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Adoption and use of software in land use planning practice: A multiple-country study

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Abstract

Planning Support Systems (PSS) are computer-based tools that assist professionals in land use planning activities. Although several researchers acknowledge the importance of such tools in planning practice, PSS use is limited due to their poor fit to users' needs and expectations as well as to their low usability. This article presents a study carried out in three different countries, namely Australia, Italy and Switzerland aiming at investigating in-depth the current situation regarding the adoption of PSS and identify factors preventing their wider use, devoting particular attention to the quality of such systems from the point of view of their users. The study also aimed at analysing planners' expectations, in order to identify relevant features that PSS should provide. The main part of the study consisted of 35 interviews with planning experts. A follow-up focus group with further six participants was also performed. The results confirmed some findings of previous studies, but also revealed new insights. This article provides suggestions on how to address the emerged issues as well as pathways for creating software that can be adopted and used with satisfaction in the planning practice.

Keywords: Planning support systems; usability; qualitative study; interviews

1. Introduction and motivation

Since the origins of Human-Computer Interaction (HCI) in the 80's, researchers have been debating how to develop computer systems that are better suited to the needs and expectations of people who use them. Models, methodologies and techniques have been defined by academic researchers, in order to create systems that are not only usable, but also able to generate a pleasant User eXperience (UX). However, despite the whole body of HCI knowledge generated in these years, the goal of creating systems that people appreciate and enjoy using has not been reached in many cases. The literature reports various studies (e.g. Rosenbaum et al., 2000; Vredenburg et al., 2002; Ji and Yu, 2006; Bak et al., 2008), performed even in recent years (Ardito et al., 2014), which showed that one obstacle to the creation of systems satisfying their users is that still too many software development companies either neglect usability and UX or do not adequately address them.

In order to get support in their working activities, professionals want system that speak a familiar and provide the right functionality, so that they can perform their tasks according to their habits without being forced by the system the way of carrying out the work. One of the consequences of not properly addressing the requirements of professionals and their organisations is that computer systems are at most adopted for a while, soon discarded and not used anymore. This situation is common to different kinds of software systems that have been developed to support professionals in various application domains. As an example, in many Italian hospitals the use of computer systems is much lower than we could expect when considering the myriads of projects carried out in the last thirty years on electronic patient records; one main reason is that these projects fail to satisfy the actual needs of all the diverse stakeholders and users (Cabitza & Gesso, 2011; Cabitza & Simone, 2010).

This article addresses the situation in land use planning practice. Planning Support Systems (PSS) are computer systems that are created with the specific goal of supporting professionals in data-driven land use planning activities. PSS provide spatial analysis and modelling functionality as well as visualisation capabilities addressing one or multiple stages of the planning process. The use of PSS in the planning practice is still very limited. The literature reports important studies in the years 2005-2008, aimed at inspecting factors that hamper the widespread use of PSS (Vonk et al., 2005; Vonk, 2006; Vonk et al., 2007). A decade after such studies, we still face a situation in which PSS are challenged with low adoption and usage rates. Planners commonly state that current PSS are not adequate to their needs and expectations.

In order to analyse in depth the current situation and get updated information on factors hampering a larger use of PSS, we performed a new study. It involved 35 planning actors in three countries, i.e. Australia, Switzerland and Italy. These countries were considered because they are very diverse, especially regarding their geographical features of their territories. The planning actors were interviewed to provide information related to two research questions. Research question 1 focuses on understanding the current situation on the use of PSS in planning activities. Research question 2 aims at determining factors that affect PSS adoption and use, also identifying planners' expectations in order to determine features that PSS should provide.

Results of this interview-based study confirmed most of the findings of the previous studies: PSS are not widely used in practice primarily because they do not properly fit user needs, they are considered difficult to use, they lack transparency and reliability. Other factors that influence the adoption and use of PSS also emerged. An interesting result is that most planning professionals revealed that they do not know the term PSS, they use various other software tools, including Geographic Information System (GIS) and Computer-Aided Design (CAD) software. However, the interviews indicated that even these software tools do not adequately fit planners' expectations.

In order to get a better understanding of planners' views on some issues emerged in the interviews, and also to gain a deeper insight into specific features of planning software that could better satisfy planners' needs and desires, a focus group was organized involving 6 Italian planning actors; the results are reported and discussed.

This article gives several contributions to the research on interactive software tools supporting planning professionals. First of all, it provides important insights into the current situation on the use of software tools in planning practice. It also reveals new findings on factors hampering a wider use of such tools, which are critical for stakeholders to improve the state of the field. Focussing on the HCI point of view, it provides further evidence that, despite the amount of research performed by the HCI community, the gap between research and practice of HCI is still very big. Usability of most software developed for planners is still very poor. The HCI research community is still failing in transferring to the practitioners the relevant body of knowledge developed in the years. Based on the study results, indications for the design of software for land use planning are provided.

The article organization is the following. Section 2 reviews related work that led to perform the presented study. Section 3 described the land use planning process. The interview-based study, specifically its design and execution, is presented in Section 4, while the results are reported in Section 5. Section 6 presents the focus group and its results. Results of interviews and focus group are discussed in Section 7, providing indications for creating better planning software and removing the obstacles that hamper planning software adoption and use in the work practice. Section 8 concludes the article.

2. Related work

Among the definitions of PSS provided in the literature (Batty, 1995; Brail, 2006; Couclelis, 2005), we consider the one by Klosterman (Klosterman, 1999): PSS are “spatial decision support systems consisting of three important components, namely: data, models and geovisualisation”. PSS are thus specific systems whose aim is at providing proper functionality to support professionals in data-driven land use planning.

During the years 2005-2008, Vonk and co-authors performed some remarkable empirical studies (Vonk et al., 2008; Vonk et al., 2007; Vonk, 2006; Vonk et al., 2005), which aimed to inspect factors hampering the widespread use of PSS. In (Vonk et al., 2005), eight-hundred people from the planning community (consultants, researchers, PSS developers and users) all over the world were asked to participate in an online survey for determining the importance of 62 factors, related to human, organizational, institutional and technical issues, in hampering adoption and use of PSS.

About one hundred people completed the survey, primarily from North America and Europe. For each factor, participants had to state whether and to what degree it prevented widespread use of PSS. The results showed that most of the 62 factors represented obstacles to adoption and use of PSS. However, the three most important bottlenecks were lack of planners' *experience with PSS* (70% of the respondents), low planners' *awareness of PSS potential* (66% of the respondents) and low *user friendliness* of PSS (66% of the respondents). The 62 factors investigated in the online survey were based on a theoretical framework originally proposed in the business field, which was specialised for PSS (Vonk et al., 2005). This framework guided a comprehensive analysis of the PSS adoption and use process by combining individual, social and organisational factors and showing the interrelations among them. The factors were organised along the following main dimensions:

i. *persuasion influences* (e.g., support, marketing and product improvement efforts by provider),
ii. *adopter characteristics* (e.g., culture of organisation, attitude of management and employees, experience of the planner with technology),
iii. *social influences* (e.g., community of practice, social pressure, persuasion by colleagues),
iv. *perceived innovation characteristics* (e.g., applicability, usability of the system, system fit to tasks, relative advantage from using the system, capability of the system to handle data, accessibility of the data and the system),
v. *external conditions* (e.g., law and regulations, negative macro-economic situation, low level of technological development and computerisation).

The authors remark that these main factors to some extent influence each other. In particular, perceived innovation characteristics are in part conditioned by social influences, adopter characteristics and persuasion influences.

After the survey, in order to gather more detailed information on PSS adoption, another more qualitative study was performed (Vonk et al., 2007). The study consisted in a series of interviews conducted at regional governmental organisations in the Netherlands with 43 participants: 15 geo-information specialists, 12 planners, 3 managers and 13 other actors involved in the planning process. The interviews were performed in groups during 12 sessions of several hours each and aimed at identifying patterns of PSS diffusion within planning organisations. Specifically, the participants were asked to describe the circumstances of PSS diffusion, when and why diffusion failed or succeeded at their workplace. The results showed, in comparison to the online survey, a slight increase in importance of organisational bottlenecks and a slight decrease in importance of technical bottlenecks. In fact, *user friendliness* of the system (53%) was the fifth most important bottleneck preceded by *attitude of management* (71%) towards the use of PSS in the organisation, *social organization of users* (70%) in planning networks, *awareness of potentials* (66%) of PSS and *implementation support* (64%) by geo-information specialists within the organization. Little intention to use PSS by planning organisations as well as by planners was explained with poor *fit* of PSS to planners' expectations. Poor fit of PSS to planners' expectations also emerged in (Vonk, 2006), when investigating why some PSS are more widely used than others; it was remarked that planners ask, in general, for less complex PSS, while researchers are interested in developing sophisticated PSS, neglecting whether these actually meet planners' demand. From a planners' view, adopting and using more sophisticated PSS is associated with higher costs (e.g. for installation and training) and risks. Instead, planners ask for incremental innovations, which are less invasive in planners' work routines, require less effort to adapt to them and are driven by planning practice and planners' demands.

The mismatch between developed PSS and users' expectations is evident. Previous research reported PSS have not been subject to well-considered design processes and evaluations; very little attention has been devoted to user-oriented aspects, since PSS development has been very much technology-oriented (Vonk & Geertman, 2008). Human-Centred Design (HCD) and usability evaluation of PSS have been rather rare (Arciniegas et al., 2013; Vonk & Ligtenberg, 2010). Few studies for evaluating PSS usability have been performed (Allen, 2008), possibly because PSS developers do not see them as part of their standard work process and/or do not have the required skills to perform them. With the exception of a study by Arciniegas et al. (Arciniegas et al., 2013), which involved 30 participants, systematic evaluations of PSS usability with high number of participants are particularly limited. This is also due to the fact that PSS are not very much used. In most cases, user-based qualitative evaluations of PSS with a rather small number of participants and with methods such as interviews, observations of users interacting with PSS, workshops with different stakeholders have been performed (Brömmelstroet & Bertolini, 2012; Pelzer et al., 2014; Salter et al., 2009). A recent study reported a user test of six planners who tested three PSS that allow creating and analysing land suitability scenarios (Russo et al., 2016). Again, the mismatch between actual PSS functionality and planners' expectations emerged. It was also highlighted that user interfaces lacked terminology familiar to the planners, and that on the whole usability was poor. The study remarked that it is instrumental to convince developers that PSS they create have to comply with planners' actual expectations, in order to become more widely used.

The value of user involvement in the design has been acknowledged in some approaches. Specifically, Vonk and Ligtenberg developed a PSS prototype by following a socio-technical approach (Ackerman, 2000; Sutcliffe, 2000), which requires close collaboration with users during system development (Vonk & Ligtenberg, 2010). In a more recent article (Pettit et al., 2014), the authors propose a co-design approach that also emphasises the participation of planners in the PSS design team. However, such approaches should evolve towards the HCD of PSS (Russo et al., 2016). HCD stresses that final users are involved from the very beginning of the system planning stage and that the identification of user requirements is a crucial phase. Such an approach would result in the PSS being developed through an iterative design-implementation-evaluation cycle, during which system prototypes of increasing complexity are created and evaluated by using one or more of the many evaluation methods developed in the last three decades of research on HCD (ISO 9241-210, 2010). A framework to support PSS developers in performing usability evaluation has been proposed in (Russo et al., 2015), in order to provide a proper guidance in PSS evaluation, particularly when no evaluation experts are available.

3. Land use planning process

Before presenting the study, performed with planning actors, it is worth providing a short description of the activities comprising a typical land use planning process. Planners manage the disposition of land for allowing people to benefit from services, infrastructures, living and work spaces. It is a complex task as it has to consider the interplay of population needs, political pressures, economic demands, demographic and climatic changes (Kieran, 2002). Planning is concerned with establishing plans and policy for achieving sustainable and effective land use. It has been argued that the planning process does not follow any standardised procedure but it has a dynamic and non-uniform character (Brömmelstroet, 2013). However, some basic activities that commonly occur can be identified. Vonk et al. described the planning process through seven stages, which do not necessarily occur in order but in varying sequence (Vonk et al., 2007): (1) *problem definition*, (2) *problem exploration and analysis*, (3) *change exploration and analysis*, (4) *consultation*, (5) *decision*, (6) *implementation*, (7) *monitoring and evaluation*.

The first stage is about presenting the existence of a problem to management and authorities. This stage also includes scheduling a plan of tasks and timeframe for solving the problem. In a second stage, planners explore and analyse the planning problem through investigating policy, community needs and economic, environmental and social conditions. Once planners understand the situation, they perform more targeted and advanced analysis such as generating and evaluating goals, options and scenarios, conducting impact assessment and developing plans (third stage). The fourth stage involves discussing with other experts and stakeholders and negotiating options and implementation modes, in order to make proper decisions (fifth stage). In the sixth stage, the decided plan is implemented. Effects of the implementation are monitored and evaluated in the seventh stage.

In order to give an example of a planning process, let us consider the following scenario. The City of Canning, a municipality in the south-east of Western Australia, faced in the last years the problem of a large population growth. As a consequence, the planning department of Western Australia addressed the following critical planning task (stage1): to identify some areas within the City of Canning where residential redevelopment could be allocated. As part of stage 2 of the planning process, the department analysed conditions such as the required size area and parameters important for precinct redevelopment. Then, by using the Online What if? PSS they performed a more in-depth analysis (stage 3) which involved conducting a suitability analysis based on the set of parameters identified in Stage 2. The outcome of the analysis, i.e. possible growth scenarios, were object of several consultation and discussion among senior planners in the department, as well as policy makers of the state Western Australia, in order to come out with a good decision (stages 4 and 5). Once a final plan was agreed upon, it was implemented (stage 6). Finally, the implemented plan was monitored and evaluated over time (stage 7).

The previous scenario description is simple, in order to facilitate the reader. In reality, the planning process constitutes a complex and challenging task, especially because the requirements amongst the community often diverge and planning has to reconcile them (Kunze et al., 2012). Decisions made will hardly fully satisfy all groups in the community, thus, the overall process has to iterate some stages, trying to find compromises to alleviate land use conflicts and addressing issues that have priority.

4. The interview-based study: design and execution

The study was undertaken in order to gain more insights into PSS adoption and use in current planning practice and to identify specific factors that should be taken into account to create PSS that users appreciate and enjoy using. It involved planners and other actors of the planning process in

Australia, Italy and Switzerland, who were interviewed to shed light on planners' mental models and expectations from different perspectives, as well as to what extent these were understood by technical people and implemented in available software. The study also aimed at getting information on planning education, in order to understand what type of training, if any, is provided on planning software in university curricula or high other institutions. This section reports how the study has been designed and executed, while the results are presented in Section 5.

4.1 Goals

Two research questions (RQ) drove this study.

RQ 1. What is the current situation on the use of PSS in planning activities?

Not only PSS offer support in planning activities, but also other software tools. Availability and accessibility of such tools is different: some are proprietary software, others are free software, available online. In order to fully understand the current situation, it is important to know the current state on software that planners actually use.

RQ 2. What factors affect PSS adoption and use?

Users have expectations on the software systems they choose and use. Generally, the more consistent system characteristics are with users' expectations, the higher is users' satisfaction and the possibility that they adopt and use the system. This research question aims at identifying planners' expectations and, based on these, specifying characteristics and functionality of PSS. It also aims at detecting if other possible factors, e.g. social and organizational, might affect planning software adoption and use. Being aware of the influence of the various factors will advance the body of knowledge for creating more satisfying PSS as well as identifying pathways on how to improve PSS adoption and use.

4.2 Method

This section illustrates how the study has been conducted, describing the participants, the design of the interviews, and their execution and data coding.

4.2.1 Participants

A total of 40 people from the planning community in Australia, Italy and Switzerland were contacted, primarily via email, and informed on the purpose and questions of the interview. Of them, 35 people agreed to participate: 16 were professional planners[1] working for private and public organizations (hereafter also referred to as planners), 5 were academic planners, i.e. university professors or researchers, and 14 were other actors[2] involved in the planning process, e.g. planning organization managers and technical specialists. Table 1 reports the participants; for each type of participants, the number of males (M) and females (F) is indicated in brackets.

Out of the 16 professional planners (46%), 10 (3 in Australia, 2 in Italy and 5 in Switzerland) worked in private planning organisations; some of them had a background in related fields such as transport planning and urban design. The remaining 6 planners (5 in Australia, 1 in Switzerland) worked in governmental organisations, which comprised local governments of different scale as well as organisations addressing planning at regional and metropolitan scale.

Table 1. Numbers and percentages of participants by job type and country.

	Professional planners		**Academic planners**	**Other actors**	***Total per country***
	Private	Governmental			

[1] Professionals concerned with establishing plans and policy for achieving sustainable and effective land use. This involves exploring possible development paths and alternatives and evaluating their effects considering economic, environmental and social conditions and trends. In Australia they are known as *strategic planners*.
The counterpart in Australia would be *statutory planners*, i.e. professionals who control development to ensure that it is compatible with current regulation. They assess proposals of changes to land use against planning policy.

[2] It is worth remarking that in (Williamson, 2012) 'actors' are not only referred to humans but also to "texts, graphical representations, and technical artefacts". In this article, the actors are humans that were interviewed because their expertise is on how planning tasks can be performed. For example, citizens as part of participatory planning have not been involved.

		organisations	organisations				
		N	**N**	**N**	**N**	***N***	***%***
Australia		3 (3 M)	5 (4 M, 1 F)	2 (2 M)	8 (4 M, 4 F)	***18** (13 M, 5 F)*	***52***
Italy		2 (2 M)	0	1 (1 F)	2 (2 M)	***5** (4 M, 1 F)*	***14***
Switzerland		5 (1 M, 4 F)	1 (1 M)	2 (2 M)	4 (2 M, 2 F)	***12** (6 M, 6 F)*	***34***
Total per job type	***N***	***10** (6 M, 4 F)*	***6** (5 M, 1 F)*	***5** (4 M, 1 F)*	***14** (8 M, 6 F)*	***35** (23 M, 12 F)*	
	%	***46***		***14***	***40***		***100***

Out of the 5 academic planners, 2 worked at the University of Melbourne in Australia. One of them had a significant experience in the United States and less in the Australian planning system since he had moved to Australia only for a year. Two academic planners were interviewed in Switzerland, at the Swiss Federal Institute of Technology (ETH) in Zurich and at the University of Applied Sciences Rapperswil (HSR). Beside their academic positions, they were also working part-time in private planning organisations. An academic planner was interviewed at the Polytechnic of Bari in Italy; she had also been responsible for 10 years for environment and planning in the regional government of the Apulia region.

The 14 other actors (8 in Australia, 2 in Italy and 4 in Switzerland) included planning organization managers, a scientific officer, an environmental engineer, a PhD student, specialists in GIS, 3-dimensional (3D) modelling and data management. Not all actors worked in the same organisations as the planners. For instance, the scientific officer worked for the Institute for Environment and Sustainability of the European Commission. The engineer worked on environment and planning at the regional government of Apulia in Italy. The PhD student was involved in a project supported by the Cooperative Research Centre for Spatial Information that developed and applied a planning support software tool for an Australian case study. The GIS specialist had expertise in data processing for use in planning support software and was part of a project team in Australia, which was involved in the development of planning support software tools.

4.2.2 The interviews

The interviews were semi-structured: they included a set of questions prepared in advance as well as questions that emerged during the interview. This type of interview allows checking what is already known but also provides the opportunity for learning new things. Often information obtained from semi-structured interviews provides not just answers, but also reasons motivating the answers (Rogers et al., 2011).

After initial questions regarding job function, work experience and educational background, the questions for professional planners focused on the usage of software tools for planning support, their strengths and weaknesses, and the context of use. Furthermore, the planners were asked about the procedures when choosing software and when needing assistance, as well as about courses on software tools to support their activities, that they attended during their study and/or working periods.

The 14 other actors were interviewed in order to gain a different perspective, with respect to planners, on the use of software in planning practice. The questions defined for professional planners were used, but they were formulated so that the interviewees would answer by referring to the planners they work with. For example, a question for professional planners was ‘What planning task do you use the software for?’. This question was asked to the other actors as ‘What planning tasks do planners use the software for?’.

It is worth remarking the importance of getting the opinions of those other actors and not being limited to only asking professional planners. In fact, it is well known that interviews have some limitations when trying to gather information on a certain practice (Rogers et al., 2011): what the interviewees say is not always what they do, know or think. One of the reasons for this is that “practitioners exhibit a kind of knowing in practice, most of which is tacit” (Schoen, 1983); in other words, some knowledge that they use in their activities is tacit and they are not able to explain it in words (Costabile et al., 2007). To avoid this limitation, interviews are often triangulated with other methods such as “observation”. Moreover, interviews are affected by a ‘please the researcher’ bias, i.e. in some cases, the interviewees answer in a way that can please the researcher. By interviewing other actors who work with planners, we aimed at getting more objective and in some case even more comprehensive answers.

The interviews with the 5 academic planners primarily aimed at providing indications on software courses in planning curricula and trends in software development and use.

4.2.3 Interview execution and data coding

The interviews took place in the interviewees' workplace and were all conducted by the first author of this article as part of her PhD research. They were performed face-to-face and one-on-one. Few exceptions occurred: in one case, the workplace of an interviewee was very distant and therefore the interview was conducted via phone call; in four cases, the interview was conducted with two people, who worked in the same planning organisation.

The interviews were conducted in order, first in Australia, then Switzerland and lastly in Italy. The international relevance of the study was additionally increased due to fact that some interviewees in Australia and Switzerland were from other countries and thus they had different cultural background and international work experience. The interviewer had to consider differences between countries in terms of planning concepts, terms, policy, etc. to avoid interviewees to be confused. For instance, the term 'strategic planning' is used in Australia and Italy but not in Switzerland where the more generic term 'spatial planning' is used. Identifying these differences and whether they influenced software use by planners was a further motivation for conducting this multiple-country study. It is worth mentioning that during or at the end of the interviews, some interviewees stepped through some activities they perform with the software they use on their computer either on their own initiative or upon request of the interviewer.

The main body of the interview (i.e. excluding warm-up and cool-off periods) lasted on average 28 minutes and were audio-recorded with permission. A plain language statement explained how information would be used and a consent form was signed by the interviewees.

The interviewer later transcribed the interviews and, together with the second author of this paper, started the analysis by following the grounded theory approach (Charmaz, 2013) and the recommended steps described in (Cruzes and Dybå, 2011). Specifically, the first step, i.e. *extract data*, was already started during the transcription, and initial ideas and identification of possible patterns in the data were shaped. In the second step, *code data*, a content analysis of the transcriptions was performed in order to code significant data. Double-scoring was conducted on 65% of these data, yielding a inter-rater reliability value greater than .85. Discrepancies were solved during a consensus meeting of the two analysts. In the third step, *translate codes into themes*, the two analysts individually translated codes into themes. Also in this case, the inter-rater reliability on identified themes was satisfactory (> .80) and all differences were solved by discussion. Eventually, the final set was discussed during a consensus meeting of all authors to get a condensed overview of the results, as reported in this article.

5. Interview-based study: results

The results obtained by the analysis of the interview transcripts are reported, with respect to the two research questions, in Section 5.1 and Section 5.2, respectively.

5.1 Software used by planners

Research Question 1 addresses the software tools used by professionals in their planning activities; they are described in Section 5.1.1, while their main features, as highlighted in the interviews, are reported in Section 5.1.2. Section 5.1.3 discusses the frequency of software use by the planners.

5.1.1 Software tools

In the interviews, it emerged that professional planners use various software tools. Table 2 reports the name of the tools mentioned in the interviews. Only tools for supporting specific planning activities, i.e. processing and visualising spatial data, were considered, while other tools, such as word processors and spreadsheets, were excluded.

It is worth noticing that the interviewer used the term 'PSS' in her questions. However, already in the first interview, the professional planner had never heard this term and did not know its meaning. The same happened with all professional planners and with most of the other actors. Even the Australian planners who said that they use Online Whatif?, CommunityViz, which are indeed PSS, do not call them PSS. Thus, in the interviews the generic term 'software' was much more used than PSS. Only the academic planners were familiar with PSS.

Geographic Information Systems (GIS) refer to software tools for managing, analysing and visualising geographical data. GIS offers a wide array of functionality applicable on geo-referenced data ranging from performing analytics and spatial queries to spatial modelling. Due to its wide applicability, it can be used in all stages of a planning process.

Table 2. Software tools used by the planners, as indicated by the interviewees.

Type	Name
Geographic Information Systems (GIS)	ESRI ArcGIS Global Mapper Intergraph GeoMedia MapInfo QuantumGIS
Computer-Aided Design (CAD) software	Autodesk AutoCAD Graphisoft ArchiCAD Vectorworks
3D modelling and visualisation software	Autodesk Infraworks Autodesk 3Ds Max ESRI City Engine Sketch up Urban Circus The Urban Engine
Graphics software	Adobe Illustrator Adobe InDesign Adobe Photoshop Microsoft Visio
Planning Support Systems (PSS)	Online What if? Placeways CommunityViz

Computer-Aided Design (CAD) is software for creating, modifying and analysing technical drawings. It allows depicting object shapes such as curves and figures in 2D space as well as the overall appearance of objects including surfaces and solids in 3D space. It is used by planners for drawing plans at small scales; they found such drawings useful for detailed analyses but also for documentation purposes.

3D modelling and visualisation software refers to systems for creating digital representations of 3D objects or so-called 3D models. Some planners use them to provide detailed realistic visual representations of urban environments through 3D modelling and therefore especially for the planning stages 1, 4 and 6 (see (Vonk et al., 2007) and Section 3). If they are based on augmented and virtual reality technology they allow users to virtually immerge in urban environments and to interact with them to improve their perception of reality. In this case, such systems can also be used for analysis purposes.

Graphics software is used for creating and manipulating graphical elements (e.g. headings, backgrounds, images) and for page layout and formatting, e.g., organising elements (text and images) on a page, defining their style and colour. Graphics software is primarily used to improve presentation and communication of information, thus for finalising products.

Planning Support Systems, as defined by Klosterman (Klosterman, 1999), use simple or complex mathematical models for analysing and forecasting development of urban or regional land use. Through different types of modelling paradigm, such as agent-based modelling (e.g. used in UrbanSim (Waddell, 2002)), rule-based modelling (e.g. used in What if? (Klosterman, 1999)) and cellular automata (e.g. used in SLEUTH (Clarke et al., 2007)), these systems provide abstract representations of land use and assist planners through the formulation of various land use scenarios. As an example, Figure 1 shows a screenshot of the Online What if? tool for the analysis of land suitability; it is a recent version of What if?, accessible via Web (Pettit et al., 2015). The user can select factors and assign them importance through weights from 0 (not important) to 100 (very important) (see left window in Figure 1); the tool computes the suitability of land units for a certain use and visualises them on a map (right window in Figure 1). The advanced analysis and visualisation capabilities of PSS allow planners to address the planning stages 3-6 of the planning process.

Hereafter, to refer to the various software types used by planners for their activities, the generic term 'planning software' is used.

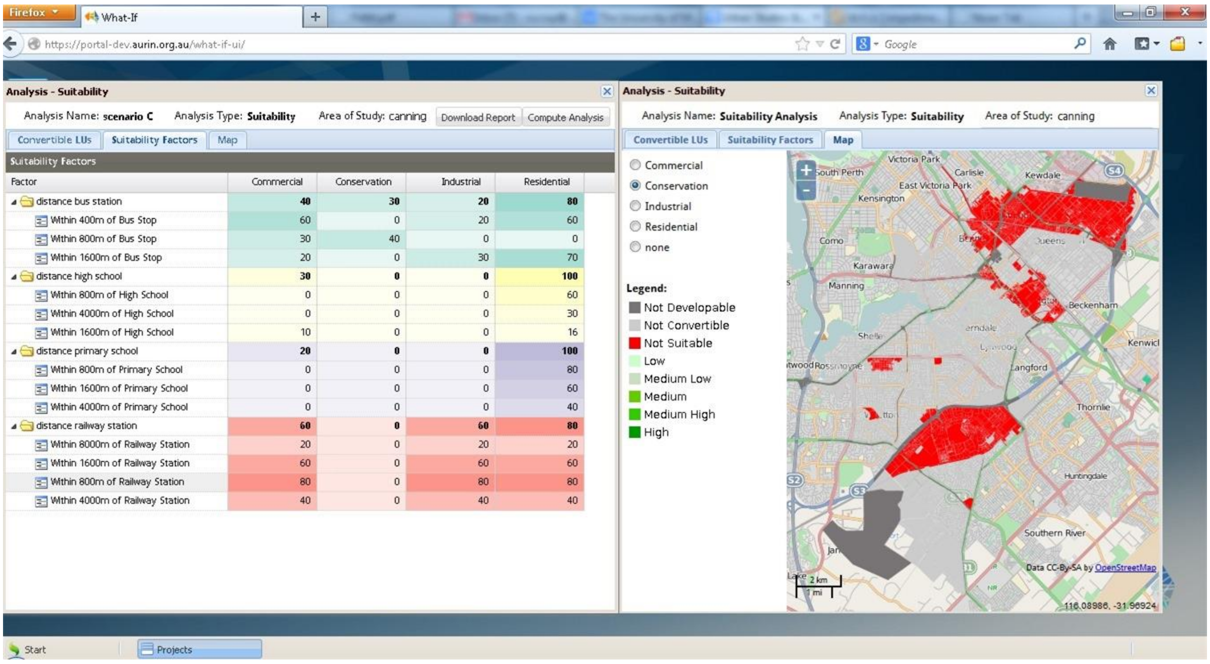

Figure 1. An example screenshot of the land suitability module in Online What if?.

The most widely used software type, as resulting from the interviews, is Geographic Information Systems (GIS), which is used by 96% of the planners (Figure 2). 35% of the planners used Computer-Aided Design (CAD) software. In relation to the number of conducted interviews, its use is higher in Switzerland (17%) than in Australia (9%). Different software tools for 3D modelling and visualisation were used by 26% of the planners. 13% of the planners used graphics and PSS. The latter was only used by interviewees in Australia.

The interviews highlighted that software tools of the same type can differ e.g. in terms of complexity, functionality, performance, as the following utterances demonstrate: *"ArcGIS is really stable but really slow, MapInfo is unstable but a lot faster"* and *"Vectorworks is probably less technical and it does not provide as many construction possibilities as other CAD software, e.g.*

AutoCAD". Software performance is important in relation to planning stages 2 and 3. In fact, in these stages the software has to manage, depending on the area under investigation, huge amount of data, in order to provide an overview of the conditions in the urban environment. This can substantially slow down the software and challenge its capacity.

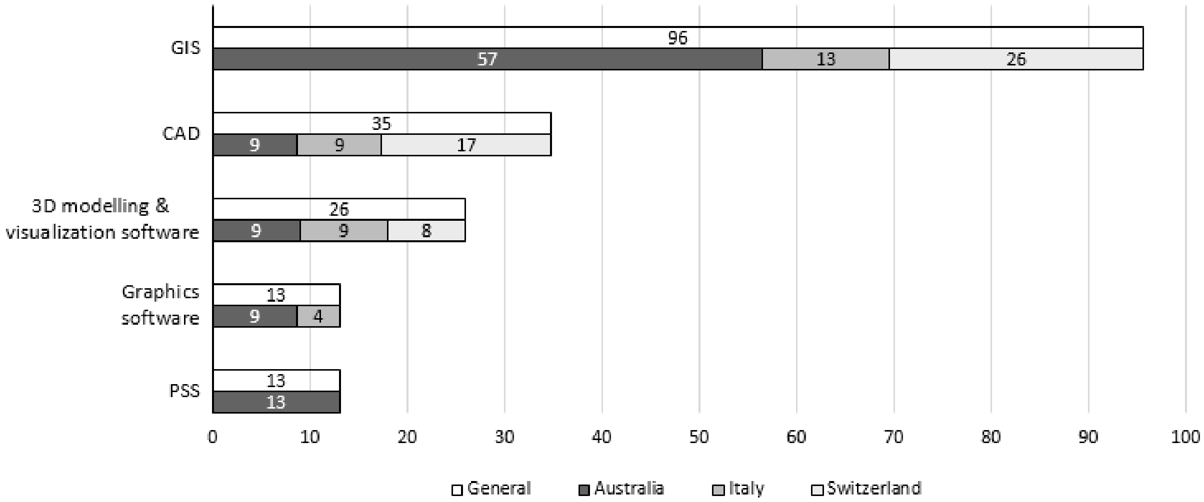

Figure 2. Software type ordered by descending percentage of use.

Furthermore, software functionality is not mutually exclusive, i. e. software tools categorised as a specific type also perform functions that are more characteristic of another software type as the following utterances show: *"AutoCAD was more for engineering drawings and now you can do a lot of GIS stuff"* and *"I've seen that CAD functionality of this GIS has improved"*.

The interviews indicated that GIS and CAD systems are also those software types that are primarily taught in universities courses as well as in technical training courses provided by other institutions. For example, the University of Applied Sciences Rapperswil in Switzerland provides courses on ArcGIS (GIS) and Vectorworks (CAD) for the bachelor curriculum on planning. Instead, at the Faculty of Architecture, Building and Planning of the University of Melbourne, in addition to a GIS course called 'GIS in Planning, Design and Development', a course called 'Urban Informatics' is offered in some years; it provides an introduction to PSS, teaching also how to use tools such as Online What if? (Pettit et al., 2015) and the Australian Urban Research Infrastructure Network (AURIN) portal; the latter supports planning and decision-making across Australian Cities (Sinnott et al., 2014). An academic planner of the ETH in Zurich said that in the master study a specific course was offered that required planning students to develop their own web-based software prototypes; prerequisite for students to attend that course was to have GIS knowledge while programming skills were acquired during the course. The interviewee said that generally at the ETH courses go beyond merely applying software and are more oriented towards doing research on software that can be re-designed, preparing planning students creation of for critical evaluation and software. The following utterances illustrate the objectives: *“We don’t want that students get out of here as users, but as novice developers or as someone who can take part in a discussion about software development”*.

The interviewee of the Polytechnic of Bari in Italy reported that planning students acquire much basic knowledge on maths, physics, etc.; they are also trained *“To apply models, may be too many, and often without a critical attitude… nobody explains students the strengths, weaknesses, opportunities and threats of applying them”*.

5.1.2 Features of software tools highlighted by the interviewees

The strengths of planning software appreciated by the interviewees are reported in Table 3. GIS functionality for managing, georeferencing, geoprocessing and mapping spatial data was seen by many interviewees as fundamental because it provides support to all planning stages. However, several interviewees indicated that the support could be improved. They found the functionality either too complex or not very specific for planning purposes. GIS were also found not very intuitive, difficult to learn and to remember, as the following utterances show: “*It is too technical for a casual user*”, *“What you think is very simple can be really complicated”*, *“It is sometimes not intuitive”*, *“Maybe it is possible but we haven’t found out yet how to do it”* and *“I often need some assistance”*.

The strength of CAD tools was attributed to the many possibilities and techniques to create line and polygon constructions of the built environment at small scale. Some planners prefer doing the layout of plans with CAD tools due to their numerous presentation possibilities. Examples of utterances that reveal this are: *"It is less difficult to do constructions in CAD than in other software and there are plenty of techniques"* and *"Especially important for us are georeferenced drawings"*.

Some interviewees indicated that being able to see the third dimension of the built environment, such as through 3D modelling and visualisation software, is useful for performing analysis tasks (planning stage 2 and 3), such as dwelling density analyses, and presentation and communication tasks through providing different views on the built environment. Especially, for stakeholders who inspect planning proposals and who are less familiar with 2D maps, 3D visualisations appear to be easier to understand. Indeed, an interviewee stated that a strength of 3D visualisations is that they allow easier communications amongst stakeholders. Utterances that exemplify this are: *"If there is the intention to change the utilisation number of an area from 120 to 140, then it is also for the planner difficult to understand what this means in terms of height or width by means of 2D visualisation"*, *"If it is about high density construction as currently in the city of Zurich, then it is easier to understand how the city is developing with 3D visualisation"* and *"Some people understand 3D objects better than plans"*. Two interviewees indicated that planners and stakeholders value high resolution imagery and are generally impressed by the immersion effect provided by augmented and virtual reality technology which allows experiencing planning proposals very close to reality, as the following utterances show: *"Users are fascinated and report about great experiences when using it"* and *"It provides planners the possibility to experience one to one their planning proposals"*.

Table 3. Strengths of the software types as evidenced in the interviews.

Software type	Strength
GIS	- Functionality for managing, georeferencing, geoprocessing and mapping spatial data
CAD	- Possibilities and techniques for creating constructions at small scale - Presentation possibilities and layout of plans
3D modelling and visualisation software	- Visualisation of third dimension - Different views of the built environment - High resolution imagery - More real experience of planning proposal (immersion effect) - Easy communication amongst stakeholders

Graphics software	- Appropriate drawing functionality - Appealing presentation and layout of plans
PSS	- Creation of projections for forecasting tasks - Comprehensive analysis Further strengths for GIS-based tools: - Improved learnability for people familiar with GIS - Direct access to GIS capabilities - Increased standardisation

The opportunity to create appealing presentations and layouts of plans were claimed to be the strength of graphics software and its provided drawing functionality; e.g., interviewees said: *"You have more options, you can insert various textures and sort of Photoshop elements"* and *"You can use it even without any knowledge and after only 1-2 hours of training"*.

The strength of PSS is that it primarily allows planners to perform advanced analysis, like comprehensive forecasting tasks, by including many land use factors and variables from different domains, as demonstrated by the following utterance: *"When you talk about land use, you will have sewerage, terrain analysis, transport analysis, you will have all these analysis involved"*. Some PSS are GIS-based, i.e. they constitute a module of a GIS. An example is CommunityViz (Walker & Daniels, 2011). Interviews remarked the following strengths of GIS-based software:

i. Improved learnability *("I learned to use CommunityViz because it is an add-on of ArcGIS and I have GIS knowledge"*)
ii. Direct access to GIS capabilities (*"GIS capabilities are at hand and can be used in parallel, for example, for data processing"*)
iii. Increased standardisation: ("*GIS has done a great job in forcing everyone in using shapefiles")*

Some weaknesses also emerged for PSS. Interviewees mentioned that it is not easy to understand how such tools process data. Low fit to user needs was remarked, as well as lack of transparency (i.e., "the extent to which the underlying models and variables of the software tool are accessible and understandable to users" (Pelzer, 2015)) and reliability, (i.e., "the extent to which the outcomes of the tool are perceived to be valid" (Pelzer, 2015)), as the following utterances show: *"It* *gives me an answer but I don't know how the answer came and I don't really trust it"*, *"Getting the people to relate to the outputs is I think a problem"* and "*Plan A is scoring 5.4 and plan B 4.9 you got no means what that means. Planners cannot see any difference between them"*. Another weakness is that social dynamics, which are important aspects in planning, are not satisfactorily modelled. Social dynamics address population changes and their effect on the community of a specific area; this population changes might be determined by e.g. criminality increasing in a neighbourhood, modification of the transportation system, etc.

Possible trends in planning software development and use also emerged which mainly contribute to improve communication amongst planning actors. According to some interviewees, a transition is occurring from standalone desktop to web-based tools (including apps, blogs) that can be easily accessed. In addition, web applications are considered by some interviewees the basis for multi-user collaborative software, in order to allow users, independently of their location, to make real-time changes to the same file (e.g. a planning proposal) and therefore to collaboratively develop a planning solution, as the following utterance shows: "*The next step is, even if already sparingly happening, the collaboration amongst different stakeholders through web applications*".

5.1.3 Frequency of software use by planners

From the interviews it emerged that the use of planning software has increased and improved over the years. The frequency of software use varies a lot as shown by the following utterances: *"I use GeoMedia ever day"*, *"I'm using ArcGIS maybe not once a week but I'm going through periods of time where I'm using it quite heavily"*, *"It can often go weeks or months without using GeoMedia"*.

Software use appeared to differ substantially amongst the interviewed planners. For instance, GIS use ranged from performing basic tasks such as visualising data *("A lot of work we do in MapInfo is purely visual mapping"*) to completing more advanced spatial analysis tasks *("We check where possibilities exist that more population actually generate more employees"*). Furthermore, some planners indicated to use CAD for visualising data while others used it for creating complex constructions and 3D models.

The use of the software also varies amongst planners within the same planning organisation as the following utterances show: "*Four of the nine planners in our organisation are able to actually create maps in ArcGIS"* and *"My colleague deals with 3D modelling and rendering"*.

It emerged that planners do not use only one but multiple software tools of different types together for performing their activities, as the following utterance shows: *"We are using these programs together, InDesign connected to ArcGIS and then we export the basemap into Illustrator"* and *"What I do is I export the map from GIS into CAD, I do the construction in CAD and then I re-export into GIS"*.

As already remarked, types of software that are different share some functionality, and for certain activities planners might change, during time, the tools they use, as the following utterance shows: *"While I did everything in ArcGIS in the past, now I export all bits and pieces into Photoshop and put them together for plan-making"*.

5.2 Factors affecting planning software adoption and use

RQ2 addresses factors that affect planning software adoption and use. Factors that can be considered specific user requirements of planning software, because they are related to the software systems, are reported in Section 5.2.1, while Section 5.2.2 is on factors not strictly related to the software.

5.2.1 System-related factors

An analysis of the factors that planners consider when choosing software for their planning activities was carried out. Figure 3 shows these factors and the percentage of the interviewees who indicated them. It showed that 43% of the interviewees uttered *fit to tasks and users* as a factor for adoption and use of software. Utterances related to this factor are: *"We use the tool because it reflects the* *planning process we adopt"*, "*We did not adopt AutoCAD because it was too technical and complex for their requirements*" and *"For the plans we develop and the functions we need, Vectorworks was the most suitable"*. Moreover, when planners use software that lack some functionality, they ask developers for modifications, in order to better satisfy their needs, as the following utterance shows *"Based on planners' feedback, the button 'transferring' was added"*.

Cost is an important factor for software adoption for 28% of the interviewees. This does not only refer to the actual cost of the software but also to additional costs, such as training of users. In particular, an interviewee valued web-based software for being easily accessible and generally not requiring any installation. For example, an interviewee referring to a web-based planning software said: *"OK, let's try this if it is not too much trouble and there is no cost involved"*. However, it is somewhat interesting that this interviewee expected ubiquitous software access at no cost.

About 20% of the interviewees reported that they adopt and use certain software because planning organisations are committed to *software compatibility*. For instance, utterances demonstrating this are: *"We adopted the same software as our client to facilitate the exchange of data"* and *"Data transfer from one tool to another one is important for taking advantage of different software functionalities"*.

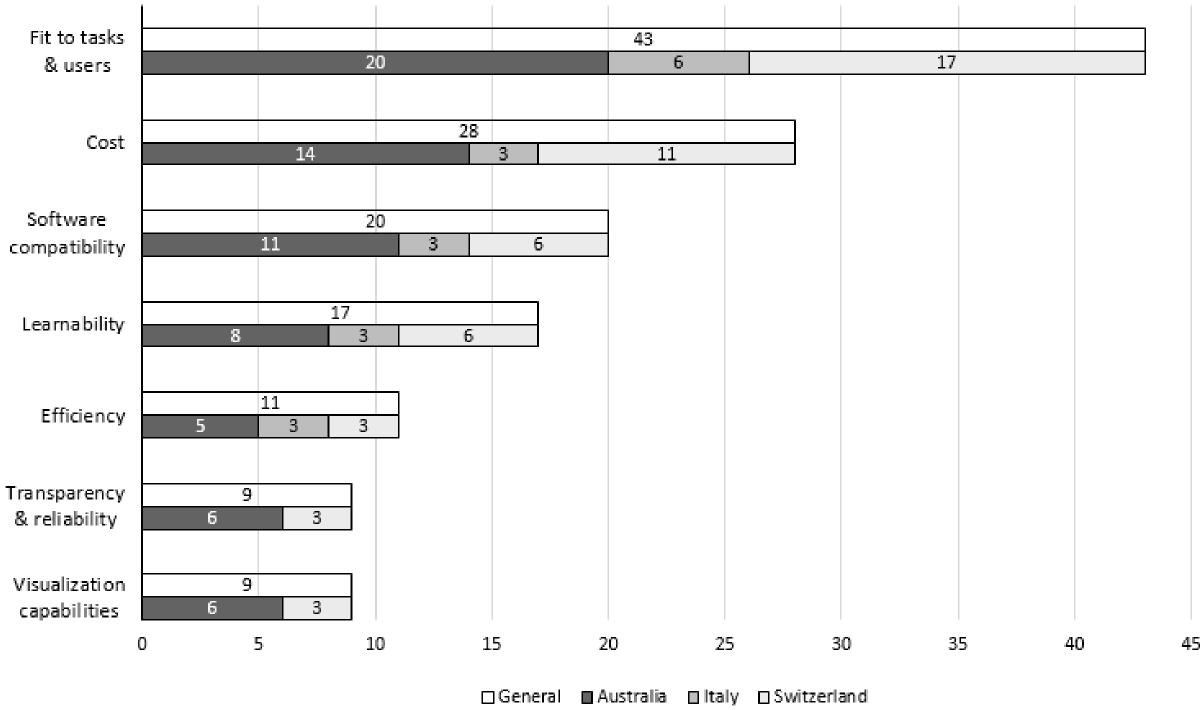

Figure 3. System-related factors influencing adoption and use of planning software. The values indicate the percentages of interviewees who mentioned the factors.

Another relevant factor for 17% of the interviewees is *learnability*, i.e., whether the amount of time required for learning how to use it is acceptable. Some interviewees uttered to adopt and use modules of software they already use because they have only to learn the functionality of the module and not of the overall software. Other utterances that remark the importance of learnability are: *"In extreme cases, if I cannot figure out in three clicks then I'm not doing it*" and *"If you have got nine thousand things to do then it is very hard to learn to use new software"*.

Efficiency, i.e. time gain when completing a task, is an important factor for 11% of the interviewees. For example, utterances demonstrating this are: "*Probably first is performance and whether it makes projects quicker and more efficient*" and "*I don't want to do everything manually because there is not enough time for that basically*".

Transparency and *reliability* were further factors indicated by 9% of the interviewees. They are already mentioned in Section 5.1.2 as weaknesses of PSS.

The opinion of 9% of the interviewees is that *visualisation capabilities* are necessary for adopting software as they are important for improving communication of results with stakeholders: *"You might have done a lot of work in the background but if you cannot communicate it then your work could go to waste"*.

5.2.2 Non-system-related factors

Figure 4 shows factors that are not related to the software systems but have also an impact on planners' adoption and use of software. Planners' *awareness*, i.e., knowledge of planning software tools and of their potentials, was indicated by 17% of the interviewees. An example is the following utterance: *"There was no interest to adopt other software also because I don't know what is out there"*.

Planners' *skills and experience* have an influence for 17% of the interviewees, as the following utterances show: *"I have intermediate and not advanced GIS skills and so I cannot do all the GIS tasks by myself"* and *"So we solve the problem with CAD because there is someone who knows how to do it, whereas nobody really knows QGIS"*. In particular, some interviewees indicated that the planning organisations they were working for adopted software because some planners in the organisation had either learned or used it during their studies. For example they said: *"We adopted Vectorworks because some of the planners, who had studied at the University of Applied Sciences Rapperswil, were taught how to use it"* and *"Some of them use sometimes a variety of CAD because quite a few of them have a background in architecture for whatever reason, it must have to do with their degree or training"*. In other cases, the knowledge that planners acquired during their study appears to be not adequate, thus they are forced to overcome such limitations once they are out of university, as the following utterance shows: *"When I finished my degree, the first thing I realised and did was to go to the IT Department and work with computers and software and on data processing"*.

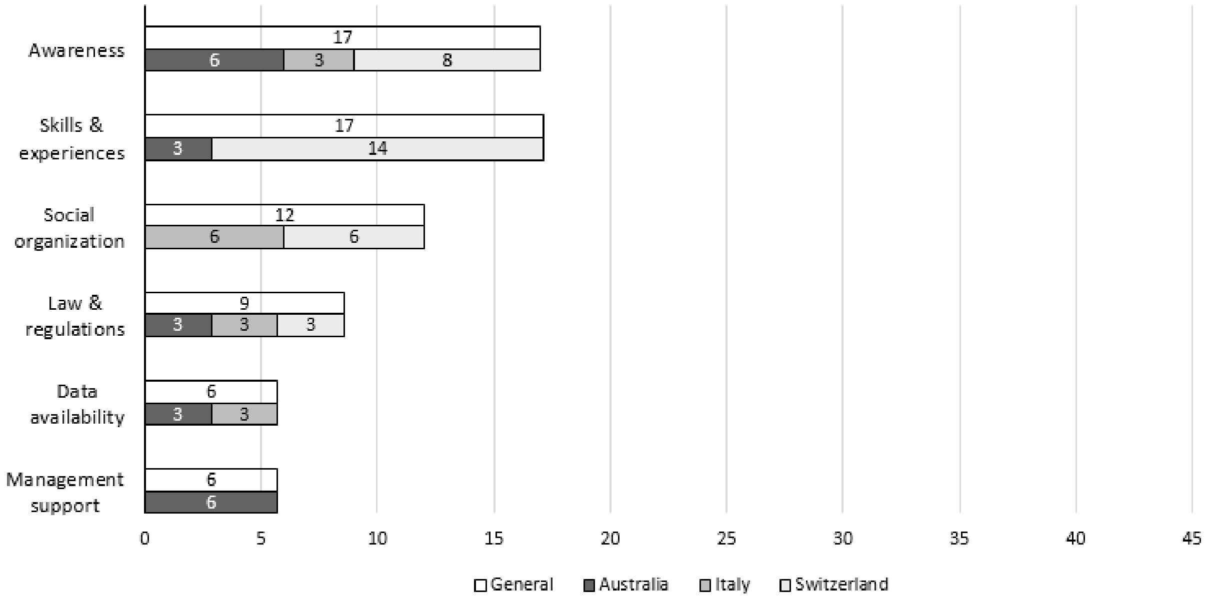

Figure 4. Non-system-related factors affecting the adoption and use of planning software. The values indicate the percentages of interviewees who mentioned the factors.

Some interviewees indicated that they are influenced by what others use, as shown by the following utterances: *"We adopted Vectorworks because it is currently popular"* and *"Once in the workforce, I noticed that all people were using AutoCAD so I did"*. According to (Vonk et al. 2005), we categorized this factor as *social organization* of users; it was indicated by 12% of the interviewees.

Planning software has to take into account planning requirements, namely *law and regulations,* that differ depending on the regions and countries in which planners work. The following utterances exemplify this: *"Planning is about policy and so rigorous methods are not important"*, "*They are not widely used as planning decisions are more political than evidence-based*" and "*The reason for developing this tool is because we have to provide specific data, which is imposed by the Region"*. This factor was mentioned by 9% of the interviewees.

Small percentages of the interviewees indicated *data availability* and *management support* as further factors. About *data availability*, 6% of the interviewees pointed out that software designed to be applied in a specific area might require data that is not available or difficult to get elsewhere. Examples of utterances are: *"The application of models depends very much on the existence and availability of data"*, "*Data requirement is tailored to data available in the UK as that is where the* *tool has been developed and designed for"* and *"If you run the model for another country there will be lack of data and information and it will be very hard to get an output"*.

Concerning *management support*, 6% of the interviewees reported that the management of the organization has to be convinced that it is a worthwhile investment, as the following utterance shows: *"They want to know what do you gain and what's the investment"*.

6. Focus Group

During the analysis of the interview results, the analysts felt the need to deepen with planners some of the issues which emerged and also to get more insights into specific design implications on planning software. We decided to perform a focus group, a widely used technique because of its several advantages (Choe et al., 2006). It allowed us to discuss with a group of planners the results of the interviews. The focus group was conducted at the Department of Computer Science of the University of Bari (Italy).

6.1 Participants

Six participants took part. Three of them had already participated in the interviews, i.e. an academic planner who was also the former planning councillor of the Apulia region, a professional planner working in a private organisation and a planning actor (engineer) working in a governmental organisation. The other three participants had not been involved in the interviews, they worked at the Planning Department of the Polytechnic of Bari; specifically, one was an assistant professor, one was a research fellow, and the third one was a PhD student with experience of work in a governmental organisation. Two researchers moderated the focus group.

6.2 Procedure and data collection

As shown in Figure 5, the participants and moderators were sitting around a table. A tag with his/her name and affiliation was put in front of each person. The participants signed a consent form that permitted taking photos and recording the audio during the session.

Figure 5. Participants and moderator during the focus group.

Of the two researchers, one was the main moderator of the focus group, the other primarily took notes, but she also intervened in the discussion. The moderator started the meeting by informing the participants about the interview-based study, its purpose as well as some outcomes, those mainly related to the features of planning software required by professionals in their daily practice. To make her presentation more effective, the moderator projected some slides on a video available in the room. She facilitated the discussion by asking some questions; however, for most of the time, she allowed an open discussion among participants in order to gather as much information and feedback as possible.

The planning process defined by Vonk et al. (Vonk et al., 2007) (see Section 3) was the other issue more discussed for two main reasons: i) to gather their opinions on the extent to which this process fits to their real life activities; ii) to discuss the software tools supporting the different stages of the process.

6.3 Results

The focus group lasted 1.5 hour. All participants took actively part in the discussion. The results reported here refer to those aspects that impact on the design of PSS. Other results, which are primarily of interests to planners, are in (Russo, 2017).

About the different types of software tools, the participants confirmed that, to the best of their knowledge, GIS is the type of tools most used by themselves and by their colleagues. It was explained that this is also due to the fact that the Apulia region, where the participants mostly operate, requires that planning organizations use GIS.

With reference to the features of planning software, and specifically to the factors that affect planning software adoption and use, *fit to tasks and users* and *visualisation capabilities* were confirmed to be very important. Regarding the former factor, a strong position emerged about planners' need to tailor their software tools. Often, they are either overwhelmed, and even confused, by too many functions which they do not need or are not adequate to their way of thinking and operating. They complain that modifications to the software tools require IT skills (i.e., programming) that planners, and most of the other involved stakeholders, do not have. About visualisation capabilities, what emerged in the interviews was confirmed, strongly remarking that lack of appropriate visualisation makes difficult communication between planners and who should use their outputs, e.g. surveyors and decision-makers.

In the discussion about the seven planning stages, the participants agreed that they actually cover planners' activities in real life. An important result that strongly emerged is that planning is a process that involves the collaboration of different professionals, e.g. transport engineer, environmentalist, sociologist, historian, geologist, etc. Each of them performs the seven stages of the process and provides planners with specific outcomes. Often, the different professionals use specific functionality of GIS and in particular ArcGIS. Planners analyse and combine the various outcomes and eventually define the overall plan.

The participants remarked that planners require fine-grained information, such as 'effects on people daily's life' and 'social dynamics', as already emerged in the interviews. The new aspect that emerged is that, today, it is worth gathering such information from social media. Indeed, planners are most of the time faced with problems citizens experience in daily activities, they are even notified by citizens who complain about too narrow footpaths, hanging tree branches, location of garbage bins causing problems. Planners increasingly get real-time data provided by citizens through applications, such as SeeClickFix, Ushahidi, or social media, e.g., Twitter, Facebook, Instagram. The developed plans should take into account such fine-grained information. Instead, planning software hardly consider such information and therefore their outputs provide little support for implementing an effective plan.

7. Study Discussion

The study conducted to analyse the current situation on the use of PSS in planning practice showed, very surprisingly, that professional planners do not know the term PSS and, in most cases, do not use such tools. This finding was reinforced through the results of the focus group. Only in Australia, some interviewees said that they use the tools categorised as PSS in Table 2, but they identify them generically as planning software, rather than PSS. Actually, PSS predominantly support stages 3 and 5 of the planning process, since they provide proper functionality for advanced analysis, such as generating scenarios and performing impact assessment, which allow making better informed decisions.

The current situation on the use of software in planning practice, illustrated in Table 2, pointed out that planners use multiple software types and tools, which provide diverse functionality. Most tools are not specifically for planning and therefore they do not perfectly fit planners' expectations and their tasks. Planners use these tools (e.g. graphics software, 3D modelling and visualisation software) to present and communicate visual representations of the built environment to other planning actors. GIS are the most used type of tools, as resulted in both interviews and focus group, possible because these systems have a large set of functionality and part of it actually supports some planning activities.

The discussion on planning software features that most impact on software adoption and use is divided in two parts, reporting in Section 7.1 indications whose interest is specific for the planning community, while Section 7.2 provides indications about features that may contribute to design planning software that better satisfies its users.

7.1 Indications for the planning community

As said above, GIS resulted as the most used type of tools. However, GIS are mainly used to visualise and explore spatial data rather than to perform more advanced analyses such as buffering, overlay and union. Professional planners in Switzerland said that they equally choose GIS and CAD systems as their basic software tools. It is interesting to observe that the interviewees said that the software most used in universities courses are GIS, and in Switzerland also CAD systems. This could explain why these software types are the most used in planning practice: planners are inclined to use software tools they know already from their university studies. We said above that only in Australia some professional planners use PSS, and it emerged in the interviews that PSS are actually taught in university courses in Australia. Thus, this is a further indication that planners tend to use tools they learned during their studies, because they are aware of their potentials and appreciate the support they may get in their working activities.

Consequently, an important indication resulting from our study is that university curricula should include study and use of PSS. This will have several advantages. As reported in (Brits et al., 2014), “planners in general do not understand models and modelling process”. PSS are tools that support decision-making (Arciniegas et al., 2013) and models are an important component of PSS (Klosterman, 1999); thus, studying PSS at university will increase students’ modelling and decision-making abilities. Houghton and colleagues analysed the importance of making ICT part of the daily practice of professional planners in order to foster innovation in planning activities (Houghton et al., 2014). To this aim, technical and software courses should be offered more extensively to planning students. Edwards and Bates analysed planning's core curriculum of master's degree programs of thirty planning schools in USA and Canada (Edwards & Bates, 2011). They showed that little attention is devoted to GIS and spatial analysis with respect to other skills. We agree with (Dawkins, 2016) on the benefits of providing a solid basic knowledge, but students have also to be informed on ICT advances that can have a positive impact on their future jobs. For example, planners, once in the workplace, could attend online courses offered e.g. through MOOC and Planetizen, in order to get better knowledge on ICT. Planning skills are analysed in (Greenlee et al., 2015), where both practitioners and educators were asked to rank skill areas. Data analysis and visual communication skills were both ranked very high. By data analysis they mean "the ability to use data and compute numerical summaries of information, creation of projections, forecasts, and scenarios". Knowledge on PSS is thus very important since, by definition, PSS provide support to data analysis. Visual communication is defined as "the ability to visualise complex information using GIS maps, tables, charts, and other illustrations". PSS actually provide visualisations like maps, tables, charts, etc. Summarising, it is very relevant to train planning students to work with PSS so that they will be prepared to adopt and use them in their work practices.

Out of the 6 non-system-related factors influencing PSS adoption and use, reported in Figure 4, five were already identified in the studies by Vonk and co-authors (Vonk et al., 2005; Vonk, 2006; Vonk et al., 2007). Among these, low *awareness* and insufficient *skills and experience* of planners resulted as the most important. The further factor that resulted in both interviews and focus group is *law and regulations*. Actually, its influence on software use, was also identified in (Brits et al., 2014) and emerged in (Russo et al., 2016). Indeed, during a test of a planning software tool, a participant was reluctant to enter data into the system because she was not sure to enter valid input conforming to current planning law and regulations. PSS developers should take this factor in serious consideration and work to the possibility of developing software that should be easily adapted to the planning law and regulations of a specific area.

7.2 Indications for the design of planning software

With reference to the system-related factors hampering adoption and use of PSS, the results of our study confirmed to some extent what other authors reported in the literature, but two new factors, namely *learnability* and *visualisation capabilities*, emerged. The other five system-related factors shown in Figure 3 were already reported in previous articles (Vonk et al., 2005; Vonk, 2006; Vonk et al., 2007). *Fit to tasks and users* is by far the most important system-related factor influencing software adoption and use. However, the interviews showed that planners have different needs, also depending on different national policies and people backgrounds, and thus different expectations of what planning software should provide. It is also well known that user needs evolve over time (Fischer et al., 2008; Fogli & Piccinno, 2013). Moreover, in the focus group, it was pointed out that the conditions and requirements change over time. Thus, designers should provide users with software environments that can be easily tailored to their needs, tasks, habits and context. Existing software is not flexible and does not enable planners to find answers to their specific and evolving requirements. Currently, as emerged both in the interviews and focus group, software modifications are performed (e.g. new functionality is implemented) by technicians to adapt software to what planners desire to do. This is very costly. To avoid this issue, *planning software should be developed according to the End-User Development (EUD) approach* (see e.g. Ardito et al., 2012; Cabitza et al., 2014a, 2014b; Diaz et al., 2015). EUD literally means that non-technical end users, i.e. people who are not programmers, are enabled to develop or modify software artefacts, in order to adapt them to their own needs and preferences. Indeed, recent technology offers such end users the possibility to perform various activities ranging from simple parameter customization to more complex activities, such as variation and assembling of components (Lieberman et al., 2006). EUD is generating a lot of attention among researchers, it represents a great challenge to software design, because it is not easy to create environments and tools that can empower end users to tailor the software they use, without being obliged to become programmers.

In line with (Vonk, 2006), further but less important system-related factors were *costs* (of software, user training, etc.), *software compatibility*, *efficiency*, and *transparency and reliability*. In particular, *transparency and reliability* were mentioned only for PSS. Some interviewees stressed that planners are and should be even more critical of the underlying assumptions and methods used by PSS in their analyses, they want to be informed by the system on how data are analysed, models are created and outputs are generated, in order to better understand the obtained results. This also emerged in the study reported in (Russo, et al., 2016). We strongly recommend to take into account *transparency and reliability* as important requirements of future PSS.

The new factors emerging from this study are *learnability* and *visualisation capabilities*. Learnability is a well-known concept. Back to 1993, Nielsen stated that a system “should be easy to learn so that its users can rapidly start getting some work done with the systems” (Nielsen, 1993). We believe that the interviewees explicitly mentioned that they want easy to learn software since there is increasing awareness amongst users that software has to be usable, no matter how complex the software might be. The concept of usability has been evolving in the last years. The emphasis is now on user experience (UX), which includes subjective attributes such as aesthetic, emotions, and social involvement. Until recently, a primary goal of software design was to provide useful and usable functionality to allow people to perform their tasks. These goals are still important but we want to make sure that the tools people use are pleasurable as well, they generate positive feeling and well-being. To the designers of future planning software we recommend to take into account usability and develop software that, beyond being easy to learn and use, also considers the attributes related to the overall user experience.

Regarding *visualisation capabilities*, in both interviews and focus group it emerged that lack of appropriate visualisations makes difficult the communication among stakeholders, which is an important activity in planning practice. In order to increase planners' acceptance of software and facilitate communication with stakeholders, planning software should provide *mechanisms for dynamically linking maps to other types of visualizations, such as graphs, charts and tables*, i.e. multiple visualisations of data could be available. This confers with work previously reported by Pettit et al. (Pettit et al., 2012).

Some interviewees, in particular software developers, reported that, in general, PSS are developed without a proper software development methodology: user requirement analysis is very poor and system functionality is implemented without taking care of what planners actually need. Once the system is used, as soon as planners complain on system functionality, developers intervene in order to fix the problems planners have indicated. Very poor attention is devoted to the user interface, that is often considered only at the very end of the system development, despite what is said in (Raskin, 2000): creating an interface is much like building a house: if you do not get the foundations right, no amount of decorating can fix the resulting structure. As emphasised in the HCI literature, but also in (Russo et al., 2016) with reference to planning software, we recommend to follow a HCD process (ISO 9241-210, 2010), in order to create systems that can satisfy their users. This may sound as a naïve recommendation, but software practitioners still neglect basic HCD principles and methods (Ardito et al., 2014).

An important outcome of both interviews and focus group is that planning software does not adequately meet planners' requirements about input data for a satisfactory planning process. It emerged that planners require up-to-date and fine-grained data regarding citizens' needs and their experiences, which are currently available through applications such as SeeClickFix, Ushahidi, or Twitter, Facebook, Instagram. Thus, an important implication for the design of software that effectively support planners is to *provide functionality that permits to easily import and analyse people-generated content from social media,* thus leveraging crowdsourcing for active citizenship (Linders 2012; Guzman and Maalej, 2015).

8. Conclusion

The study reported in this article was performed in order to investigate why PSS are not very used in the work practice and identify relevant features that PSS should provide, in order to meet users' expectations. The study consisted in interviews with 35 planning actors of three different countries and a follow-up focus group involving six Italian planners.

Even if PSS are software systems that are being developed for about 20 years with the aim of assisting professionals in planning activities, one surprising result of the study is that most professional planners do not know the term PSS and do not use such tools. In order to be supported in their work, they use different types of software, including GIS and CAD, generally defined as planning software. As further results, factors that most affect adoption and use of planning software were identified. Based on those factors specifically related to software systems, indications about the design of software that can be adopted and used with satisfaction in the planning practice were provided.

The results presented in this paper are based on a qualitative study. Qualitative research is increasingly appreciated, since it helps researchers exploring more deeply the practice of software engineering (Dittrich et al., 2007; Seaman, 1999). Traditionally, most researchers appreciated quantitative methods more than qualitative ones, because the former provide objective measurements and permit to replicate the study. Validity of qualitative studies is questioned because they are based on subjective interpretation. More recently, researchers acknowledged the importance of qualitative methods if the collected data are analysed with methods that ensure study objectivity and soundness (Rogers et al 2015), as done in the presented study. The collected data were carefully analysed according to content analysis, which allows identifying, analysing and reporting themes in a systematic way (Kim et al., 2014). In addition, the interpretative power of the content analysis was increased by the use of the grounded theory theoretical framework.

The interview-based study involved 35 participants. This number was considered adequate with reference to the theoretical saturation concept (Strauss & Corbin, 1998). Of course, the number of participants does not permit a wide generalisation of the result. Now that useful insights are gained, it is possible to frame the design of further studies to provide better indications of the magnitude of the researched phenomenon. We are confident that the research presented in this paper will stimulate further work, in order to foster the adoption and use of software by professional planners.

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