measures you can put at the local level."
	How the local community experience and think about the flooding	"you can see that everything is different... pavements, type of surface, whether there are open areas or not, type of constructions... it's all important."
	Physical and social contributors to the flooding in Urdesa	
About the other stakeholders	Different roles they and other stakeholders have in adaptation	"[we] could see a different focus, that [adaptation] is not only the municipality's responsibility, but the other authorities also have a role".
	The challenges and abilities of the other stakeholders	

New learning types identified in the case study, with examples and quotes from the case

New learning type	Specific learning examples	Illustrative quotes
About planning practice	Value of planning support tools	"[W]hen everyone is focusing on the table, discussion starts very quickly. It's like, because you are not sitting looking at each other, you're less self-conscious… everyone is focused on the table and you just start playing around."
	Value and efficiency of collaborative planning workshops	"We have to plan for the short, medium and long term. The tool helped see short term measures that can be implemented while we wait for decisions about the bigger solutions."
About interventions/ measures	Different blue-green measures and their effectiveness	"The idea about the [bioswale] is a good one… it contributes 5% of the storage. I never thought it was so effective." "The tool is useful to see different alternatives, that is its value"
About workshop organization	Community participation must be organized separately from institutional stakeholders (learning on the part of project managers)	"We have to work with the community differently. That is clear"
	How the AST supports different design process (learning on the part of the facilitators)	"When I compare my group (Group 2) to Group 1… I think it is interesting that the touch table makes the dynamics so different…"

C.3 List of data

		N
Pre-workshop data		
	Expert interviews (long form)	9
	Community interviews (short form)	20
	Planning documents and records	9
	Observation notes, based on protocol	
	Records of workshop planning activities	
	Urdesa field visit notes and photographs	
Workshop data		
	Pre-workshop questionnaire	13
	Post-workshop questionnaire	13
	Observation notes, based on protocol	
	Observations from facilitators	
	Photographs of group work	
	Workshop documents (agenda, attendance, handouts, etc.)	
	Plans developed by Groups 1 and 2	2
	Documentation of planning process and decisions (notes, lists, etc.)	
	Workshop PowerPoint presentations	3
	Presentations of plans developed by Groups 1 and 2	2
Post-workshop data		
	Expert interviews (long form)	5
	Project documents for first phase of planning	2
	Follow-up interviews on project first phase of planning activities	4

C.4 Synthesis of Atlas.ti analysis steps and codes

Code all data according to the evaluation framework

1. BACKGROUND	
	Location and case information
	Institutional setting
	Project structure and process
2. INPUT	
	Aim and role of activity
	Organization
	Stakeholders and participants
3. CONTENT	
	Depth and breadth
	Data and information
	Tool and methodology
	Procedures
	Communication
	Way of working
	Organization
4. RESULTS	
	Outcomes
	Documentation
	Value and relevance
5. USE	
	Direct use
	Indirect use
	Unused
6. EFFECTS	
	Learning effects
	Problem situation effects
	Planning process effects
	Decision effects
	Intended effects

Review results by evaluation framework and note themes

Code all data by contextual factors

1. Style of tool use
2. Phase of planning
3. Local project setting

Identify themes in contextual factors and refine the contextual factor codes

1. Style of tool use	
	Facilitation
	Physical manner of tool use
2. Phase of planning	
	Early-phase
	Overall project
3. Local project setting	
	Local stakeholder capacity
	Data availability
	Level of social-economic development
	Culture

Check for contextual aspects missing from evaluation

Code all data by levels of added value

1. Individual level	
	Learning about object of planning
	Learning about the other stakeholders
	Other learning
2. Group level	
	Collaboration
	Communication
	Consensus-building
	Efficiency
3. Outcome level	
	Better informed plans (workshop level)
	Better informed decisions (project level)

Identify emergent themes in added value

C.5 Questionnaires translated to English

Pre-workshop questionnaire (translated to English)

Q1. In your opinion, what are the three most important challenges and opportunities for the flooding problem in Urdesa?

Q2. Please briefly explain your role in, or connection to, adaptation in Urdesa:

Q3. Please indicate your reason or motivation for participating in this workshop, check all that apply:

- ☐ I am required to by my boss
- ☐ I want to share my knowledge, my experiences, or opinions
- ☐ I want to show my support for adaptation efforts, because I believe they are important
- ☐ I want to have a say in the solutions to
- ☐ I want to learn about adaptation or something new
- ☐ Other (please describe): _____

Q4. Please briefly describe what you hope to achieve or get out of this workshop:

Q5. Please answer the following

	Completely	Somewhat	Neutral	Not really	Not at all
1. How committed do you feel toward the process of this workshop?	◯	◯	◯	◯	◯
2. How committed/interested are you in adaptation, in general?	◯	◯	◯	◯	◯
3. How interested and open do you feel to new ideas or discussions in this workshop?	◯	◯	◯	◯	◯
4. How comfortable and familiar do you feel working with the other participants in this workshop?	◯	◯	◯	◯	◯
5. How valuable do you expect this workshop to be for your objectives?	◯	◯	◯	◯	◯

Post-workshop questionnaire (translated to English)

Q1. In your opinion, what are the three most important challenges and/or opportunities for making Urdesa more resilient to climate change?

Q2. In your own words, please describe what was achieved in the workshop:

Q3. Based on your experience in this workshop, please answer the following:

	Absolutely	Somewhat	Unsure	Not really	Not at all
1, Did you gain new insights into the problem or possible solutions?	◯	◯	◯	◯	◯
2. How openly did you communicate your views or knowledge?	◯	◯	◯	◯	◯
3. How committed/interested are you in implementing adaptation?	◯	◯	◯	◯	◯
4. Are you satisfied with the extent to which data and information were used in the workshop?	◯	◯	◯	◯	◯
5. Did you find the data, information and assumptions acceptable?	◯	◯	◯	◯	◯
6. Was the workshop objective clear to you?	◯	◯	◯	◯	◯
7. Was the workshop objective relevant for your work/interests?	◯	◯	◯	◯	◯
8. Did the discussions cover the problems and solutions sufficiently?	◯	◯	◯	◯	◯
9. How valuable was the workshop for your understanding and work?	◯	◯	◯	◯	◯
10. Do you find the results of the workshop relevant and useful?	◯	◯	◯	◯	◯
11. Did the workshop support you in achieving your objectives?	◯	◯	◯	◯	◯
12. Did the touch table tool used in the workshop help you to think of climate adaptation in new ways?	◯	◯	◯	◯	◯
13. Did the tool help you to communicate or understand others?	◯	◯	◯	◯	◯
14. Did the tool support a better result (innovation, added value, performance, representativeness, other_____)?	◯	◯	◯	◯	◯

Q4. Please describe briefly what aspects of the workshop were most valuable to you? Why?

Q5. Please describe briefly what aspects of the workshop were least helpful to you? Why?

Q6. Please describe briefly what aspects of the tool you found most helpful in this workshop? Why?

Q7. Please describe briefly what aspects of the tool you found least helpful in this workshop? Why?

C.6 Interview guidelines translated to English

Pre-workshop

Flooding

1. Can you tell me about the flooding problems in the district?
   - ☐ Why is flooding a concern in the area?
   - ☐ How do flooding events occur?
   - ☐ What factors contribute to flooding?
   - ☐ When do flooding events occur and how often does it happen?
2. What are the effects of floods?
3. Which were the institutions that have provide assistance during the flood events?
4. What role does your institution play in preventing, responding and recovering from floods?
5. When does flooding become a problem? (Threshold)
6. How often are you able to deal with a flood event? (Frequency)
7. Do you/your institution have performance criteria for flooding (damages, level, frequency)?
8. How are you/your institutions prepared for dealing with floods?
9. What measures do you think would be useful for flood control here?
10. What do you know about blue-green infrastructure measures?
    - ☐ Impressions of their effectiveness?

Climate change

11. What impacts do you think climate change will have on flooding here? When?
12. Are you/your institution planning for climate change?
13. How do you account for climate change in your work?

Planning

14. What role do you/your agency play planning climate change adaptation?
    - ☐ Who makes decisions
    - ☐ Who implements
15. Which planning regulations/practices are most important for adaptation planning?
16. What are the barriers you experience in adaptation planning?

Project background

1.7 Please tell me about the project this workshop is a part of and the role of the workshop in the project?
   - ☐ Reason for the project?
   - ☐ Desired/intended outcome of the project?
   - ☐ Role of the workshop in the project?
   - ☐ Steps preceding the workshop?

18. Project: Can you tell me what you think are the important driving factors for this project?
    - ☐ Problems
    - ☐ Opportunities
    - ☐ Constraints

19. Role: Can you tell me about the role you play in this project and in the workshop?
    - ☐ Role in the project
    - ☐ Role in the workshop

Input

20 Participation: Can you tell me about why you chose a participatory approach and how you organized this?
    - ☐ Why participatory approach?
    - ☐ What do you want out of participation? What is most important?
    - ☐ How were participants identified? And selected?
    - ☐ Who do you think needs to be there?
    - ☐ Who was left out?
    - ☐ How will decisions be made? Who can decide?
    - ☐ Why the selected method for participation?
21. Workshop: Can you tell me about your objectives for the workshop and what you hope to achieve?
    - ☐ Objective of workshop?
    - ☐ Hoped for results?
    - ☐ How will results be used?
22. **Context:** Can you tell me about any problems you foresee with the participatory workshop?
    - ☐ Conflicts, interests or personal?
    - ☐ Cultural/organizational comfort with way of working?
    - ☐ Differences in background, level of understanding?
    - ☐ Relationship/ power distances between participants?
    - ☐ What makes this project/location appropriate for participation?
    - ☐ Time constraints, sense of urgency
22. Open: Is there anything important that we did not discuss, or that you would like to tell me?

Post workshop

Overall impressions of the workshop

Process

1. During the workshop, were there any moments that stick out for you as important or significant? Why?
2. Can you tell me your impressions of the participation in the workshop – if anyone important was missing, how you found the group dynamic?
   - ☐ Who was missing? Why are they important?
   - ☐ Openness and engagement
   - ☐ Comfort with way of working
   - ☐ Relations between participants

Content

3. Do you feel that the workshop supported the inclusion of many different factors and systems that are relevant to the plan?
   - ☐ Spatial scale
   - ☐ Integration of issues
4. Can you tell me your impressions of the tool that was used and whether it helped, or not? Was something else more helpful?

Outcome

5. Value: Broadly speaking, what do you think were the most important outcomes of this workshop for you? *Why?*
   - ☐ Anything new in understanding or solutions?
   - ☐ Connections or information
6. Quality: How do you feel about the quality of the results, in terms of their validity, innovation, viability and relevance?
   - ☐ Validity of results
   - ☐ New ideas
   - ☐ Relevance to the problem
   - ☐ Acceptability
   - ☐ Viability
7. Efficiency: As an organizer, do you think the workshop was an efficient use of resources?
   - ☐ Time, Money, Personnel
8. What are the next steps for you? Do you think you will use the results of the workshop?
9. Do you think you would use participatory workshops in the future? Or tools like the AST?
10. In your work, what do you find is the biggest hurdle to adaptation projects, like this one?

Appendix D: General supplementary material for cases

Contents

D.1 Interview protocols

Pre-workshop interviews

1. Introductions
   a. Personal introduction, position and focus of research – decision making and the role of collaborative workshops in urban adaptation to climate change
   b. Who is supporting and financing the research – Deltares, TU Delft, GRACeFUL project
   c. Role/purpose of interviews in research
   d. Interview outline – semi-structured interview with a few questions, one hour, recording
   e. Importance of openness + anonymity
2. Confirm participation
   a. Comfort proceeding, any conditions, questions or concerns to discuss
   b. Review consent form
3. Interview questions
   a. Open questions
   b. Review check list to be sure all important topics are covered.
4. Closing
   a. End of interview, thanks for time and sharing views
   b. Ask if they have any questions or points of discussion
   c. Confirm post-workshop interview appointment
   d. Share card and agree on whether they wish to receive the transcriptions and results.

Following interview, review responses and make notes of clarifications or additional information that can be asked in second interview.

Post-workshop interviews

1. Opening
   a. Interview outline – semi-structured interview with a few questions, one hour, recording
   b. Openness
   c. Comfort proceeding, any conditions, questions or concerns to discuss
2. Interview questions
   a. Open questions
   b. Check list
3. Closing
   a. End of interview, thanks for time and sharing views
   b. Questions or points of discussion
   c. Future contact for clarifications, follow up

Ask for clarifications and elaborations on points from first interview or survey responses, if needed.

D.2 Examples of pre- and post-workshop interview guidelines

Pre-workshop interview with participants

2. **Project:** Can you tell me about the project and what you think are the important factors?
   - ☐ Problems
   - ☐ Opportunities
   - ☐ Constraints
3. **Topic:** Can you tell me about climate change adaptation planning efforts in the city? What actions are being taken and why? What are your thoughts on this?
4. **Role:** Can you tell me about the role you play in this project and in the workshop?
   - ☐ Role in the project
   - ☐ Role in the workshop
   - ☐ Steps preceding the workshop
5. **Workshop:** Can you tell me about your involvement in the workshop, why are you participating and what outcomes are you hoping for?
   - ☐ Objective for workshop
   - ☐ Hoped for results
   - ☐ Intended use of outcomes
   - ☐ Feelings towards the workshop and project
   - ☐ Expected value/relevance of the workshop
6. **Context:** Can you tell me about any problems you foresee with the participatory/collaborative workshop?
   - ☐ Conflicts, interests or personal?
   - ☐ Relationship/ power distances between participants?
   - ☐ Relationship/power differences between project and participants?
   - ☐ Level of understanding/technical skills related to the topic and tool?
   - ☐ Priorities, time, sense of urgency?
7. **Open:** Is there anything important that we did not discuss, or that you would like to tell me?

Post-workshop interview guideline with organizers

- Before we begin, I'm curious to hear your overall impressions of the workshop.
- Follow-up / clarifying questions identified after pre-workshop interview

Process

11. During the workshop, were there any moments that stick out for you as important or significant? Why?
12. Can you tell me your impressions of the participation in the workshop – if anyone important was missing, how you found the group dynamic? How comfortable/open were you?
    - ☐ Who was missing? Why are they important?
    - ☐ Openness and engagement
    - ☐ Comfort with way of working
    - ☐ Relations between participants

Content

13. Do you feel that the workshop supported the inclusion of many different factors and systems that are relevant to the plan?
    - ☐ Spatial scale
    - ☐ Integration of issues
14. There are many uncertainties in planning under climate change, what the impacts will be, how to best adapt and when, for example. Do you think uncertainty was considered in the workshop?
15. Can you tell me your impressions of the tool that was used and whether it helped, or not? What did it help with exactly? What else did you find helpful?

Outcome

16. Broadly speaking, what do you think were the most important outcomes of this workshop for you? Why?
    - ☐ Anything new in understanding or solutions?
    - ☐ Connections or information
17. What is your impression of the quality of the results?
    - ☐ Validity of results
    - ☐ New ideas
    - ☐ Relevance to the problem
    - ☐ Acceptability
    - ☐ Viability
18. Do you think the workshop was an efficient use of resources? What would you have changed? Do you think you would organize/participate in collaborative workshops in the future? The AST? Why/not?

Next steps

19. What are the next steps in this project for you? Do you think you will use the results of the workshop?
20 What do you think will be the biggest hurdle to the next steps of this project?

D.3 Examples of pre- and post-workshop questionnaires

Pre-workshop questionnaire

Participant Name/Number:
Organization/group/interest you are representing:
In your opinion, what are the three most important factors for making [project location] more resilient to climate change?

1. _____

2. _____

3. _____

Please briefly explain:

Your role in the [project]and [workshop]:

Your reason or motivation for participating in this workshop:

What you hope to achieve or get out of this workshop:

Please answer the following:	Completely	Somewhat	Neutral	Not really	Not at all
How cooperative do you feel toward the process of this workshop?	◯	◯	◯	◯	◯
How interested do you feel in new ideas or discussions in this workshop?	◯	◯	◯	◯	◯
How comfortable and familiar do you feel working with the other participants in this workshop?	◯	◯	◯	◯	◯
How valuable do you expect this workshop to be for your aims?	◯	◯	◯	◯	◯

Post-workshop questionnaire

Participant name/number:
Organization/group/interest you are representing:

In your opinion, what are the three most important factors in making [project location] more resilient to climate change?

1. _____
2. _____
3. _____

In your own words, please describe the plan or other outcomes from the workshop. If more than one alternative was developed, please indicate which you prefer**.**

Based on your experience in this workshop, please answer the following:	Absolutely	Somewhat	Unsure	Not really	Not at all
Did you gain new insights into the problem or possible solutions?	◯	◯	◯	◯	◯
How openly did you communicate your views or knowledge?	◯	◯	◯	◯	◯
How committed do you feel to the next steps in the project?	◯	◯	◯	◯	◯
How satisfied are you with the extent to which data and information were used in the workshop?	◯	◯	◯	◯	◯
Did you find the data, information and assumptions acceptable?	◯	◯	◯	◯	◯
Was the workshop objective relevant to you?	◯	◯	◯	◯	◯
Did you find discussions of the problems, solutions and impacts sufficiently broad?	◯	◯	◯	◯	◯
How valuable was the workshop for your understanding?	◯	◯	◯	◯	◯
Do you find the outcomes of the workshop relevant to your work?	◯	◯	◯	◯	◯
Did the workshop support you in achieving your objectives?	◯	◯	◯	◯	◯
Did the tool help you to think of climate adaptation in new ways?	◯	◯	◯	◯	◯
Did the tool help you to communicate or understand others?	◯	◯	◯	◯	◯
Did the tool support a better outcome (innovation, added value, performance, representativeness, other_____)?	◯	◯	◯	◯	◯

Please describe briefly:

What aspects of the **tool** did you find *most* helpful in this workshop? Why?

What aspects of the **tool** did you find *least* helpful in this workshop? Why?

What aspects of the **workshop** supported your interests?

In what ways did the w**orkshop** *fail* to support your interests?

D

D.4 Workshop observation and data collection protocol

At the beginning of the workshop:

- Personal introduction and explain you are evaluate workshop and tools used in climate adaptation planning. This research is part of a PhD project at TU Delft, also supported by Deltares and the GRACeFUL project.
- Explain that you will be asking them to fill out short questionnaires at the beginning and end of the session. The first will only take 5 minutes.
- Emphasize the importance of being completely honest in their responses, to feel free to add annotations or ask for clarifications.
- Thank everyone for taking part in your study and stress that the results will be anonymized and stored securely for use only by myself.
- Provide the consent form and the pre-workshop questionnaire.

During the workshop:

- Where is the workshop located?
- Did any expected participants fail to show up? Why?
- How convenient is the time of the workshop?
- How comfortable do participants appear in their surroundings?
- What is the tone of the leadership? How clear are the aims and roles?
- Are they sticking to the agenda?
- Role and attitude of the facilitator?
- How comfortable do participants appear with each other? – openness, questions, discussions
- How comfortable do participants appear with the tool/method?
- What is the balance between participants? How are conflicting values handled? Respectfulness?
- Is there sufficient time for the discussions to be carried out at the depth and breadth desired? Is the process productive, structured and on topic?

At the end of the workshop:

Provide the post-workshop questionnaire and a business card.

- Explain the second questionnaire will take about 10 minutes to complete.
- Remind them to be as honest as possible in their responses, to feel free to add annotations or ask for clarifications.
- Point out that they each have your business card, should they have questions or wish to contact you in the future.
- How connected are the outcomes to the goals/problems?
- Did new ideas get picked up? How did they emerge?
- What agreements were made for next steps? What will happen with outcome of workshop? Communication?
- What is the atmosphere among participants at the end of the day?

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Sadie McEvoy
Delft, June 2019

Curriculum vitae

Sadie McEvoy was born June 17, 1982, in Chicago, USA. Sadie studied civil engineering at California State University, Chico, graduating Cum Laude in 2006. Following the completion of her undergraduate studies, Sadie worked in international water resources management, based in San Francisco, California. Through this experience, Sadie developed an interest in the role of decision making in water resources planning and management. She pursued this interest in post-graduate studies at the Department of Water Management, at Delft University of Technology's Faculty of Civil Engineering and Geosciences, where she graduated with an MSc thesis on economic valuation for real-time control in urban water systems.

In 2015, Sadie began her PhD research in Policy Analysis, at Delft University of Technology's Faculty of Technology, Policy and Management. Under the supervision of Jill Slinger (Policy Analysis) and Frans van de Ven (Water Management), Sadie's research focused on the role of planning support tools in collaborative planning workshops for urban adaptation to climate change. In particular, Sadie evaluated how particular tools, called Planning Support Systems, influence the workshops in which they are used, the plans and other outcomes produced, and the subsequent activities and decisions in the planning process. This research was carried out with Deltares, as part of the European project, GRACeFUL. Sadie completed her PhD in 2019.

During her PhD research, Sadie became involved in the Society for Decision Making under Deep Uncertainty, where she served on the local organizing committee for the annual meetings in 2015 and 2019, on the scientific steering committee for the annual meeting in 2018 and 2019, and was elected to the Society's leadership committee in 2019.

Sadie continues to work on climate change adaptation planning with Deltares, as a researcher in water resources and delta management, and as Chapter Scientist for the the IPCC 6th Assessment Report Working Group II.

List of publications and presentations

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