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The influence of context on the use and added value of Planning Support Systems in workshops: An exploratory case study of climate adaptation planning in Guayaquil, Ecuador

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ABSTRACT

Planning Support Systems (PSS) are a promising tool for involving stakeholders in urban adaptation workshops. Past research has focused on the use and added value of PSS. While earlier studies have widely acknowledged the importance of context in determining the effectiveness of PSS, there has so far been no dedicated study of the influence of context on the use and added value of these tools in real planning workshops. To address this gap, we made an in-depth exploratory case study of a PSS, called the Adaptation Support Tool (AST), used in an adaptation planning workshop in Guayaquil, Ecuador. The workshop used the AST to support collaborative spatial planning for urban water management, at the neighbourhood scale. Interviews, questionnaires, observations and document review were used to investigate the influence of three contextual factors on the use and added value of the AST. The studied contextual factors are: 1) the style of tool use, 2) the phase of planning, and 3) the local project setting. 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 during the workshop. Meanwhile, the phase of planning appears to be critical for achieving impacts at the project level. This exploratory case study is a modest first contribution to understanding the influence of context on the use and added value of PSS in practice. Nevertheless, the findings indicate that further exploration of this topic could offer important insights to PSS use in practice.

The influence of context on the use and added value of Planning Support Systems in workshops: an exploratory case study of climate adaptation planning in Guayaquil, Ecuador.

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 & Geertman, 2008). A growing body of research on PSS has provided valuable insights into their use, usability and usefulness (Pelzer, Geertman, & van der Heijden, 2016; Russo, Lanzilotti, Costabile, & Pettit, 2018a; te Brömmelstroet, 2016; Vonk, 2006). Among this research, Pelzer, Geertman, Heijden, and Rouwette (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)

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are ubiquitous in the literature (e.g. Eikelboom & 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 in workshop settings. 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. This single exploratory case study is a modest first step toward understanding the role of context in the use and added value of PSS.

2. Context and PSS

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, Eikelboom, Verhoeven, & Brouns, 2014). The most common contextual factors recognized in PSS research are users' backgrounds (e.g. Arciniegas & Janssen, 2012; Goodspeed, 2015; Russo, Lanzilotti, Costabile, & Pettit, 2018b), the quality of facilitation (e.g. Pelzer, Goodspeed, & te Brömmelstroet, 2015; te Brömmelstroet, 2016), the phase of planning in which the tool is used (McEvoy et al., forthcoming; Pelzer, 2017), and the political, cultural and economic settings of applications (Mayer, Bueren, Bots, Voort, & Seijdel, 2005; Pelzer, 2017; Russo et al., 2018b).

2.1. Contextual factors used in this study

For this study, three contextual factors were 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 difference between participants' professional backgrounds (e.g. general public, planning professionals, etc.) 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.

2.1.1. 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 & Janssen, 2017; Pelzer & Geertman, 2014; van de Ven et al., 2016). The second claim is that the interactive nature of the touch tables on which many PSS are used, and the physical act of participants working around a common tool, create a dynamic and collaborative atmosphere (Arciniegas & Janssen, 2012; Hopkins, Ramanathan, & Pallathucheril, 2004; Pelzer et al., 2015). 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.

2.1.2. 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 & Geertman, 2014) and planning decisions (McEvoy, Ven, & Brolsma, forthcoming). Given the apparent importance of the phase of planning for tools' effectiveness, we wished to explore tool use in the earliest, *initiative phase*, when the problem is known, but the solution space is still open and the process is not 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.

2.1.3. 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, like 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., 2018b). 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., 2018b). 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., 2018b). 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*.

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.

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 and its focus on practice. We selected our particular case because the workshop employed the Adaptation Support Tool, a PSS we have used and evaluated in other cases (McEvoy, van de Ven, Blind, & Slinger, 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. As explained further below, we conducted a mixed-methods case study research design which involved the qualitative analysis of 91 documentary sources, including: 18 participant interviews, 20 community interviews, 13 pre- and post-workshop questionnaires, project materials, field notes, 9 earlier planning documents and reports, and 2 official follow-up documents (Supplementary Material D).

3.1.1. 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, Green, Nicholls, & Corfee-morlot, 2013). The district of Urdesa is representative of the larger city, in terms of physical characteristics and flooding problems. In 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 initiative phase of a larger flood-risk management project, for which the problems and 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 Adaptation Support Tool.
- A plenary session where each group presented and discussed their plan.

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.

3.1.2. 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,[1] 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 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 & van de Ven, 2015) (Fig. 1).

3.2. Method

In the 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 tool was set up with the input conditions and adaptation 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.

3.2.1. 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 & Janssen, 2017; Goodspeed, 2013; Pelzer et al., 2016; Pelzer, Arciniegas, Geertman, & Kroes, 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 (Fig. 2).

3.2.2. 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 1. 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.

3.2.3. Studying the phase of planning

The workshop was held in the initiative phase of a project, providing the opportunity to study PSS use early in the planning process. The AST was designed to support preliminary planning (van de Ven et al., 2016), suggesting task-technology fit. These conditions offered a useful comparison with previous experience (McEvoy et al., forthcoming) and reports in literature, which suggest that a PSS'

[1] “Blue-green” infrastructure, such as green roofs and urban ponds make 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 more traditional infrastructure, often based on concrete (grey), like storm drains.

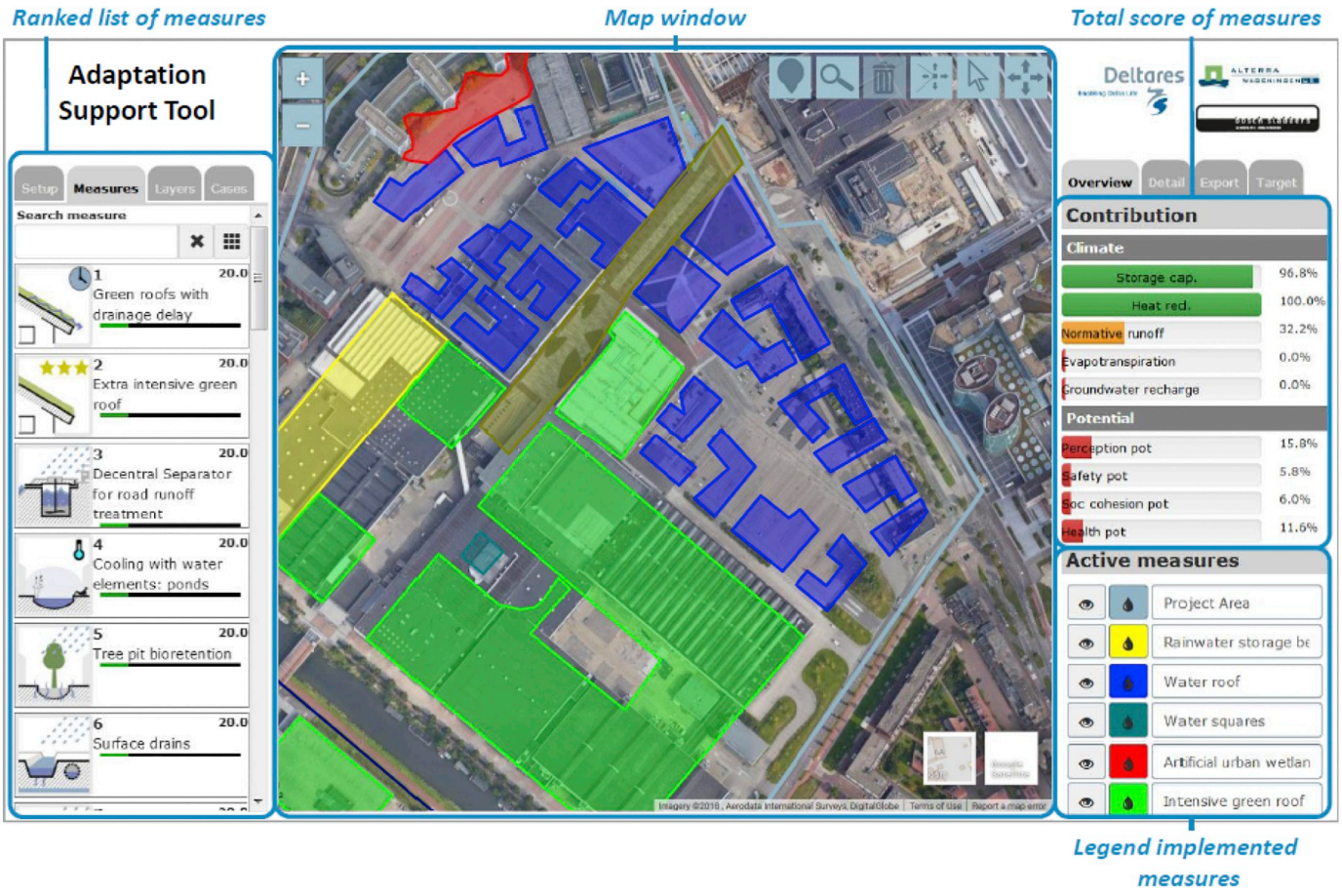


Fig. 1. Adaptation support tool interface.

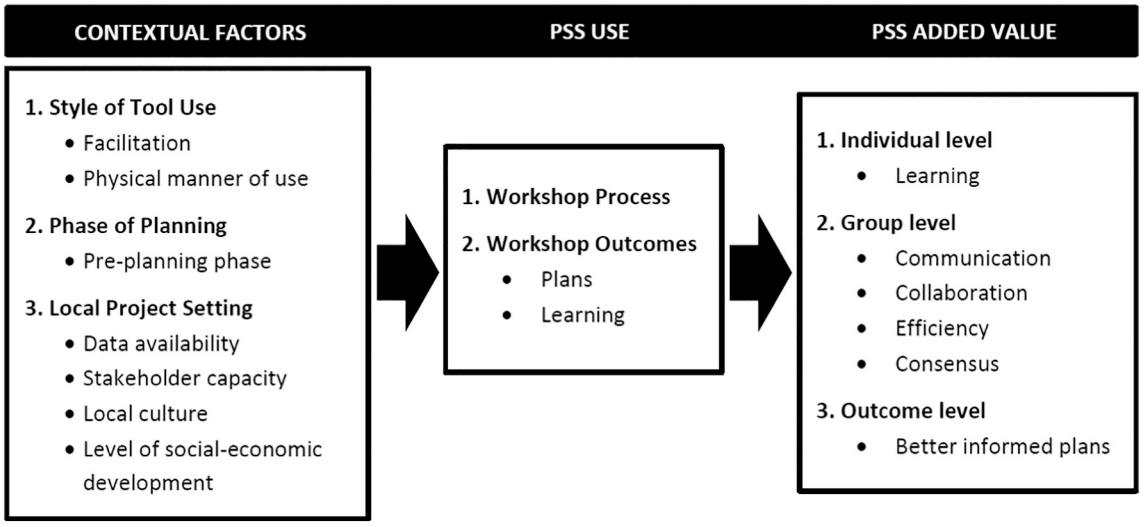


Fig. 2. Conceptual structure of this research.

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 & Geertman, 2014). In studying the phase 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.

3.2.4. 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

Table 1
Style 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.

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.

3.3. Data and data analysis

Interviews, questionnaires, observations and documents were used in our analysis (Supplementary Material D). Thirteen semi-structured interviews of one to two hours were carried out with expert stakeholders and project managers. Nine interviews were carried out before and four after the workshop. These interviews covered four areas: perspectives and information on local flooding problems and climate change; planning practices in Guayaquil; expectations of the workshop; and experiences of the workshop and the AST (Supplementary Material A). 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 community members 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.

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 (Supplementary Material B). A designated observer was present throughout the workshop and the facilitators of both groups were debriefed for their impressions. Field notes before, during and after the workshops were taken using a prepared protocol. Workshop documents and documentation were collected, including all materials provided or presented to participants and the group working materials. Finally, background documents, including planning documents, earlier project reports, project proposals, project documents and communications (Supplementary Material D).

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 (Supplementary Material C). 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. Our reasons for applying this framework are elaborated in (McEvoy et al., 2018, forthcoming). 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 (Fig. 2). The questionnaire results were analysed in the text analysis. A quantitative analysis is not reported due to the small N.

4. The influence of context on the use and added value of PSS

The following section comprises five parts. First, the workshop process is summarized, followed by an overview of the workshop outcomes. This provides important information 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.

4.1. Workshop process

Following a 1 h 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 1). Each group was given the same assignment and roughly 3 h to develop an adaptation plan that achieved the 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 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 work strategy. This group began immediately exploring measures by implementing them directly 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 implementation strategies. 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.

4.2. Workshop outcomes

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

4.2.1. 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 (Fig. 3).

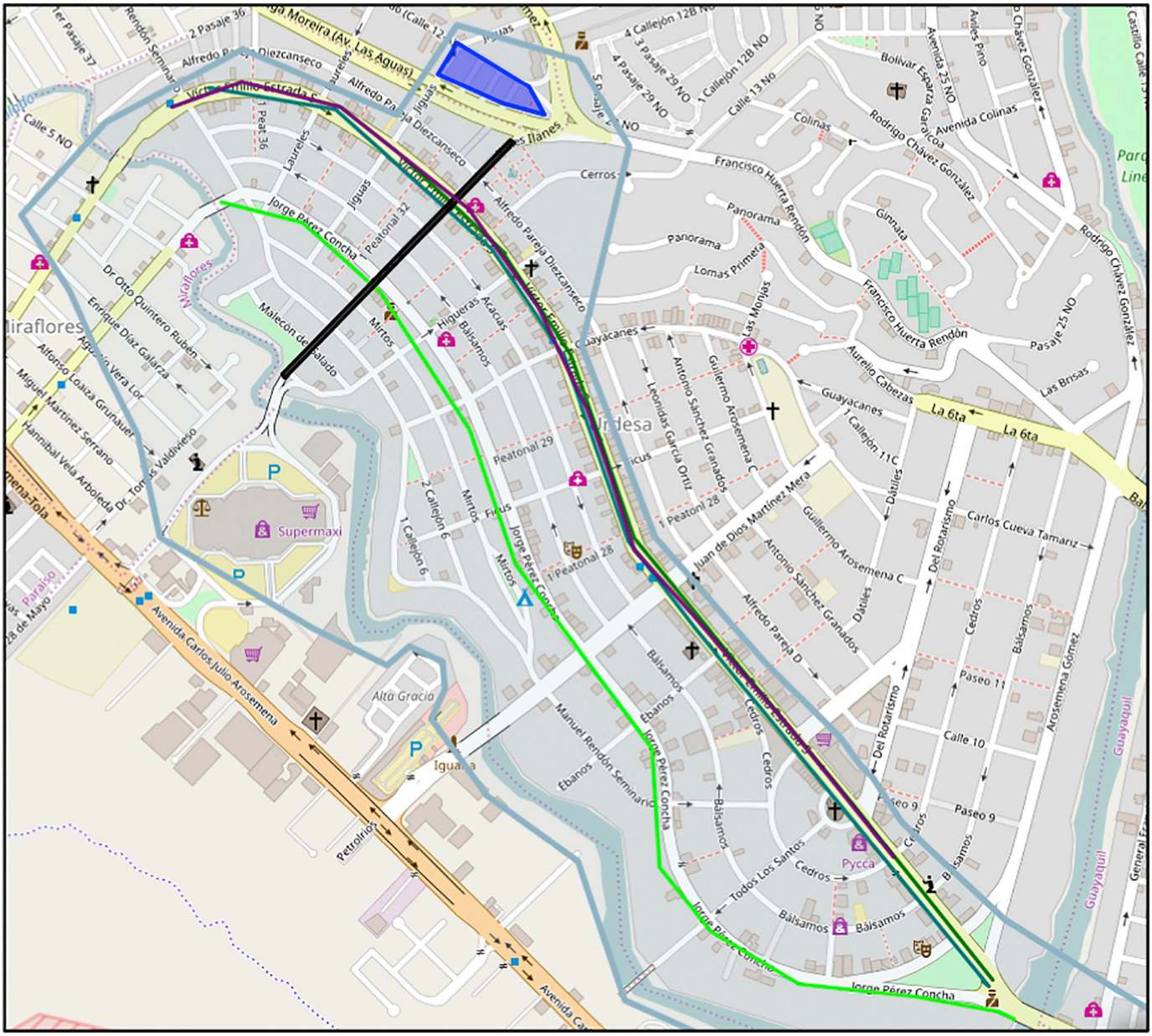


Fig. 3. Group 1's adaptation plan for lower Urdesa. measures include adding trees, bioswales, grassed swales, a water square and pervious pavement, and replacing leaking storm drains. This plan is notable for its detail and realism.

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 (Fig. 4). The reason the group took this approach was "to see what is possible".

4.2.2. 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 Supplementary Material D). 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.

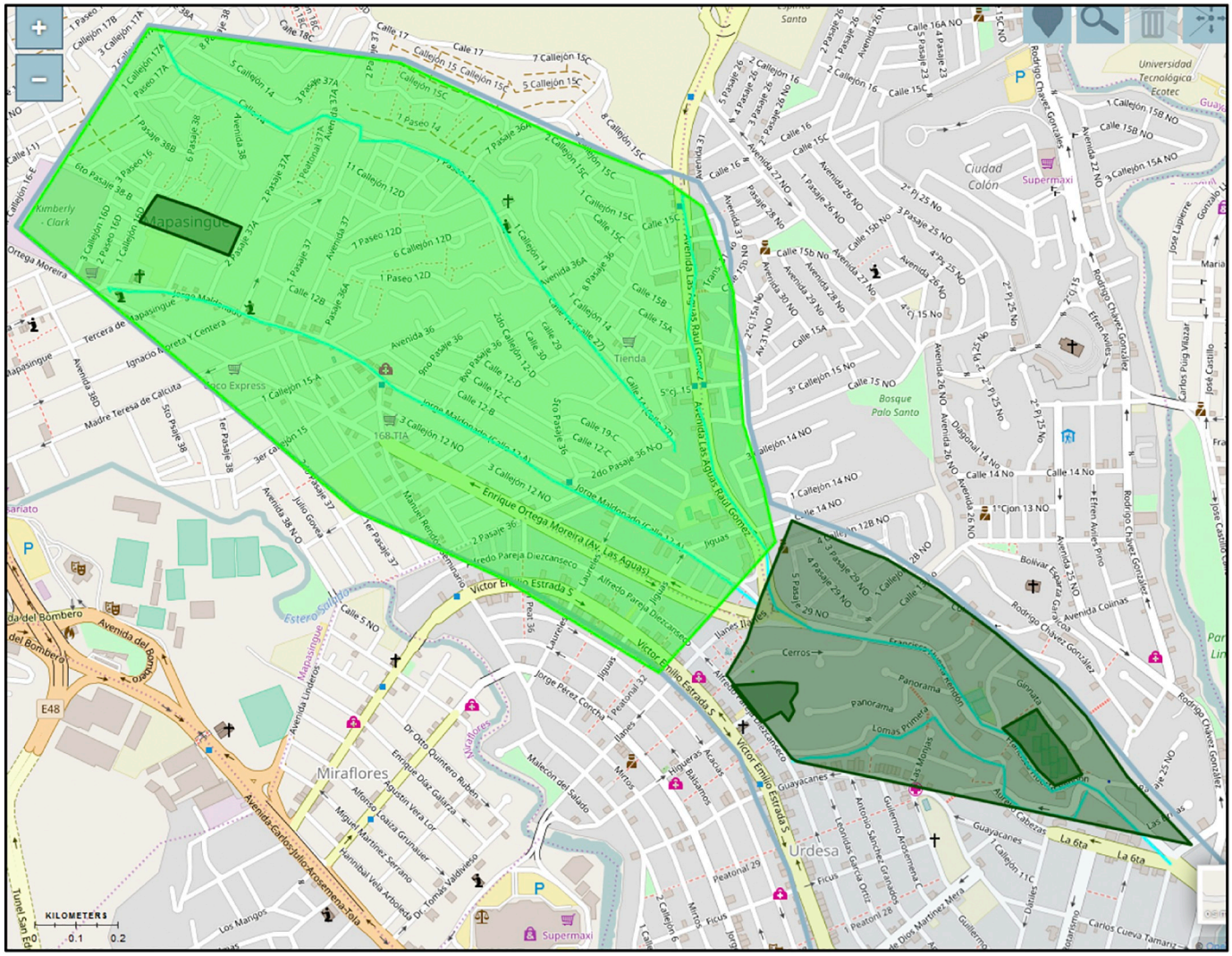


Fig. 4. Group 2's adaptation plan for upper Urdesa. measures include adding turf grass in the street, pervious pavements, cisterns and green roofs. This plan is notable for its conceptual nature and lack of detail.

4.3. 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 (Fig. 5). 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.

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 (Fig. 6). 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.

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.



Fig. 5. Illustration of group 1 working, based on photograph. The group is focused on dialogue and the facilitator, the tool is in the background.



Fig. 6. Illustration of group 2 working, based on photograph. The tool forms the focal point of the group and the dialogue.

4.3.1. 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, although 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 & 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. 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 following the workshop, 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, its 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 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.

4.4.1. Analysis: Influence of the phase of planning

4.4.1.1. 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.

4.4.1.2. PSS added value: individual level. Holding a workshop in the initiative phase of planning 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. 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.

4.4.1.3. PSS added value: group level. Because the workshop occurred in the initiative 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 learn about different measures, their effectiveness and local suitability, and to foster open communication between participants, via their responses to content in the tool.

4.4.1.4. 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., forthcoming; van de Ven et al., 2016).

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 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.

4.5.1. Analysis: influence of the local setting

4.5.1.1. 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 inclusion of satellite images and open street maps allowed participants to recognize the area and draw upon their embedded knowledge of social and technical systems in the area, at the city-block scale.

4.5.1.2. 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 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 disparities and the implications for implementing 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.

4.5.1.3. 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 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.

4.5.1.4. 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.

5. Findings on the influence of context on PSS

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.

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., 2018b). 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.

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 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 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 in workshop settings, 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 (2018a) 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 & 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 & Janssen, 2012; Pelzer et al., 2014; Russo et al., 2018a), 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 & Janssen, 2012; Goodspeed, 2013; Pelzer et al., 2016, 2014; te 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. 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 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 te Brömmelstroet, 2010), broadening our view on

learning would benefit future research.

The single case study carried out in this research aimed to explore the influence of context on the use and added value of PSS in collaborative workshop settings. The findings offer insights for practice and further research. Additional case studies of PSS applications in practice would broaden and deepen our understanding of their use and usefulness in the context-rich real world. Comparative and longitudinal case studies would both make important contributions. Case studies focused on different types of users and comparing collaborative and non-collaborative use would also be especially valuable. We are perhaps most curious to see if PSS can support different types of stakeholders, such as community members and technical experts of different backgrounds, to collaboratively plan urban adaptation to climate change.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.compenvurbsys.2019.101353.

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