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A framework to bridge digital planning tools' utilization gap in peri-urban spatial planning; lessons from Pakistan

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ABSTRACT

As cities grow, the continued development pressure and land-use change of peri-urban areas pose a key challenge for urban planners to address. In the planning of peri-urban areas, the complexity of intertwining physical, environmental, transportation, social and institutional planning dimensions, rapidness of change, demand for precision, and subjectivity of the situations; application of digital planning tools (GIS, PSS and similar) offers a result-oriented and at times the only way out for realistic planning. Like many other countries, peri-urban growth in Pakistan is being managed by the preparation of Peri-Urban Structure Plans (PUSPs). Since, 2009, such plans have been prepared for 36 urban centres of various scale which offer a considerable size to explore the usage pattern of digital planning tools in real-world practice and learn the lessons. Despite wider development and adoption of geographic information systems (GIS) based planning support system (PSS) in spatial planning all over the world, the utilization of digital planning tools in Pakistan to support planning practise has been very limited. This research adopts a case study-based methodology to review the legal requirements of peri-urban plan-making and highlight tasks where digital planning tools can add value. It investigates why there is a paucity of up taking digital planning tools in the spatial plan preparation and documents key stumbling factors. To understand the user's perspective, a survey of (n = 108) urban planners has been undertaken using an online questionnaire. The survey assesses their understanding of the terms and their perception behind the current utilization level of digital planning tools for plan preparation. The analysis reveals a very low familiarity of urban planners with digital planning tools, particularly planning support systems, in Pakistan which is aligned with the findings from technologically advanced countries. The causes behind low utilization have been documented and grouped under three dimensions, adopted from previous research including 'user acceptance', 'instrument quality' and 'diffusion'. Finally, the paper concludes by proposing a framework for bridging the utilization gap to improve spatial planning practice.

1. Introduction

We are living in the age of cities with prolific population growth, as globally we are moving toward 9.7 billion people living on our planet by 2050, with major share residing in urban areas (United Nations, 2014, 2015). Pakistan, with more than 212 million inhabitants, is a point in case with the population estimated to become predominantly urban by 2025 (GOP, 2015; Jan, Iqbal and Iftikharuddin, 2008). Overtime, spatial planning practices to manage peri-urban areas have been changing in Pakistan and the form of spatial plans have been shifting from comprehensive master plans and outline development plans to structure plans and peri-urban plans (Anjum, 2008). After the implementation of Punjab Land-use Rules, 2009, peri-urban growth is managed primarily through peri-urban structure plans (PUSPs), a mandatory requirement for development controlling agencies (The Urban Unit, 2009). To date, PUSPs for 36 cities have been completed.

An important dimension which contributes or hinders the adoption of digital planning tools in plan making is the list of tasks presented in legal documents as plan preparation process. Those tasks provide the need and justification for a specific set of analysis which, in return,

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create demand for the use of advanced tools. In the case of Punjab, Land use Rules, 2009 and its subsequent amendments are the main legal documents defining peri-urban areas and their spatial planning process (The Urban Unit, 2009). This research provides the synthesis of the plan-making related governing rules and the relevant provisions that can generate a need for the use of geospatial technologies.

Following the conventional plan-making process of Patrick Geddes (Boardman, 1978), the preparation of spatial plans in Pakistan follow stages including a survey of existing situation; projection of future population, employment, and land requirements; identifying land-use constraints and opportunities, and formulation and review of planning scenarios proposals to meet those needs (Zaidi & Mayo, 2006). These plans are being prepared using a conventional plan-making approach with limited support from digital planning tools such as PSS. Previous studies have revealed that major factors contributing to the poor conformance and performance of spatial plans have their roots in the plan-making stage. The possibility of occurrence of human-induced and procedural errors is more likely without the support of data-driven approaches and can sometimes result in inferior quality planning documents (Ahmad, 2012; Anjum, 2008; Hussnain, 2013; Hussnain et al., 2014; Mayo, Zaidi, & Hussain, 2006). The adoption of PSS in planning practice is the need of the hour as we move into an era of smart cities (Pettit et al., 2018).

Digital planning tools primarily including GIS-based PSS have emerged as effective tools to support the planning process and contribute to the quality of planning outputs (Brail & Klosterman, 2008; Geertman, 2015; Hussnain et al., 2016; Kim, Jaesung, & Kim, 2012; Klosterman & Pettit, 2005; Pettit et al., 2013; Timmermans, 1997; Yeh, 1990). As acknowledged elsewhere (Yeh, 1990), GIS can be used at various stages of the planning process including resource inventory, analysis of the existing situation, modeling, and projections, development, and selection of planning options, planning implementation and evaluations.

Considering peri-urban as ‘a zone of chaotic urbanization leading to sprawl’, some researchers declare them as ‘spatial planning challenge of the twenty-first century’ (Nilsson et al., 2013). While handling various planning needs of future growth areas, many scholars have documented the beneficial outputs of PSS. Pettit explained the PSS role in enhancing collaboration while formulating development scenarios (Pettit, 2005). Klosterman and others have appreciated the PSS for improving the quality of land suitability application (Pettit et al., 2015). In their later works, Pettit et al. has specifically documented the PSS usability in peri-urban regions and emphasized at the need for *‘generic tools’* to support strategic planning of urban growth occurring in the expansion areas (Pettit et al., 2013). Similarly, Hussnain has documented PSS use in real life peri-urban planning project for scenario development (Hussnain et al., 2019). In summary, peri-urban planning demands for digital planning tools which may assist in the dissection of interlinked problems, the exploration of processes, the estimation of future needs and forecasts, the engagement of stakeholders and the building of scenarios in an iterative way to understand the correlation and impacts of each future planning option.

Nevertheless, there seems to be a mismatch between demand and supply of GIS-based planning support systems (PSS), as well as user needs resulting in the low adoption of PSS. Vonk et al. have documented bottlenecks to adoption in three dimensions including instrument quality (supply of PSS), diffusion (toward and within planning practice) and user acceptance (demand for PSS) (Vonk, 2006; Vonk & Geertman, 2008). Furthermore, others have discussed PSS use by planners and documented suggestions to eradicate such mismatch between PSS functionalities and planners' expectations including the empirical studies undertaken by (Russo, 2015; Russo, Lanzilotti, Costabile, et al., 2018a) in evaluating the experiences and perception of planning practitioners in using PSS. These studies have found that education and training are a significant barrier along with the usability and awareness of PSS. Other such empirical studies include the work of Arciniegas et al., (Arciniegas, Janssen, & Rietveld, 2013) and Pelzer et al. (Brömmelstroet et al., 2013; Pelzer et al., 2014; Pelzer et al., 2015). Despite understanding the delicate difference between the terms GIS, SDSS and PSS (Batty, 1995; Geertman & Stillwell, 2003; Kamps & Tannier, 2008; Kim et al., 2012; Li & Jiao, 2013), this research uses the term ‘digital planning tools’ as an overarching term to denote GIS and/or PSS tools for planning. This has been done to account for the low familiarity of urban planners with specific terms in the case study.

When compared with the developed world, utilization of information technology in spatial planning has been very limited in countries including Pakistan (Hussnain, 2013; Mayo et al., 2006). Although, GIS utilization in spatial planning preparation has increased in the last decade. For example, recent plans of Lahore, Multan, Karachi employed GIS mapping techniques (CDG, 2007; NESPAK, 2004, 2012); whereas digital data has become an integral part of the plan-making process. Punjab Municipal Development Fund Company (PMDFC) has used GIS to digitalize land use data and create land use maps for many sub-districts and cities (100+ tehsils) (Iqbal, 2016). These applications have, however, been intermittent and less structured. GIS use in spatial planning has been mostly associated with capturing and digitalizing data and mapping to visualize existing and proposed land-use demarcations. Until recently, a relatively more advanced GIS application in PUSP has been related to the land-use suitability analysis in Faisalabad, the third-largest city in Pakistan with more than 3.2 million population (Government of Pakistan, 2018). This PUSP appears to be the first spatial plan in Pakistan where the term SDSS (spatial decision support system) has been used and an ArcGIS-Model Maker based tool has been used to perform land suitability analysis (The Urban Unit, 2015). Another rare example where a formal planning support system has been used in the Muzaffargarh PUSP which has employed the Online What If? (OWI) PSS for spatial plan making (Hussnain et al., 2017, 2019; Wakil, Hussnain, Yusuf, et al., 2016). Although these two plans provide early examples of digital planning tools in the form of GIS-based PSS in Pakistan. A review of both academic and grey literature in Pakistan and identified a paucity of documented planning studies which utilize GIS-based PSS and hence it can be summarized that the overall practice of spatial planning in Pakistan suffers from a very low utilization of such digital planning tools to support data driven planning and evidenced based city policy.

This research answers the question of why there is digital planning tools' utilization gap in spatial planning of Pakistan and how that can be bridged. It explores the current status of the utilization of digital planning tools in plan making, identifies the gaps and documents the underlying impeding factors from both demand and supply side. Finally, it provides a framework to improve the current situation.

2. Materials and methods

This research follows a case study approach focusing on the state of play of digital planning tools across Pakistan with a three-prong method to dissect various dimensions of the subject research question. Under the first stream, the PUSP documents have been reviewed to understand the current state of planning practice vs digital planning tools usage. Under the second stream, primary data has been collected from practising urban planners about their perceptions regarding digital planning tools' utility and reasons behind the current utility level. Those open-ended responses have been analyzed for grouping and categorized as per Vonk's (2006) classes which are explained in more detail later in the paper. Similarly, under the third stream, legal requirements for peri-urban plan making have been reviewed to identify planning stages where digital planning tools can meaningfully fit-in to improve quality. The research framework is diagrammatically presented in Fig. 1.

First, this paper outlines the key PUSP making stages in the light of regulatory documentation (the Land-use Classification, Reclassification and Redevelopment Rules, 2009). It links the PUSP making stages with the proven applications of digital planning tools. This objective has

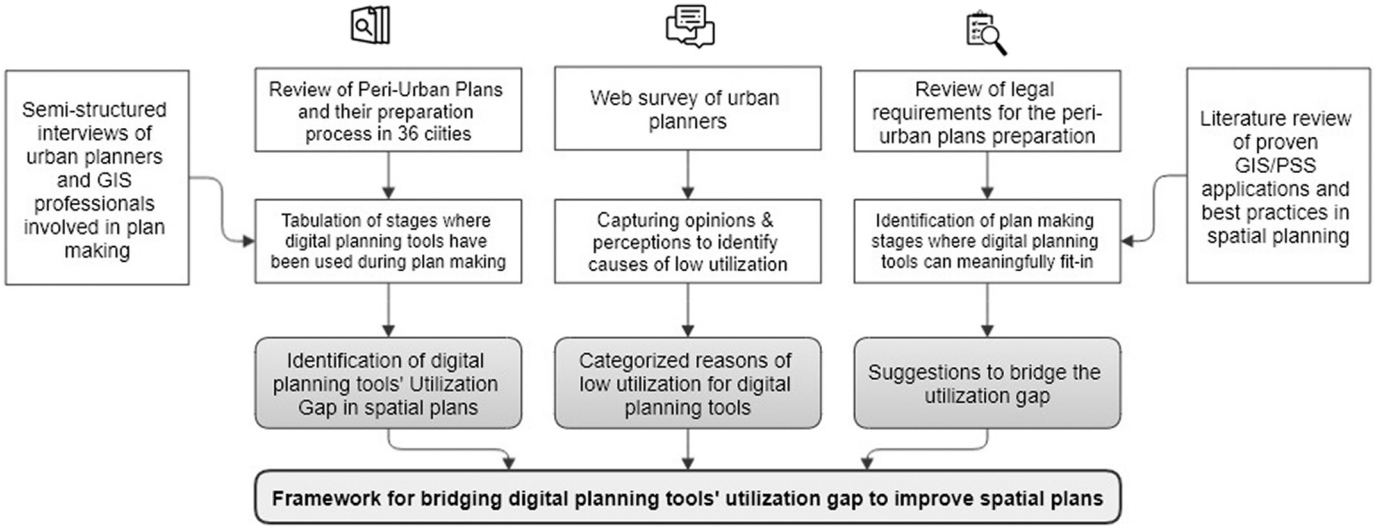

Fig. 1. Research framework.

been achieved by adapting the *task-technology fit* framework concept used by many researchers for explaining and exploring the usefulness of PSSs (Pelzer et al., 2015; Vonk, 2006; Vonk & Geertman, 2008; Vonk, Geertman, & Schot, 2005).

To assess the current utilization of digital planning tools in the plan-making, a detailed review of the peri-urban structure plans (PUSP) of 36 cities of Punjab (developed between 2010 and 2016) has been conducted. These represent the 100% of the plans developed since the enforcement of Punjab Land use rules, 2009. Since the plans are neither available at a single place nor in the form of a digital database repository. Hence, these have been collected from the respective authorities in hard copy format. This study focuses only on the plan-making process and tabulates the stages where GIS has been used. Looking at the PUSP preparation stages and Yeh's model (Yeh, 1990) of GIS integration in urban planning, the utilization of GIS has been explored primarily in the critical stages of PUSP preparation including a) base map preparation, b) data collection, c) spatial Analysis of existing situation, d) suitability analysis, e) land-use allocation and f) visualization. From each plan, methodology section was reviewed against a checklist to note down if and how the digital planning tools have been used at the given six stages. Furthermore, the evidence of usage was triangulated from the later sections of these plans. For example, if a PUSP mentions that the GIS has been used in its base map preparation; that base map must exist in the upcoming sections of the document.

The web survey tool was designed to capture experience-based opinions from the practising urban planners who have been involved in various spatial plans preparation (including PUSPs) exercises. While designing the survey form, the findings of earlier researches (Revilla & Ochoa, 2017) about survey length, the attractiveness of questions, visual appeal, placement of trap questions, and respondents' trust about data anonymity have been duly considered. The survey tool has been designed and deployed online using Google Forms (Google, 2017). To reach the respondents, the list of registered town planners was obtained from Pakistan Council of Architects and Town Planners (PCATP); the federal regulatory authority for registering professional town planners in Pakistan. A total of 128 registered planners were contacted through personalized emails to achieve higher response rate. Resultantly, the responses were received from 108 urban planners.

In the survey, the respondents were presented with a set of 36 mixed open and close-ended questions and statements to describe their opinions. The first part covered the respondent's profile (experience, type of organization, job nature, and level of involvement in spatial planning etc.) while the next part covered their experience of digital planning tool contribution to spatial planning practice. Factors affecting utilizations have been listed under three main categories adapted from Vonk's research (Vonk & Geertman, 2008) including 'User acceptance', 'Instrument quality' and 'Diffusion (match between technology and planning task)'. Respondents could rate their level of agreement on a Likert scale ranging from 'strongly disagree', 'disagree', 'neutral/don't know', 'agree' to 'strongly agree'.

Based on the inferences, a framework is suggested to bridge the utilization gap and to eventually improve the quality of spatial plans.

3. Results and discussions

3.1. Legal requirements for peri-urban structure plan preparation

Land-use management in peri-urban areas is governed by the Punjab Land-use Rules, 2009 (Classification, Reclassification, and Redevelopment). The sections 25 to 31 provide key stages and ingredients for the preparation of peri-urban structure plan (PUSP) (The Urban Unit, 2009; Hameed & Nadeem, 2011; Hussnain et al., 2017). The rules instruct to initiate the process with the preparation of a base map using satellite imagery which should be used for conducting a baseline survey to capture existing land-uses information. Furthermore, the boundaries of established built-up area and approved housing schemes are earmarked on the map.

Secondly, it advises demarcating the external boundary of the peri-urban area considering the direction and trend of the urban sprawl, population growth rate and land requirements for the next twenty years. Later, it refers that the PUSP must have proposed road networks, division of the area into blocks and the proposed land uses for various blocks. Finally, the rules ask for the public consultation by inviting objections or suggestions from the public on the salient features of the plan and by organizing a public hearing. Such hearing may lead to the objections and queries from the public which may call for adjustments in previous stages.

The sequence followed during the peri-urban plan preparation process is illustrated in Fig. 2. The feedback loops represent the changes in any highlighted stage which may occur due to the findings or outputs of subsequent stages.

Although the regulations suggest steps for the formulation of PUSPs along with the underlying needs for the use and adoption of GIS and/or PSS. However, no specific and categorical direction is present which can justify and emphasize the need for the use of computer-assisted tools. In summary, these rules are neither emphasizing nor they are preventing the adoption of digital planning tools. In contrast, Houghton and Russo have found that even in developed counties like Australia,

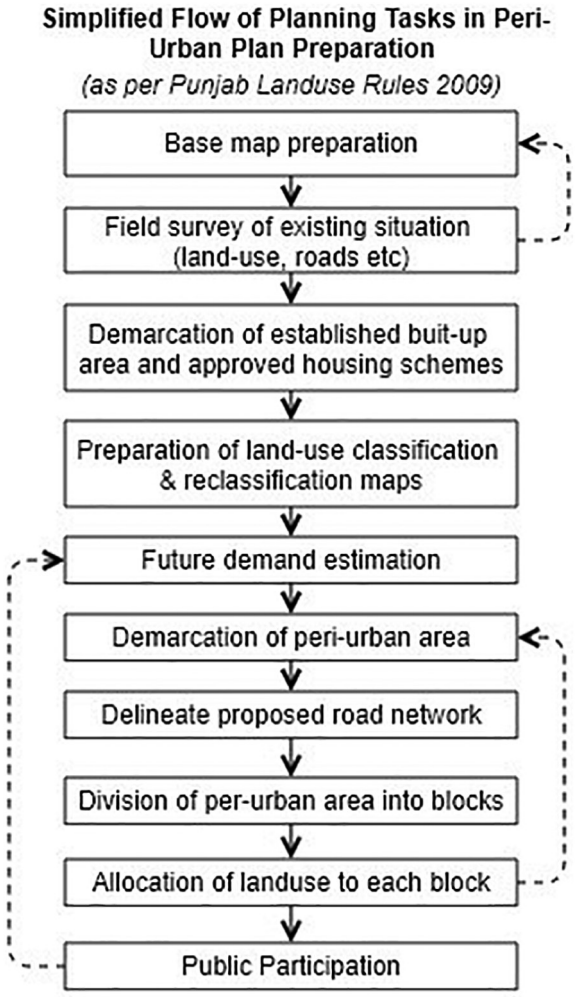

Fig. 2. Simplified flow of peri-urban structure plan preparation process.

planners felt that the regulations had bound them not to go for innovative tools and stay within tightly controlled processes (Houghton, Miller, & Foth, 2014).

Considering the enlisted tasks, a thorough review of the literature has been done. Table 1 presents the list of relevant researches where digital planning tool has been used to perform tasks very similar to the PUSP task requirements.

It is evident that the legal requirements for peri-urban plan making offer enough potential space for the application of digital planning tools (demand side) and on the other hand, there are tested tools to respond to the given need.

3.2. Current level of GIS utilization in peri-urban plan-making

In Pakistan, peri-urban structure plans have been prepared by a variety of institutions, having varied human resources and capacities, including city district government (CDG), private consultants, development authorities (DA) and tehsil municipal administration (TMAs). So far most of the peri-urban structure plans have been prepared by the private consultants. Moreover, most of these plans were initiated in the year 2011. Fig. 3 shows the location of urban areas where PUSPs have been prepared.

A schematic view of digital planning tools' utilization in all the PUSPs under study is presented in Fig. 3. The analysis reveals that all 36 plans have used GIS for the preparation of base maps where satellite images have been used to derive block level or parcel level vector datasets to represent land use, as well as water bodies, road network, and other infrastructure lines. Similarly, all these plans have used GIS to visualize the data and create thematic maps.

In contrast, only 64% (n = 23) plans have used digital planning tools in data collection which mostly includes the use of GIS-based parcel/block-level maps in land-use data collection, collection and management of locational information of points of interest (public buildings, education, health etc.) using GPS, demarcation of civic infrastructure, collection and identification of right of ways.

A relatively lower proportion of plans (n = 22) has benefited from digital planning tools during the spatial analysis of the existing situation. At this stage, most of the PUSPs have used GIS to understand the spatial distribution of various land-uses, their concentration or deficiency in spatial terms, or highlighting potential and constraints for development in different locations.

Allocation of future land-uses to pre-defined blocks of land is an integral stage of PUSP preparation which requires land suitability and land-use allocation analysis. However, the use of digital planning tools on these stages is extremely low. So far only two plans (Faisalabad and Muzaffargarh PUSPs) have used GIS-based land suitability analysis to identify the most suitable locations for various future land uses, while only one (Muzaffargarh PUSP) has used a further advanced land-use allocation analysis to allocate most competitive land-use to defined blocks.

Fig. 4 provides a graphical summary of this discussion and highlights the digital planning tools' utilization gap. It is worth mentioning that the level of utilization at each stage has varied among different PUSPs depending upon preparing agency, team capacity and availability of financial and time resources. Furthermore, the use of digital planning tools has been very intermittent, non-goal oriented, less structured and, targeting merely at the visualization purposes.

This finding can be correlated with the provisions available under legal rules as well. Chapter 3, section 20 of Land-use Rules, 2009 (The Urban Unit, 2009) has recommended the use of satellite images for base maps preparation. Resultantly, GIS use in base map preparation has been very high in that stage as compared to any other stage.

3.3. Planners' perception and reasons for low utilization of digital planning tools in plan preparation

In terms of the respondents' characteristics, 52% (n = 56) have been from government organizations, 29% (n = 31) from private consulting firms and 19% (n = 21) from academic institutions. Furthermore, 30% of these respondents had more than 10 years of experience, 34% had 5–10 years of experience while 36% had 5 or fewer years of experience (Table 2).

3.3.1. Planner's familiarity with GIS versus PSS

The analysis reveals that familiarity of planners with the term 'planning support systems' is far too less (36%) as compared to familiarity with GIS (96%). Out of these respondents, only 31% have read about PSS, merely a 9% have used any PSS as a demo while only 4% have implemented a PSS in a real-life project. These findings are aligned with the other recent studies conducted in the developed world. The challenge of low awareness was initially highlighted by Vonk a decade ago and has been recently re-emphasized by Russo (Russo, 2017; Vonk et al., 2005). However, the planners' familiarity with GIS and its applications in urban planning reflects a positive picture where the values for these indicators are on a comparatively higher side as seen in Fig. 5. It has been observed that most of the senior urban planners serving at the management positions in the development authorities are not familiar with GIS or PSS and its applications in real planning tasks. These facts can be triangulated with the academic courses being taught to urban planners of Pakistan in public and private universities. Throughout the country, only five universities are offering graduation while seven are offering masters level accredited courses in urban planning. However, GIS for urban planning related subjects have

Table 1
Potential digital planning tools' applications in peri-urban plan preparation.

Tasks	Peri-urban structure plan making requirements	Potential applications of digital planning tools
1	Base map preparation using satellite imagery	Digital data (parcels/blocks, roads linear network, infrastructure lines etc.) preparation using 0.6 m resolution Imagery (Adeel, 2010; Bhalli, Ghaffar, & Shirazi, 2012; Christiane, Petropoulou, & Hirsch, 2005; Xiao et al., 2006) Demarcation of administrative boundaries and service areas (Delamater et al., 2012; Park, 2012; Sherman et al., 2005; Upchurch et al., 2004)
2	Conducting a field survey to collect existing land uses	Land use information and collection of point data of landmarks using GPS devices (Hussnain et al., 2014) Optimized zoning for sample data collected to avoid Modifiable Areal Unit Problem (MAUP) e.g. To prevent bias when point-based measurement such as population density is aggregated into districts. (Lembo et al., 2006; Páez & Scott, 2005)
3	Marking boundaries of the established built-up area and approved housing schemes on the base map.	Urban boundary delineation through temporal land cover analysis of Landsat images. Vectorization and cleaning. (Adeel, 2010; Brook & Davila, 2000; Christiane et al., 2005; Jat, Garg, & Khare, 2008; Sudhira, Ramachandra, & Jagadish, 2004; Xiao et al., 2006)
4	Demarcate external boundary of the peri-urban area based on: direction and trend of the urban sprawl; population growth rate; and requirements of urban development for the next twenty years.	Directional distribution (Standard Deviational Ellipsoid) analysis Urban compactness analysis (Adeel, 2010; Angel & Sheppard, 2005; Bhalli et al., 2012; Christiane et al., 2005; Xiao et al., 2006)
5	Proposed road networks	Roads proximity analysis, (Chang, Parvathinathan, & Breeden, 2008; Xu et al., 2015) Proposed road impact assessment (Blair, Hine, & Bukhari, 2013; Li et al., 1999; Ortega, Otero, & Mancebo, 2014)
6	Division of peri-urban area into blocks	Multicriteria analysis (e.g. area limit, no water body crossing etc.) (Dahal & Chow, 2014; Xu et al., 2015; Yang et al., 2008)
7	The proposed land uses for various blocks	Land suitability analysis for various uses (Adeel, 2010; Duc, 2006; Javadian, Shamskooshki, & Momeni, 2011; Pettit et al., 2015; Yang et al., 2008) Land-use Allocation analysis (Duc, 2006)
8	Public participation	Public participation GIS (PPGIS) for master plan preparation process (Kahila-Tani et al., 2016)

been introduced very recently (since 2007). It is important to highlight that the courses such are "Introduction of GIS" and "Applications of remote sensing and GIS" being offered in urban planning schools are still limited to introducing primary software (such as ArcGIS, QGIS) with conventional contents, rather than the introducing planning support systems as theory and practice. Resultantly, most of the student find a gap between what they have learnt and what is needed to resolve a practical problem. Eventually, the awareness in planners about the PSS tools and their capabilities remains very limited. None of the universities is offering any course designed around the usage and application of planning support systems. This fact gets triangulated with the results presented in Fig. 7. Again, this aligns with the findings from Russo on education in relation to PSS (Russo, Lanzilotti, Maria F. Costabile, et al., 2018) (Fig. 6).

3.3.2. *Causes and perceptions about low utilization of digital planning tools*

Investigation into the causes of low utilization in spatial planning reflects that the planners in Pakistan consider 'instrument quality' related factors to be the biggest bottlenecks where every factor got an average agreement of 72%, followed by 'diffusion' related factors (Avg. agreement of 62%) and then the factors associated with 'user acceptance' (52%). Furthermore, the top five bottlenecks include the unavailability of comprehensively integrated digital planning tools, data hungriness of tools, the mismatch between GIS-based planning and top-down nature of planning decision, unavailability of geospatial data on urban themes, and unavailability of academic course on PSS in urban planning degree programs (see Fig. 7).

In terms of the overall causes listing, the specific causes identified in our research are quite aligned with the overarching findings presented by Vonk et al. where they discussed the challenges toward the widespread usage of planning support systems (Vonk et al., 2005; Vonk & Geertman, 2008). However, their findings put 'user experience with PSS' and 'user awareness about the potential of PSS' to be the top reasons, followed by the 'accessibility to the system' and 'attitude/ intentions to use'. They believe that the negative attitude to try PSS may be a result of 'transparency of the system, user-friendliness of system'. We consider these aspects under 'instrument quality'. A prominent reason resulting in the reverse order of importance may the background of survey participants (developed country vs developing country.

Analysis under 'Instrument Quality' domain reflects that 86% of the planners believe that comprehensively integrated digital planning tools are not available for planners. They believe that routine planning tasks require the use of multiple tools/function which are generally distributed in multiple generic software tools. The hassle of switching between software tools and data formats reduces the interest of users to adopt digital planning tools for planning tasks. Similarly, the vast majority of planners (80%) believe that using digital planning tools for planning tasks is too data-hungry. In Pakistan where availability of spatial data on urban themes is very limited, usage of digital planning tools drops significantly since the planners find it very challenging to complete data needs of these tools to generate significant analysis. In addition to this, 69% have a perception that digital planning tools cannot really support planners in planning decision and assume that GIS applications are limited to map making and visualization support only rather than more subjective and complex planning decisions. Furthermore, 55% of the respondent planners believe that available digital planning tools are not user-friendly. Their graphical interfaces, icon sets, and models are difficult to comprehend and not all planners can spare time to dive into detailed user manuals to understand and run digital planning tools for a given task. Eventually, it reduces the adoption of digital planning tools in day to day tasks. It must be interesting to compare these findings with the recent works of Russo (Russo, 2015; Russo, 2017; Russo, Lanzilotti, Costabile, et al., 2018b). Russo Agreeing to the importance of factors associated with instrument quality, she has progressed on PSS 'user interface' evaluation, which is an integral part of instrument quality.

Under the domain of 'User Acceptance', seven key reasons have been identified behind the low GIS utilization. These include a) the unavailability of urban geospatial data (79%), b) unavailability of forums to discuss digital planning tools' applications in local context (71%), c) lack of awareness about availability of tools (57%), d) lack of access to well-integrated planning related spatial analysis tools (49%), e) existence of believing that manual planning is more creative than GIS-based allocations (44%), f) lack of expertise on GIS and its usage in planning (32%) and g) the lack of willingness to use digital planning tools for planning tasks (22%). Some of these findings can be contrasted with Russo's results. While developing an inventory of PSS tools, she has identified 108 digital planning tools through various sources (AURIN,

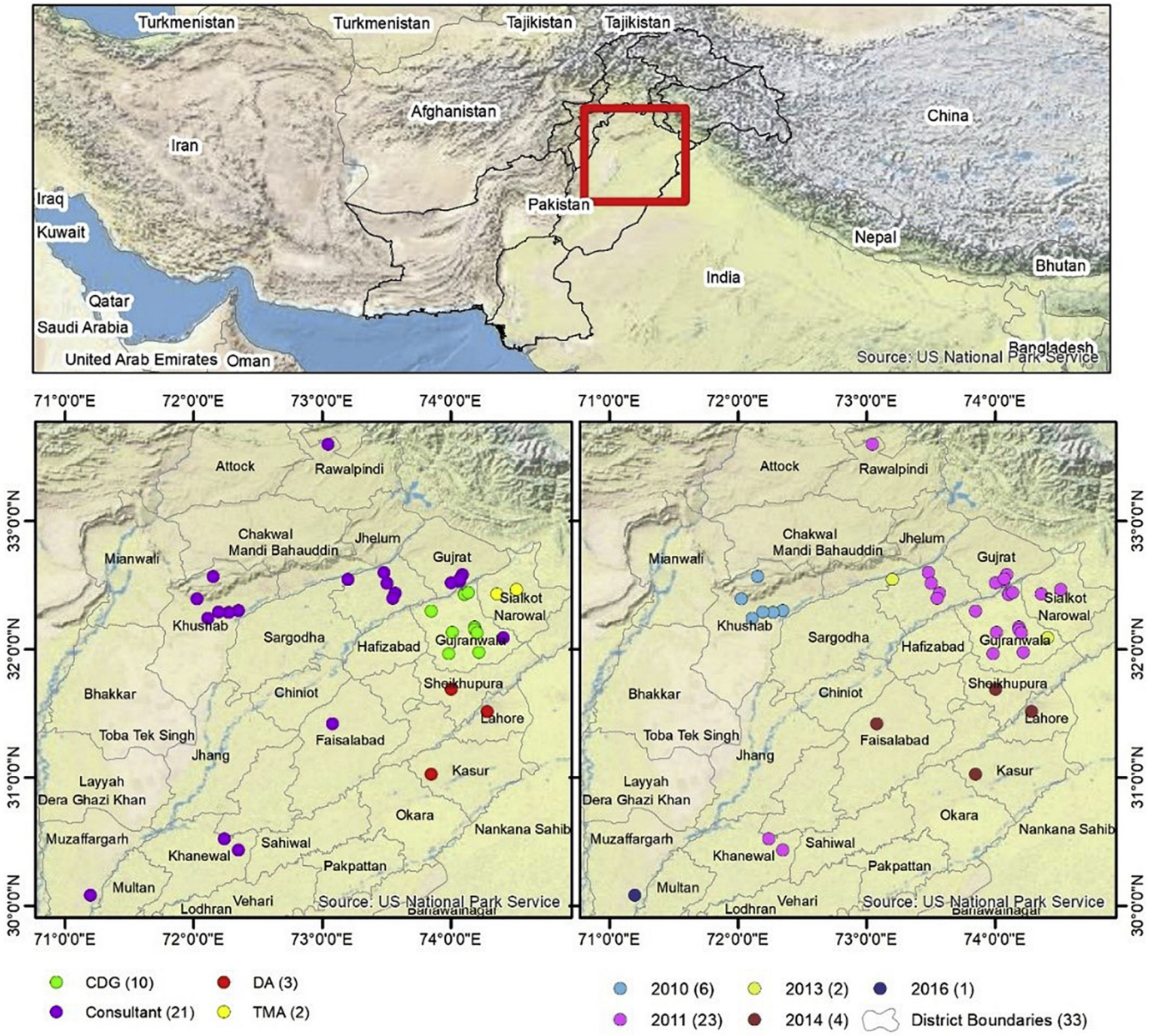

Fig. 3. Location of urban areas where PUSP has been prepared in Punjab, Pakistan (Left: categorization by 'preparing agency'. Right: categorization by 'initiation year').

2015), out of which only 50 could have a valid URL, making them hardly accessible to users. She summarized that 26% of the PSS were intended for academic purposes only, 11% were for adoption in a specific area (i.e. not easily adaptable to other geographies). She believed that almost a third of the nineteen PSS have not been designed for professional use. While commenting about the 'tools availability', she has documented that many PSS were not designed for professional planners or their adoption required specific skills and knowledge, and most of the PSS didn't followed a system development approach making them hardly fitting to planners' requirements.

Another interesting finding is that the absence of forums to discuss digital planning tools' applications and local case studies has appeared as a highly agreed reasons behind the low utilization. Although global knowledge is now widely available and reasonably accessible but still planners find it difficult to relate with their localized urban problems. Similarly lack of access to good quality digital planning tools for planning is also one of the major stumbling blocks. Respondent believes that most of the good tools are available in the form of commercial products which are not widely available in academic or professional institutions. This reason is very closely related to another reason which is the lack of awareness about the availability of tools. Previously Fig. 5 has expressed the low familiarity of responding planners with PSS. This triangulates the reason why the level of awareness about the variety of available tools and their functional capacities has been reflected by most of the planners.

4. Recommendation to bridge digital planning tools' utilization gap

Enhancing the utilization of digital planning tools in the spatial planning process remain a challenge yet there are promising signed in an era of Smart Cities digital planning tool such as GIS and PSS are beginning to see wider adoption in the use of evidence-based planning and policy-making (Pettit et al., 2018). Even in the developed world,

City/ Location (plan prepared by, year)	Plan Preparation Stages					
	Base map preparation	Data collection	Spatial Analysis of existing situation	Suitability analysis	Landuse allocation	Visualization
Muzaffargarh (Cons, 2016)	✓	✓	✓	✓	✓	✓
Faisalabad City (Cons, 2014)	✓	✓	✓	✓		✓
Sheikhupura (DA, 2014)	✓					✓
Pattoki (DA, 2014)	✓					✓
Raiwind (DA, 2014)	✓					✓
Malakwal (Cons, 2013)	✓	✓	✓			✓
Ferozwala (Cons, 2013)	✓	✓	✓			✓
Sambrial (TMA, 2011)	✓					✓
Sialkot (TMA, 2011)	✓	✓	✓			✓
Gujranwala City (CDG, 2011)	✓	✓				✓
Rawalpindi City (Cons, 2011)	✓	✓	✓			✓
Wazirabad (CDG, 2011)	✓					✓
Kamonke (CDG, 2011)	✓					✓
Nowshera Virkan (CDG, 2011)	✓					✓
Rasul Nagar (CDG, 2011)	✓					✓
Ghakhar (CDG, 2011)	✓					✓
Eminabad (CDG, 2011)	✓					✓
Sodra (CDG, 2011)	✓					✓
Alipur Chattah (CDG, 2011)	✓					✓
Qila Didar Singh (CDG, 2011)	✓					✓
Mandi Bahauddin (Cons, 2011)	✓	✓	✓			✓
Mangat (Cons, 2011)	✓	✓	✓			✓
Phalia (Cons, 2011)	✓	✓	✓			✓
Qadirabad (Cons, 2011)	✓	✓	✓			✓
Gujrat (Cons, 2011)	✓	✓	✓			✓
Jalalpur Jattan (Cons, 2011)	✓	✓	✓			✓
Kunjah (Cons, 2011)	✓	✓	✓			✓
Shadiwal (Cons, 2011)	✓	✓	✓			✓
Mian Channu (Cons, 2011)	✓	✓	✓			✓
Tulamba (Cons, 2011)	✓	✓	✓			✓
Khushab (Cons, 2010)	✓	✓	✓			✓
Jauharabad (Cons, 2010)	✓	✓	✓			✓
Hadali (Cons, 2010)	✓	✓	✓			✓
Mitha Tiwana (Cons, 2010)	✓	✓	✓			✓
Quaidabad (Cons, 2010)	✓	✓	✓			✓
Naushera (Cons, 2010)	✓	✓	✓			✓

Fig. 4. Digital planning tools' utilization in the preparation of peri-urban structure plans.

Table 2
Respondents profile.

Organization type	Qualifications in urban planning	Experience in years			Grand total
		Up to 5	6–10	More than 10	
Academic		11	3	7	21
	BSc	*5*			*5*
	MSc	*6*	*2*		*8*
	PhD		*1*	*7*	*8*
Government		18	27	11	56
	BSc	*8*	*13*	*2*	*23*
	MSc	*10*	*14*	*9*	*33*
Private firms		10	7	14	31
	BSc	*6*		*2*	*8*
	MSc	*4*	*7*	*10*	*21*
	PhD			*2*	*2*
Grand Total		37	39	32	108

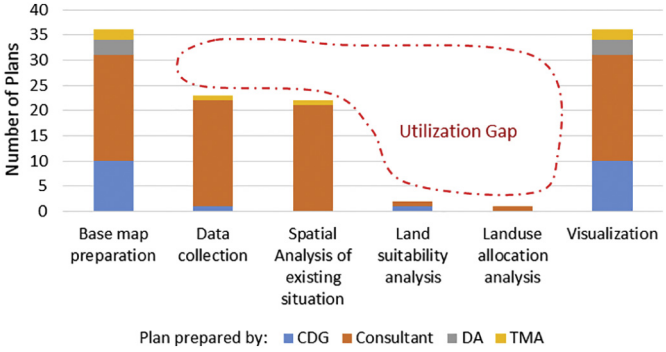

Fig. 5. Number of peri-urban structure plans using digital planning tools at various preparation stages.

this process has taken a considerably long time. Learning from international examples and discussions with senior professionals, a three-tier framework has been proposed (see Fig. 8). The very first tier encompasses the *factors creating an enabling environment* to support digital planning tool' utilization, including good governance with unbiased

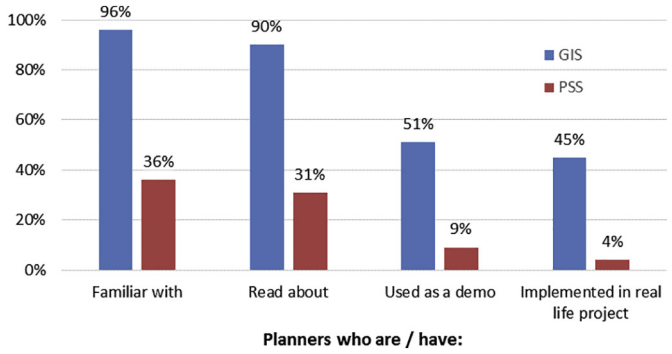

Fig. 6. Familiarity of Planners with GIS vs PSS (n = 106).

political support, shared vision with the urge for informed decision making in urban planning, supportive legal framework, and availability of geo-spatial resources on urban themes

The second tier contains the *key stakeholders and actors* including academia, state planning agencies, planning professionals and digital tool developers and private planning agencies. These are the stakeholders who either lead the spatial planning process, fund the spatial planning tasks, approve the planning products or execute the planning proposals. In the case of Pakistan, academia would include the universities offering courses on urban planning and GIS. State planning agencies would include development authorities, city district government, local governments, and policy & planning units. Planning professionals refer to the registered urban planners practising in either government or private sectors. While the private planning agencies refer to the registered firms enrolled with PCATP and authorized to undertake spatial planning projects. Without the active engagement of these actors, the goal of optimum PSS utilization cannot be achieved.

The third tier of the framework enlists the *actions* required from the *actors* on short to long term basis. These actions can be classified under five major branches focusing on raising awareness, enhancing data availability, introducing PSS in academic courses, supporting research on PSS related topics, developing forums to share local case studies and increasing access to PSS tools.

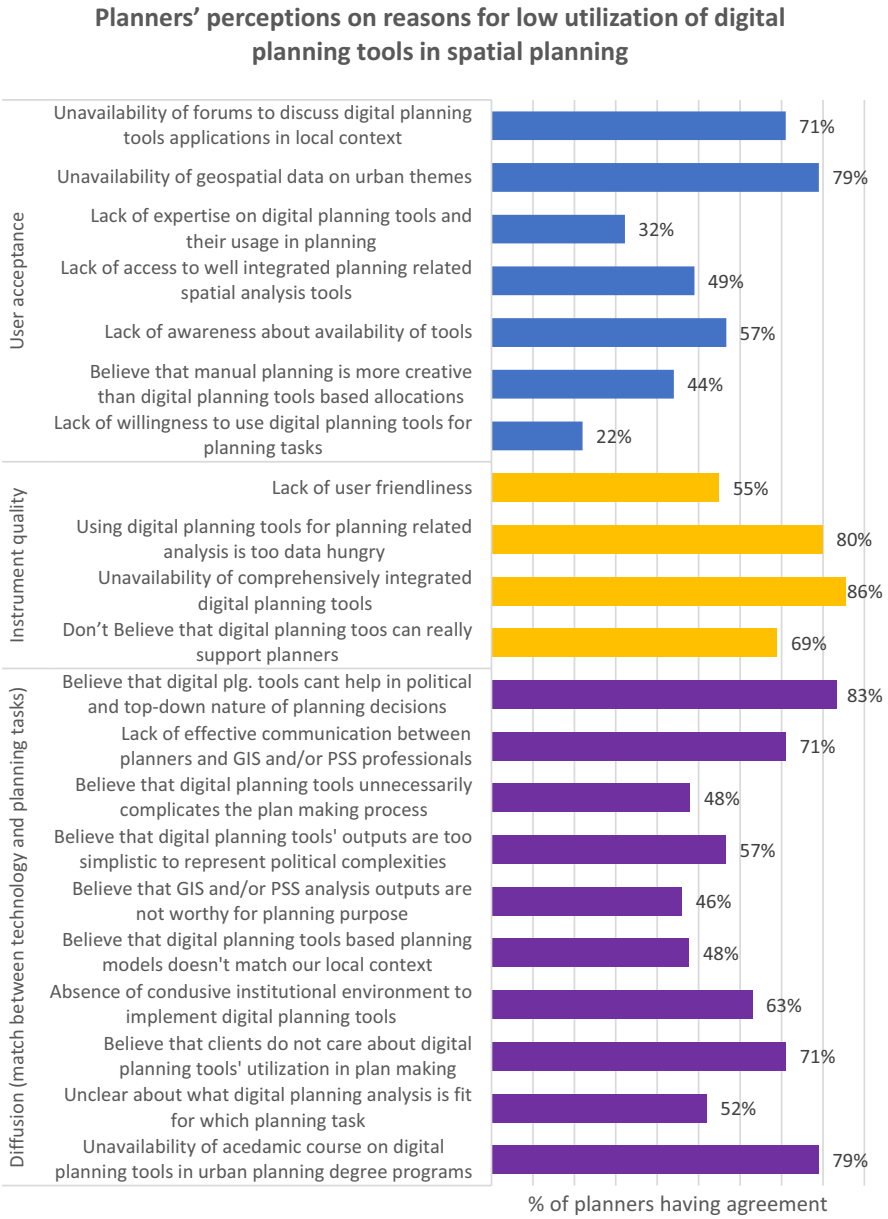

Fig. 7. Planners' perceptions and reasons for low utilization of digital planning tools in plan preparation (Note: Digital planning tools refer to GIS and/or PSS tools).

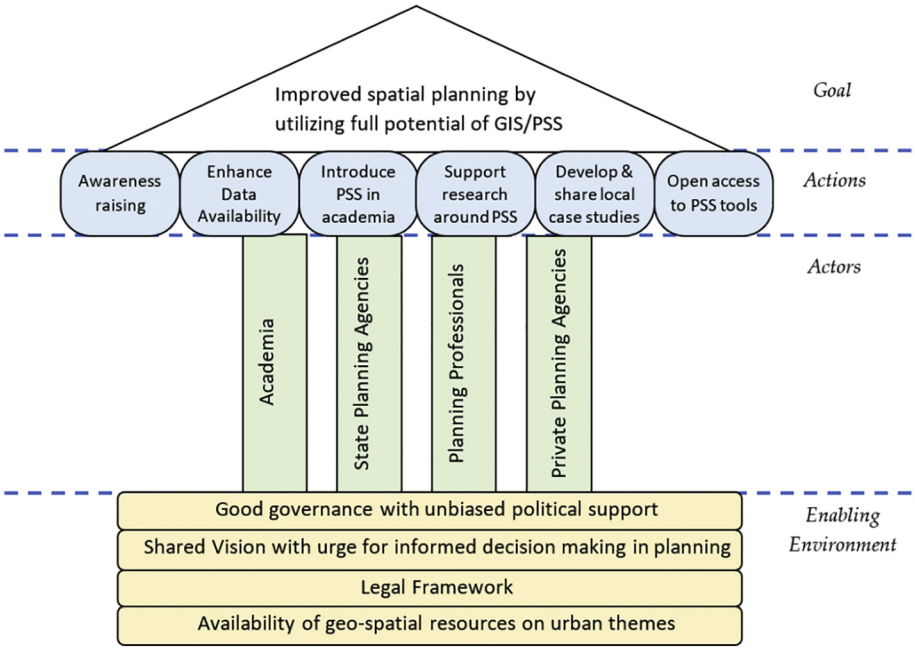

Fig. 8. Framework to bridge digital planning tools utilization gap.

4.1. Raise awareness

Majority of the reasons contributing to the low utilization of digital planning tools have their roots related to the lack of understanding and knowledge about the availability of PSS tools and their capabilities to ease and improve the spatial planning process. Such perception-based reasons can be effectively tackled by creating awareness among the stakeholders. There is a need to propagate about the presence of tools and their abilities to help professionals in planning tasks.

Academic and professional conferences are a useful way of propagating the newly developed tool or sharing applications of the previous ones. Government has recently prioritized its focus for disruptive technologies by declaring funding under the Presidential Initiative for Artificial Intelligence & Computing (PIAIC)(GoP, 2019). Such policy shifts on enhancing the applications of artificial intelligence, machine learning and big data will expectedly have a positive contribution to the spread of PSS. From academia, National University of Sciences and Technology (NUST) has demonstrated an interest in developing and propagating PSS tools for the past few years. Very recently, University of Management and Technology (UMT) has offered a workshop series for professional planners on 'managing cities with geo-spatial technologies' along with the launch of 'Future Cities Initiative'. As a result of these interventions, a new community of PSS users has taken birth with more than 50 graduate students who are using Online WhatIf? PSS in their academic assignments. On the industry side, organizations like City Pulse have been recently establishing portals on planning support systems (https://citypulse.com.pk/pss) with the aim of enhancing access of planners to the available tools. As far as financial support for the awareness-raising is concerned, academia may fetch funds from two low hanging fruits; prime minister's initiative and HEC's conference funding while international financial support can be obtained from various urban-related SDG initiatives. Similarly, the industry can meet their financial needs from their corporate social responsibility and advertisement budgets or by adopting public-private partnership models which are in practice for similar awareness-raising tasks.

4.2. Enhance data availability

Deficiency of open geospatial data on urban themes has also been highlighted as a major stumbling block. Although in Pakistan, some forums (like PakistanGIS (CityPulse, 2018)) exist which share the geospatial data on urban themes in the open domain. However, there is a need to enhance the data supply from the government and the private sector. The data of urban themes lies with government bodies such as development authorities, local governments and professional consulting firms such as the Urban Unit (UU), NESPAK, MMP, Shehersaaz, City Pulse, Master Consultants, Usmani and Graana.com etc. For instance, datasets on urban limits and administrative cadastral boundaries are available with UU; NESPAK and MMP has wealth of geospatial data generated as a result of urban master planning exercises across Pakistan; City Pulse undertook a year-long initiative to generate locational data on streets, points of interests and land uses for many intermediate to small cities; similar efforts have been made by TPLMaps. Most recently, Graana.com has completed building polygonal database of urban properties in all major cities. Punjab Intermediate Cities Improvement Investment Program (PICIIP) possesses geospatial data on social services infrastructure. As of now, all these datasets stay in isolation, with different level of restricted availability to the public. Debate on the establishment of national spatial data infrastructure (NSDI) has been under discussion for last many years where government organizations like Survey of Pakistan (SoP) have taken the lead under the legal cover of Surveying and Mapping Act, 2014 (SoP, 2014). However, progress has been too slow to produce results. SoP has conducted a series of stakeholder conferences and workshop to initiate raising awareness on the subject. Very recently, a web portal has been launched (http://nsdi.gov.pk/), however, no data has been populated on the portal yet. The effective execution of 'the right of access to information act' (GoP, 2017) can help to ensure the conditional availability of urban data to the public.

On the other hand, the situation of data availability is far better in the developed part of the world, still 'opening access to data' has been identified as a major area of focus by Lincoln Institute of Land Policy (LILC)(Holway et al., 2012). Due to the increasingly available data in technologically advanced countries, informatics and big data supported PSS are being developed at a relatively rapid pace. If enough measures are not taken to enhance data availability in developing countries, the adoption gap may get further wider day by day. Increasing availability and quality of data and decreasing acquisition costs will eventually improve the PSS development and usage. Holway believes that access to data can be enhanced without any intensive resources and may be

started by convincing public and private organizations to share their data for reuse. Falco et al. have recommended the use of 'infostructure' approach to improve urban services with the support of open data. They believe that providing access to even small datasets acts as a seed to grow larger open data sharing communities (Falco et al., 2018). Developing countries may benefit from the adaption and replication of urban data sharing model of platforms such as the Australian Urban Research Infrastructure Network (AURIN).

4.3. Introduce PSS in academic courses

Currently, planning institutions are offering introductory courses on GIS and its applications. Those courses are mostly limited to the basic level of GIS tasks, data generation, mapping and visualization using the primary level software, especially ArcGIS. None of the university in Pakistan is offering any course about PSS in urban planning or GIS related departments.

Looking at the development and progression of academic programs in neighbouring countries, we can infer that most of the short courses or long terms programs started as a combination of GIS and urban planning. Later, as the PSS knowledge stream evolved, more specialized courses emerged in two ways; a) as short-term high-end stand-alone courses, b) as elective courses in graduation or post-graduate study course. For instance, many academic institutions in India, especially, Indian Institute of Technology (IIT), Global Initiative on Academic Network (GIAN) and Indian Institute of Remote Sensing (IIRS) have been offering basic to advanced courses focusing of the application of digital planning tools in urban planning. However, a deeper look at the curriculum reveals that majority of them focuses on capacitating urban planners about the basic of GIS and RS. Some short courses by IIRS such as 'Geospatial Technologies for Smart City Planning' give a deeper dive to the digital planning tools. As compared to India, the evolution of academic programs in China appears more structured where researchers have tried to observe the evolution and direct the path of merging the two fields. For instance, Qi-ming has been discussing the setup of core courses around GIS in Chinese universities (Qi-ming, 2003), while Fuling and others have also documented the problems, innovations and development of GIS in higher education of China (Fuling, Shaohua, et al., 2008). On the other hand, Chapin has reviewed the core curricula of more than 60 programs from various urban planning schools in North America and discussed the reasons behind the slow adoption of GIS in core urban courses. Furthermore, he has documented potential recommendations to improve academic courses with minimal disruption to the existing programs. (Chapin, 2003). LeGates has studied the incorporation of GIS in urban curricula across the United States. After documenting the exemplary, replication worthy courses, he has prescribed an instructional module for adopting GIS in urban studies. (LeGates, 2006)

In contrast, technically advanced countries have been offering richer contents on planning support systems. A few examples include the University of New South Wales (Australia) offering 'Digital Cities' and 'Programmable Cities'; The University of Melbourne (Australia) offering 'Urban Informatics', the Griffith University has 'Urban Analysis', the University of Michigan (USA) has 'Public Sector Scenario Planning: Theory and Practice', the University of Southern Maine offers 'Land Use Modeling and Visualization', the University of Utah (USA) has 'Scenario Planning in Envision Tomorrow Plus' and the Cornell University has 'Cities, Place, Technology' (Goodspeed, 2015). All these courses expose students to hands-on practice with planning support systems, rather than primary GIS tools. In Pakistan, there is a dire need to improvise the existing curricula of planning schools and enrich them with the latest advancement in the field of PSS and associated disruptive technologies.

Recently, NUST has initiated adapting courses on PSS with financial support from the Higher Education Commission (NRPU's 2017 grants) (HEC, 2019). Similarly, University of Engineering and Technology (UET) has expressed its interest to revise curricula for graduate students which are in process of approval from the academic body of PCATP.

Introduction of PSS related courses in planning departments will create grass-root level understanding in the professional planners. Once trained with hands-on experience, they will not feel alienated with the application of these digital planning tools in spatial planning. For practising planners, consultants and allied professionals, PCATP can offer professional development courses.

4.4. Support research around PSS

Currently, it is rare to find Pakistan based research about PSS and its applications. There is a dire need to divert the focus of research on this area so that the future challenges of urbanization can be tackled in a systematic way. Academia can play a strong role in this theme and can focus on developing more localized PSS and GIS tools for urban planning considering the local norms and regulations.

Recent works by Hussnain et.al have indicated the need for developing PSS which use local urban planning and development control regulations and policy conditions as part of their knowledge module. This is particularly useful because physical planning standards and developmental control regulations in Pakistan may considerably differ from the developed countries. Resultantly, the baseline parameters used in 'imported PSS tools' do not always help in problem-solving. Hence, the research work may adopt two streams; a) implementing already developed PSS in local context and exploring their usefulness in national context and b) developing new tools to response local planning problems such as the PSS tools for the impact evaluation of housing projects, PSS to find suitable land for Prime minister's 5million houses project without compromising the agriculture land, PSS for property evaluation and PSS for evaluating comparative neighborhood designs.

4.5. Develop forums to share local applications and case studies

Just like other technologies, there are only a few lead learners and early adopters for PSS as well. A major factor affecting user acceptance has been the unavailability of forums to share digital planning tools' applications in the local context. There is a need to generate and document local case studies and share them on those forums. At the global level, examples of such forums exist in the form of 'Consortium of scenario planning (LILP, 2018) and AURIN (AURIN, 2014). A similar mechanism should be adopted for Pakistan to generate awareness, share knowledge and capacitate planners with PSS use.

A consortium of academia, industry and government; lead by academia and financed by industry can work in Pakistan's context. By virtue of authors' interactions with urban planning schools, it is perceived that academia is getting more and more conducive to lead such initiatives. For shorter span, funds can be sought from government research initiatives such as PIAIC and industry while for long term more sustained funding can be explored by engaging with CSR funding of local industry or with global initiatives such as Cities and Climate Change Initiative (CCCI) and City Prosperity Initiative (CPI) by UN-Habitat or Consortium for Scenario Planning by LILC etc.

4.6. Open access to digital planning tools

Opening access to digital planning tools is very much dependent on their open availability at the global level and in developed countries where PSS development and associated research is at a well advanced stage. Although not all are well documented, there have been examples of localized PSS tools (Hussnain et al., 2016, 2017; Hussnain & Wakil, 2006; Wakil, Hussnain, Naeem, et al., 2016) which are not well disseminated even at the national level. Steps should be taken to open access to those tools and share them for wider adoption. In the advanced world, similar findings have been presented by Pettit and Russo (Russo et al., 2018a) to enhance the usability of PSS tools.

Initially, the responsibility of opening access would stay with the

academia which has been the developers of the tools so far. Later, when the industry gets engaged in PSS application and development, advocacy can be done with developers to open access for wider users.

4.7. Improve legal and institutional setup

The current legal documents which provide the basis for the formulation of spatial plans in Pakistan need to be strengthened in a way that the need for information-based decision making should be clearly chalked out. In the absence of explicit guidelines, the adequate usage of digital planning tools cannot be ensured. For example, the plan-making regulations should clearly state the need for data-backed planning proposals and information-based analysis. More specifically, Land use Rules and regulations of relevant development authorities may clearly mention the use of scenario planning tools when deciding about future land use allocations. Similarly, the impact evaluation of proposal spatial plan should be backed by the PSS tools.

Similarly, in the institutional setup of development controlling authorities, urban planners with a comprehensive understanding of digital urban science should be inducted to meet the upcoming challenges. In terms of institutional setup, no structural changes are required to enhance adaptation of digital planning tool. However, the quality of human resources in urban planning sections must be improved. This can be achieved by engaging more skilled planners who are well versant with PSS science. While hiring the new staff in development agencies or local bodies, the due balance should be achieved by engaging urban planning or GIS professionals who have experience/ expertise with digital planning tools so that the organizations remain well equipped to handle the future disruptive technologies.

5. Conclusion

Peri-urban spatial planning is one of the instruments being implemented in Pakistan to face the challenge of rapid urbanization. In Punjab, Punjab Land-use Rules, 2009 provides the legal framework under which 36 PUSPs have been prepared so far by various development control agencies. This research highlights the tasks from the Land-use Rules, 2009 and explains how digital planning tools can be applied for those tasks. It has been found that although the rules provide an umbrella framework for plans formulation, however, no specific directions are present to emphasize or hinder the usage of digital planning tools. Since there is a clear mention of GIS in base map preparation, the overall utility of GIS in the plan preparation stages is very high. From the review of PUSPs, it has been found that, in past few years, the use of GIS in spatial plan-making has increased but it is still limited to the base map preparation, data collection and basic visualizations. There exists huge utilization gap at stages requiring relatively advanced analytical analysis including land suitability, land-use allocation, alternate comparison, community consultations, review and evaluation.

Major reasons behind this gap include the unavailability of comprehensively integrated GIS tools coupled with lack of awareness among planners, data hungriness of digital planning tools during planning related spatial analysis attached with unavailability of geospatial data on urban themes, the mismatch between GIS-based planning and top-down nature of planning decision, and unavailability of academic course on PSS in urban planning degree programs. Although in terms of the level of detail, many of the findings are new, yet they are aligned with the findings of researchers from advanced countries. The research recommends a series of measure to improve the situation which is not only applicable to Pakistan's context but can potentially benefit other developing countries with a similar level of technological advancement. These measures include raising awareness about the availability of digital planning tools, enhancing data availability, introducing digital planning tools in academic courses and supporting research on them, developing forums to share local applications & case studies, enhancing access to tools and improving the legal and institutional setup. Since the planning conditions in Pakistan are very similar to the other developing countries (rapid urbanization pressure, less democratic planning process, data deficiency, lack of awareness and access to digital planning tools and many more), it is believed that the findings of this research will equally benefit other developing countries of similar geospatial context.

References

Adeel, M. (2010). Methodology for identifying urban growth potential using land use and population data: A case study of Islamabad Zone IV. *Procedia environmental sciences. 2. Procedia environmental sciences* (pp. 32–41). Elsevier.

Ahmad, N. (2012). *Development plan practices to manage spatial growth in major cities of Pakistan a case study of Peshawar City*. Lahore: University of Engineering and Technology. Retrieved from http://prr.hec.gov.pk/Chapters/1671S-0.pdf.

Angel, S., & Sheppard, S. (2005). *The dynamics of global urban expansion, Transport and Urban.* https://doi.org/10.1038/nature09440.

Anjum, G. A. (2008). Assessment of urban land development and management practices in five cities of Punjab. Lahore. Retrieved from http://www.urbanunit.gov.pk/PublicationDocs/28.pdf.

Arciniegas, G., Janssen, R., & Rietveld, P. (2013). Effectiveness of collaborative map-based decision support tools: Results of an experiment. *Environmental Modelling & Software, 39*, 159–175. https://doi.org/10.1016/j.envsoft.2012.02.021.

AURIN. Online Planning Support Systems Resource. (2014). Retrieved from http://docs.aurin.org.au/projects/planning-support-systems/ Accessed: 10 September 2015.

AURIN (2015). Online Planning Support System Resource. Retrieved from https://docs.aurin.org.au/projects/planning-support-systems/.

Batty, M. (1995). Planning support systems and the new logic of computation. *Regional Development Dialogue, 16*(1), 1–17.

Bhalli, M. N., Ghaffar, A., & Shirazi, S. A. (2012). Remote sensing and GIS applications for monitoring and assessment of the urban sprawl in Faisalabad-Pakistan. *Pakistan Journal of Science, 64*(3), 203–208.

Blair, N., Hine, J., & Bukhari, S. M. A. (2013). Analysing the impact of network change on transport disadvantage: A GIS-based case study of Belfast. *Journal of Transport Geography, 31*, 192–200 Elsevier.

Boardman, P. (1978). *The worlds of Patrick Geddes : Biologist, town planner, re-educator, peace-warrior.* London; Boston: Routledge and K. Paul.

Brail, R. K., & Klosterman, R. E. (2008). *Planning support Systems for Cities and Regions.* Cambridge: Lincoln Institute of Land Policy.

Brömmelstroet, M., et al. (2013). Do planning support systems improve planning ? Testing the claim in a controlled experiment. *Planning Support Systems for Sustainable Urban Development,* 1–21.

Brook, R. M., & Davila, J. D. (2000). *The peri-urban interface: A tale of two cities.* School of Agricultural and Forest Sciences, University of Wales.

CDG (2007). Karachi Strategic Development Plan 2020. Karachi. Retrieved from https://www.scribd.com/doc/6788059/Karachi-Master-Plan-2020.

Chang, N.-B., Parvathinathan, G., & Breeden, J. B. (2008). Combining GIS with fuzzy multicriteria decision-making for landfill siting in a fast-growing urban region. *Journal of Environmental Management, 87*(1), 139–153 Elsevier.

Chapin, T. S. (2003). Revolutionizing the Core: GIS in the planning curriculum. *Environment and Planning B: Planning and Design, 30*(4), 565–573. https://doi.org/10.1068/b12993.

Christiane, W., Petropoulou, C., & Hirsch, J. (2005). Urban development in the Athens metropolitan area using remote sensing data with supervised analysis and GIS. *International Journal of Remote Sensing, 26*(4), 785–796. https://doi.org/10.1080/01431160512331316856.

CityPulse. PakistanGIS. (2018). Retrieved from www.citypulse.com.pk/pakistangis Accessed: 1 January 2018.

Dahal, K. R., & Chow, T. E. (2014). A GIS toolset for automated partitioning of urban lands'. *Environmental Modelling & Software, 55*, 222–234 Elsevier.

Delamater, P. L., et al. (2012). Measuring geographic access to health care: Raster and network-based methods. *International Journal of Health Geographics/BioMed Central, 11*(1), 1.

Duc, T. T. (2006). Using GIS and AHP technique for land-use suitability analysis. *International Symposium on Geoinformatics for Spatial Infrastructure Development in Earth and Allied Science* (pp. 1–6). .

Falco, E., et al. (2018). Smart city L'Aquila: An application of the "Infostructure" approach to public urban mobility in a post-disaster context. *Journal of Urban Technology, 25*(1), 99–121. https://doi.org/10.1080/10630732.2017.1362901 Routledge.

Fuling, B., Shaohua, W., et al. (2008). Problem, innovation and development of GIS higher education in our country'. *Proceedings of the International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Citeseer. 37. Proceedings of the International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Citeseer* (pp. 269–272).

Geertman, S., et al. (2015). *Planning Support Systems and Smart Cities.* S. Geertman et al. Springer.

Geertman, S., & Stillwell, J. (Eds.). (2003). *Planning support Systems in Practice.* Heidelberg: Springer.

Goodspeed, R. (2015). *Scenario Planning Course Development Guide.*

Google. Google forms. (2017). Retrieved from https://www.google.com/forms/about/ Accessed: 2 December 2018.

GoP (2017). The Right of Access to Information Act, 2017. Pakistan. Retrieved from http://www.na.gov.pk/uploads/documents/1506960942_594.pdf.

GoP (2019). Presidential Initiative for Artificial Intelligence & Computing (PIAIC). Retrieved from https://www.piaic.org/.

GOP, M (2015). National Report of Pakistan for HABITAT III. Islamabad. Available at http://unhabitat.org/wp-content/uploads/2015/04/Pakistan(National Report).pdf.

Government of Pakistan, G (2018). *6th population and housing census 2017 (provisional results)*. Islamabad: Pakistan Bureau of Statistics. Retrieved from http://www.pbscensus.gov.pk/.

Hameed, R., & Nadeem, O. (2011). Punjab land use classification, reclassification and redevelopment rules: A predicament or new approach to urban management. *Ali, 4*(67), 67–76.

HEC (2019). National Research Program for Universities. Retrieved from https://www.hec.gov.pk/english/services/universities/nrpu/Pages/Introduction.aspx.

Holway, J., et al. (2012). Opening access to scenario planning tools, Policy Focus Report. Cambridge. Available at https://www.lincolninst.edu/pubs/2027_Opening-Access-to-Scenario-Planning-Tools.

Houghton, K., Miller, E., & Foth, M. (2014). Integrating ICT into the planning process : impacts, opportunities and challenges. *Australian Planner, 51*(1), 24–33. https://doi.org/10.1080/07293682.2013.770771 Taylor & Francis.

Hussnain, M. Q. (2013). *A study on the utilization of information and communication Technology in Preparation and Implementation of development plans: A case study of Rawalpindi.* Lahore: University of Engineering and Technology.

Hussnain, M. Q., & Wakil, K. (2006). *A handbook of Planner's key*. Lahore: University of Engineering and Technology, Lahore Retrieved from http://citypulse.com.pk/publications/HAND_BOOK_OF_PLANNER's_KEY.pdf.

Hussnain, M. Q., et al. (2014). Improving efficiency in data collection for urban development plans through information and communication technology. *International Conference on Town Planning and Urban Management (ICTPUM). Lahore*.

Hussnain, M. Q., et al. (2016). A planning support system to optimize approval of private housing development projects. *IOP Conference Series: Earth and Environmental Science, 37*, 012050. https://doi.org/10.1088/1755-1315/37/1/012050.

Hussnain, M. Q., et al. (2017). A planning support system to aid spatial planning in Pakistan. *15th International Conference on Computers in Urban Planning and Urban Management (CUPUM2017)*. Adelaide, Australia: University of South Australia.

Hussnain, M. Q., et al. (2019). Application of the online WhatIf? Planning support system in Peri-urban spatial planning; case study of Muzaffargarh, Pakistan. In M. Schrenk, V. V. Popovich, P. Zeile, P. Elisei, C. Beyer, & J. Ryser (Eds.). *24th international conference on urban planning and regional development in the information society, 2019, Karlsruhe, Germany* (pp. 77–87). .

Iqbal, I. (2016). *Critical evaluation of the Punjab municipal services improvement program.* Lahore: University of Engineering and Technology.

Jan, B., Iqbal, M., & Iftikharuddin (2008). Urbanization trend and urban population projections of Pakistan using weighted approach. *Sarhad Journal of Agriculture, 24*(1), 173–180. Available at http://www.aup.edu.pk/sj_pdf/Urbanizationtrend and rban population projections of pakis.DOC.pdf Accessed: 15 May 2016 .

Jat, M. K., Garg, P. K., & Khare, D. (2008). Monitoring and modelling of urban sprawl using remote sensing and GIS techniques. *International Journal of Applied earth Observation and Geoinformation, 10*(1), 26–43 Elsevier.

Javadian, M., Shamskooshki, H., & Momeni, M. (2011). Application of sustainable urban development in environmental suitability analysis of educational land use by using AHP and GIS in Tehran. *Procedia Engineering, 21*, 72–80 Elsevier.

Kahila-Tani, M., et al. (2016). Let the citizens map—Public participation GIS as a planning support system in the Helsinki master plan process. *Planning Practice and Research, 31*(2), 195–214. https://doi.org/10.1080/02697459.2015.1104203.

Kamps, S., & Tannier, C. (2008). A planning support system for assessing strategies of local urban planning agencies. *6th International Conference of Territorial Intelligence: Tools and methods of Territorial Intelligence. Besançon* (pp. 10). doi: 10.1000.

Kim, Y. M., Jaesung, B., & Kim, H. S. (2012). A planning support system as a tool for sustainable urban planning. In M. Schrenk, (Ed.). *Proceedings REAL CORP 2012. Schwechat* (pp. 1111–1119). .

Klosterman, R. E., & Pettit, C. J. (2005). An update on planning support systems. *Environment and Planning B: Planning and Design, 32*(4), 477–484. https://doi.org/10.1068/b3204ed.

LeGates, R. (2006). GIS in US urban studies and planning education. *CalGIS Annual Meeting* (pp. 4–7). .

Lembo, A. J., et al. (2006). Use of spatial SQL to assess the practical significance of the modifiable areal unit problem'. *Computers & Geosciences, 32*(2), 270–274 Pergamon.

Li, X., et al. (1999). GIS based map overlay method for comprehensive assessment of road environmental impact. *Transportation Research Part D: Transport and Environment, 4*(3), 147–158 Elsevier.

Li, Y., & Jiao, J. (2013). Comparative analysis of three planning support software (PSS) programs and current applications of planning support system in China. *Proceedings from the 13th international conference on computers in urban planning and Urban Management, Utretch, Netherlands* (pp. 1–20). .

LILP. Consortium for Scenario Planning. (2018). Retrieved from http://www.scenarioplanning.io/ Accessed: 12 December 2018.

Mayo, S. M., Zaidi, S. S., & Hussain, M. (2006). Assessing potentials of RS and GIS based intelligent master planning approach against conventional master planning practices for disaster afflicted difficult areas: A case study of Bagh town, Azad Jammu and Kashmir. *2006 International Conference on Advances in Space Technologies* (pp. 108–112). . https://doi.org/10.1109/ICAST.2006.313808.

NESPAK (2004). Integrated Master Plan for Lahore 2021. Lahore. Retrieved from http://uu.urbanunit.gov.pk/Documents/Publications/0/99.pdf.

NESPAK (2012). Integrated Master Plan for Multan (2008–2028). Multan. Available at http://www.mda.gop.pk/images/MMP-Vol-1.pdf.

Nilsson, K., et al. (2013). *Peri-urban futures: Scenarios and models for land use change in Europe, Peri-Urban Futures: Scenarios and Models for Land use Change in Europe.* https://doi.org/10.1007/978-3-642-30529-0.

Ortega, E., Otero, I., & Mancebo, S. (2014). TITIM GIS-tool: A GIS-based decision support system for measuring the territorial impact of transport infrastructures. *Expert Systems with Applications, 41*(16), 7641–7652 Elsevier.

Páez, A., & Scott, D. M. (2005). Spatial statistics for urban analysis: A review of techniques with examples. *GeoJournal, 61*(1), 53–67 Springer.

Park, S. J. (2012). Measuring public library accessibility: A case study using GIS. *Library & Information Science Research, 34*(1), 13–21 Elsevier.

Pelzer, P., et al. (2014). The added value of Planning Support Systems: A practitioner's perspective. *Computers, Environment and Urban Systems, 48*, 16–27. https://doi.org/10.1016/j.compenvurbsys.2014.05.002 Elsevier Ltd.

Pelzer, P., et al. (2015). Planning support systems and task-technology fit: A comparative case study. *Applied Spatial Analysis and Policy, 8*(2), 155–175. https://doi.org/10.1007/s12061-015-9135-5.

Pettit, C., et al. (2018). Planning support systems for smart cities. *City, Culture and Society, 12*(November 2017), 13–24. https://doi.org/10.1016/j.ccs.2017.10.002 Elsevier.

Pettit, C. J. (2005). Use of a collaborative GIS-based planning-support system to assist in formulating a sustainable-development scenario for Hervey Bay, Australia. *Environment and Planning B: Planning and Design, 32*(4), 523–545 SAGE Publications.

Pettit, C. J., et al. (2013). *The online what if? Planning support system. 195*, Springer107–125. https://doi.org/10.1007/978-3-642-37533-0.

Pettit, C. J., et al. (2015). The online what if? Planning support system: A land suitability application in Western Australia. *Applied Spatial Analysis and Policy, 8*(2), 93–112. https://doi.org/10.1007/s12061-015-9133-7.

Qi-ming, Q. (2003). Discussion on the Core courses setup of GIS major in Chinese universities. *Geomatics World, 4*.

Revilla, M., & Ochoa, C. (2017). Ideal and maximum length for a web survey. *International Journal of Market Research, 59*(5), 557–565. https://doi.org/10.2501/IJMR-2017-039.

Russo, P. (2015). Investigating usability of planning support systems and improving their adoption and use by land use planners. In: *Proc.of CHItaly 2015 Doctoral Consortium, Rome(Italy)* (pp. 67–76). .

Russo, P. (2017). *Usability of planning support systems : Analysing adoption and use in planning practice.* The University of Melbourne.

Russo, P., Lanzilotti, R., Costabile, M. F., et al. (2018a). Towards satisfying practitioners in using planning support systems. *Computers, Environment and Urban Systems, 67*, 9–20. https://doi.org/10.1016/j.compenvurbsys.2017.08.009 Elsevier Ltd.

Russo, P., Lanzilotti, R., Costabile, M. F., et al. (2018b). Adoption and use of software in land use planning practice: a multiple-country study. *International Journal of Human-Computer Interaction, 34*(1), 57–72. https://doi.org/10.1080/10447318.2017.1327213 Taylor & Francis.

Sherman, J. E., et al. (2005). A suite of methods for representing activity space in a healthcare accessibility study. *International Journal of Health Geographics, 4*(1), 1 BioMed Central.

SoP (2014). Surveying and Mapping Act 2014. Pakistan. Retrieved from http://www.na.gov.pk/uploads/documents/1397721138_588.pdf.

Sudhira, H. S., Ramachandra, T. V., & Jagadish, K. S. (2004). Urban sprawl: Metrics, dynamics and modelling using GIS. *International Journal of Applied Earth Observation and Geoinformation, 5*(1), 29–39 Elsevier.

The Urban Unit (2009). *The Punjab Land-use (Classification, Reclassification and Redevelopment) Rules'.* Lahore: Local Government & Community Development Department. Available at http://www.punjabcode.punjab.gov.pk/public/dr/THEPUNJAB LAND USE RULES 2009.doc.pdf.

The Urban Unit (2015). Faisalabad Peri-urban Structure Plan 2035. Lahore. Retrieved from http://pcgip.urbanunit.gov.pk/docs/DLIs/DLI5/FPUSPReport.pdf.

Timmermans, H. (Ed.). (1997). *Decision support Systems in Urban Planning.* London: E & FN SPON.

United Nations (2014). *World urbanization prospects: The 2014 revision.* New York, Unitedhttps://doi.org/10.4054/DemRes.2005.12.9.

United Nations (2015). *World population prospects: The 2015 revision.* United Nations. New Yorkhttps://doi.org/10.1017/CBO9781107415324.004.

Upchurch, C., et al. (2004). Using GIS to generate mutually exclusive service areas linking travel on and off a network. *Journal of Transport Geography, 12*(1), 23–33 Elsevier.

Vonk, G., & Geertman, S. (2008). Improving the adoption and use of planning support Systems in Practice. *Journal of Applied Spatial Analysis and Policy, 1*(3), 21. https://doi.org/10.1007/s12061-008-9011-7.

Vonk, G., Geertman, S., & Schot, P. (2005). Bottlenecks blocking widespread usage of planning support systems. *Environment and Planning A, 37*(5), 909–924. https://doi.org/10.1068/a3712.

Vonk, G. A. (2006). Improving planning support - the use of planning support systems for spatial planning. Retrieved from http://dspace.library.uu.nl/handle/1874/8576.

Wakil, K., Hussnain, M. Q., Naeem, A. M., et al. (2016). Regulating outdoor advertisement boards; employing spatial decision support system to control urban visual pollution. *8th IGRSM International Conference and Exhibition on Geospatial and Remote Sensing.* IOP Conference Proceedings: Kuala Lumpur.

Wakil, K., Hussnain, M. Q., Yusuf, A., et al. (2016). *Project report: Scenario planning based participatory urban growth management plans using ICT, Islamabad*.

Xiao, J., et al. (2006). Evaluating urban expansion and land use change in Shijiazhuang, China, by using GIS and remote sensing'. *Landscape and Urban Planning, 75*(1), 69–80 Elsevier.

Xu, J., et al. (2015). GIS-modelling based coal-fired power plant site identification and selection. *Applied Energy, 159*, 520–539 Elsevier.

Yang, F., et al. (2008). Spatial analyzing system for urban land-use management based on GIS and multi-criteria assessment modeling'. *Progress in Natural Science, 18*(10), 1279–1284 Elsevier.

Yeh, A. G. (1990). Urban planning and GIS. *Geographical Information Systems, 2*, 877–888.

Zaidi, S. S.-H., & Mayo, S. M. (2006). Implementation of Master Plans in Punjab, Pakistan. In: *Proc. Gulf First Urban Planning and Development Conference, Kuwait. Kuwait* (pp. 20–22). .