# Challenges of Spatial Decision-Support Tools in Urban Planning: Lessons from New Zealand's Cities

Mirjam Schindler[1]; Rita Dionisio[2]; and Simon Kingham[3]

**Abstract:** Urban planning decision-makers face wicked problems and are required to make complex decisions regarding the functioning of cities. Spatial decision-support tools (SDSTs) have the potential to change the way decisions are being made and play an important role in shaping future cities. Yet decision-makers experience challenges around SDSTs. This article analyzes what lessons can be drawn for the wider community from New Zealand's urban planning context and SDSTs developed for New Zealand's cities on (1) how SDSTs might influence decision-making; (2) what the challenges are toward the appropriate adoption of spatial tools; and (3) how data, technical, and procedural issues may influence the adoption of SDSTs in planning practices. It contributes an integrated view, drawing from literature on complex systems, theories of sociotechnical interactions, and synoptic planning practices based on engagement, and a survey of urban planning stakeholders. The key challenges identified are around technological and user subjectivity and tailored recognition of local contexts. These can be addressed through flexible SDSTs developed with stakeholder engagement and by viewing SDSTs in a wider, spatial sociotechnical system to fully leverage their potential and ensure improved urban outcomes accounting for the local context.
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## Introduction

Contemporary urban planning faces an increasing number of wicked challenges at a range of scales, from global to local. Communities, planners, and decision-makers are required to make complex decisions regarding the life of cities in ever-changing environmental, social, and political contexts. Some of these planning challenges include the need to address population growth in cities without degrading the local environment, while promoting social and environmental sustainability, livability, health, and wellbeing. Conversely, there are also significant pressures to urban transformation, with the rise of national and transnational standards and the neo-liberalization of investment, construction, and material sectors across countries (Boddy et al. 1997; Yusuf et al. 2001; Narayana 2010). This poses a series of unprecedented challenges to urban planning, with varying degrees of scale and complexity. In the last few decades, attempts to address some of these issues have led to significant advances in urban planning, such as the rise of evidence-based practice and the advance of public participation frameworks. These new ways of doing planning have narrowed the gaps between urban planning practice, research, and community know-how (Faludi 2007; Krizek et al. 2009; Glackin and Dionisio 2016).

Conversely, the unprecedented rise of "big data" and open data is transforming urban planning, its methodologies, and practices. For example, real-time analysis of transport networks or bus routes offers the potential to optimize them (e.g., Pinelli et al. 2016). Urban modelling has also advanced due to the availability of new types of data to input into spatially and temporally scaled models (Long and Liu 2016). This has prompted technological advances in spatial decision-support tools (SDSTs) (e.g., Stevens et al. 2007; Chevalier et al. 2012; Schetke et al. 2012; Glackin et al. 2016), which has expanded the array of opportunities with respect to data collection, analytics, inter-organizational collaboration, and community engagement.

Despite these advances, the relevance of SDSTs for urban planning decision-making has been questioned because planners often rely on tools that may be inadequate (e.g., Uran and Janssen 2003), hindering the potential for collaborative planning due to practical limitations, and increased costs to implement them within local planning environments (e.g., Bagstad et al. 2013). Sometimes it can be just a lack of suitable, timely, and trustworthy data to input into the SDSTs (e.g., Timmermans 2005; Vonk et al. 2005; Chevalier et al. 2012). To address some of these limitations, planning authorities often allocate a considerable amount of resources to external services to obtain suitable evidence, and/or to access adequate SDSTs, or even to develop ad hoc strategies to make available data "fit" into local planning environments (Schindler et al. 2018). Yet the levels of influence of evidence-based practices in shaping decisions in urban planning remain discretionary in many planning systems across diverse political contexts (Carr and Dionisio 2017).

The case of Aotearoa New Zealand's urban planning, which we explore in this paper, is a good exemplar of some of these endemic planning issues. Like many places, urban planners and decision-makers are frequently confronted with complex urban challenges related to urban intensification, sustainable regeneration of inner city areas, and mixed-used development, while needing to improve urban wellbeing, socioeconomic equity, and walkability through

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**Fig. 1.** Key current wicked challenges for Aotearoa New Zealand's urban planning.

appropriate local urban forms (Fig. 1). While there is a general consensus on the need to achieve such urban planning outcomes in New Zealand's cities, and on the rationale behind such needs, there is not always consensus on how to achieve these outcomes, accounting for complex interdependencies between environmental, social, and economic components of urban planning. The availability of suitable data and adequate SDSTs is unevenly distributed across the country; larger local councils have far more resources, fit-for-purpose data, and access to external services for evidence-based practices, whereas smaller, rural, and peri-urban councils are often more constrained in their ability to access adequate SDSTs. There are also sociotechnical and organizational limitations across the spatial data system, which can hinder the collaborative potential in New Zealand's urban planning (see Schindler et al. 2018). Overall, it is difficult to anticipate the underlying complexity and interdependency between these urban challenges, and it is complex to use SDSTs in a systemic approach. While urban planning SDSTs, developed both within New Zealand and elsewhere, offer significant potential in supporting a better understanding of how these challenges can be best addressed, they also pose specific challenges of being appropriate to local contexts, improving decision-making, and yielding desired urban outcomes. Yet there is still limited knowledge about the use and implications of SDSTs in New Zealand's urban planning practices.

This paper aims to investigate what lessons can be drawn from New Zealand's urban planning for others on (1) how spatial planning tools might influence decision-making; (2) what the challenges are toward the adoption of appropriate spatial tools; and (3) how data, technical, and procedural issues may influence the adoption of tools in planning practices. A better understanding of these questions can help in advocating for appropriate guidelines and deeper forms of engagement in local planning practices, toward the adequate adjustment of SDSTs' standardized model approaches to local contexts, to improve both the decision-making processes and urban outcomes.

This article focuses on stakeholder perspectives to assess the needs and barriers in decision-making and planning processes, and add insights on the demand side of SDSTs. It focuses on *spatial* decision support tools because urban issues are inherently spatial and high spatial variability is observed in urban areas. The analysis is based on stakeholder engagement on a suite of SDSTs developed for Aotearoa New Zealand's cities as part of the National Science Challenge 11 (NSC11) "Building Better Homes, Towns and Cities: *Ko ngā wā kāinga hei papakainga*," and on an online survey distributed among key informants, including urban planners and decision-makers in local planning authorities.

While much of the relevant literature draws from findings in Europe and North America, the case study of this analysis is the spatial planning community in New Zealand. New Zealand's spatial planning differs due to the relatively small size of the country, its relatively short spatial planning history (e.g., Miller 2006), and its current planning paradigms advocating for synoptic and participatory planning approaches (McDermott 2016). New Zealand has a population of approximately 4.8 million (Statistics New Zealand 2017) distributed among the three main centers (Auckland, Wellington, and Christchurch) and a range of small cities with a population below 200,000. There is a population growth in many of the main urban areas, especially in the largest city, Auckland, leading to significant pressures on, among other issues, housing affordability and transport mobility (e.g., Austin 2016). New Zealand's spatial planning system is organized across three spatial scales (national, regional, and territorial) and around three key statutes: the 1991 Resource Management Act, which plays a key role in New Zealand's urban planning by promoting the sustainable management of natural and physical resources, and having opportunities for public participation in the planning system (New Zealand Legislation 2018); the 2002 Local Government Act, which provides the general framework and powers under which New Zealand's local authorities operate (New Zealand Legislation, 2018); and the 2003 Land Transport Management Act, which provides the system for national and regional transport strategy, planning and funding (New Zealand Legislation 2018). These features make New Zealand an interesting test case study for our research questions, whose findings can be valuable to other countries with much more complex planning systems. Further, issues such as scalability, transferability of modeling methodologies, adaptability of data models, and appropriateness of analytical outcomes, as are discussed in this paper, are relevant internationally.

The remainder of this paper is structured as follows. Next, the theoretical framework is discussed and the international literature reviewed with specific focus on the three research questions. The "Methodology" section explains the stakeholder engagement work and online survey. The "Case of Aotearoa New Zealand" section analyzes New Zealand's specific local context in light of the three research questions, with a particular focus on stakeholders' perspectives. The "Discussion: Local Context Matters" section provides a discussion, connecting the international literature and

the New Zealand case study, concluding with a set of recommendations for New Zealand and lessons for the wider community. Finally, the Conclusion resolves our research.

## Theoretical Framework

This research draws from three theoretical frameworks (Fig. 2), integrating a sociotechnical, computational, and planning perspective: the theory of sociotechnical interactions, complex systems theory, and the theory of synoptic and participatory planning.

Postmodern and contemporary urban planning has placed emphasis on rational models of planning in order to address complex urban challenges. Synoptic planning with its key elements of (1) goal-setting, (2) an emphasis on quantitative analysis, (3) evaluation of means against ends, and (4) identification of alternative policy options, and its further integration of participatory planning (Lane 2005) has shifted the planning paradigm toward a systems view. Furthermore, analyzing urban issues with a synoptic approach led to the rise of complex systems models. Treating cities as complex systems (Batty 2009a) staged the emergence of algorithmic approaches and modeling methodologies to analyze the complexity of systems (e.g., White et al. 2012). However, the theory of sociotechnical interactions (Clarke et al. 2006) addresses challenges around the uptake of technology in local practices. Vatrapu (2009) emphasizes that sociotechnical interactions involve technological intersubjectivity and user subjectivity, influencing the interaction of users with technologies, and the dynamics of groups interacting using technologies. Technology such as SDSTs can support interactional relationships between actors; yet users still affect the technological support and output. Clarke et al. (2006) highlight the cultural, organizational, interactional, and psychological context in which systems are used in order to establish trust in and dependability of technology.

This theoretical framework supports the research by providing the context on SDSTs in urban planning with a multifaceted approach (sociotechnological, computational, and planning). Furthermore, this research links these three strands of literature while examining the influence of spatial planning tools in local decision-making, the challenges toward the adoption of appropriate tools, and which issues may influence such practices (i.e., data, technical, and procedural). In the following sections, the relevant literature within this theoretical framework is reviewed in light of the three research questions.

## Urban Planning Decision-Support Tools and Associated Challenges in the Literature

### Interaction between Urban Planning Tools and Decision-Making

There is a wealth of different types of (S)DSTs, ranging from simple spreadsheets to GIS-based platforms (e.g., Randall et al. 2003; Coutinho-Rodrigues et al. 2011) and sophisticated spatially explicit modeling and simulation approaches (e.g., White et al. 2012; Gerber et al. 2018). In this paper, we follow Rutledge et al. (2007) in defining SDSTs as "integrated frameworks designed to help explore weakly-structured or unstructured problems characterised by many actors, many possibilities, and high uncertainty." (S)DSTs are being developed to store, organize, access, and process data and knowledge (e.g., Wang and Zou 2010), and to help with structuring complex problems and decisions (Rizzoli and Young 1997). Urban planning decision problems, such as in urban regeneration (Bottero et al. 2016), are unstructured problems with multiple actors, views, values, many possible outcomes, and high uncertainty. SDSTs can potentially facilitate structuring decision processes and making trade-offs explicit (Gamper and Turcanu 2007), providing a rational evaluation support to tackle complexity (Bentivegna 1995). Further, SDSTs are increasingly relevant owing to the need for holistic system approaches (e.g., Lombardi and Ferretti 2015) and change of scale by looking beyond a single building (Nault et al. 2018). The literature also refers to planning support systems (PSSs) when referring to SDSTs particularly used in the planning context, which are defined as "information frameworks that integrate the full range of information technologies useful for supporting the specific planning context for which they are designed" (Vonk et al. 2005). We prefer the more generally defined and widely used term, SDSTs.

Better (spatially explicit) visualizations enabled through many SDSTs are known to potentially facilitate collaboration (Grêt-Regamey et al. 2017), allowing the verification of the efficiency of choices

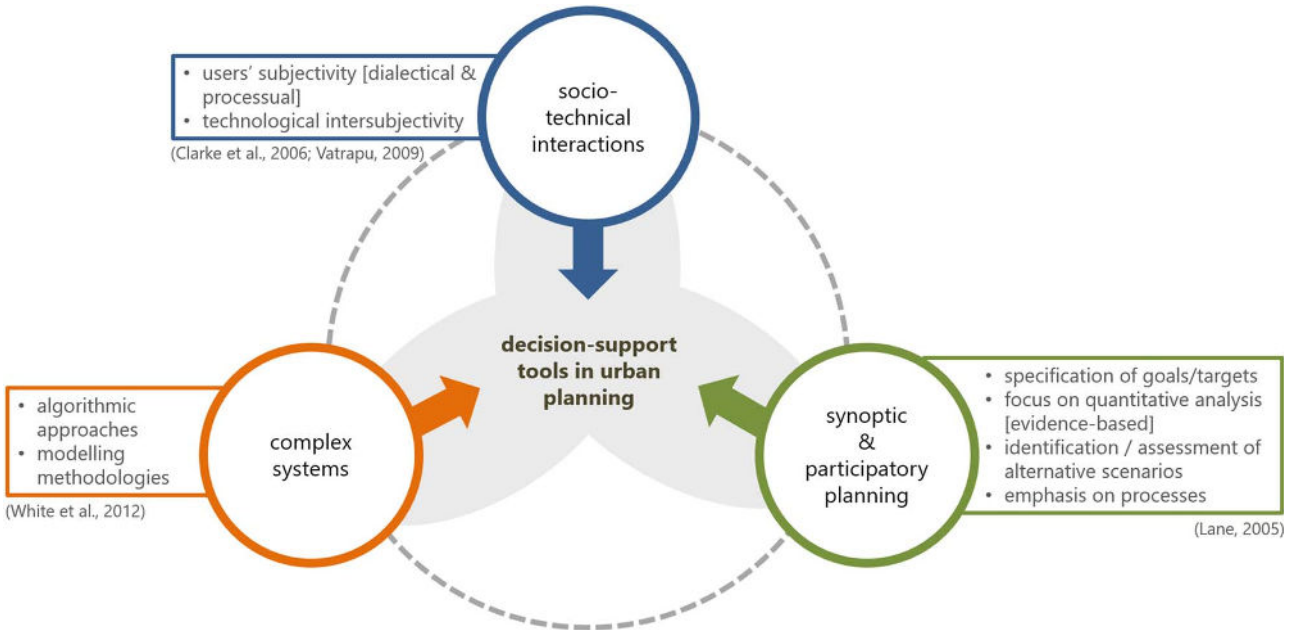


**Fig. 2.** Theoretical framework: positioning decision-support tools.



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through increased transparency and enhanced collective learning processes (Bentivegna 1995). They are essential tools that provide the opportunity to deliver more consensual and participative decision-making processes (Batty 2009b). They can be used to explore alternative futures, encourage public discourse via providing "virtual test beds" (Kim 2012), enabling storytelling (e.g., Batty and Torrens 2005; Couclelis 2005), and raise awareness of potential implications, positive and negative, that can support long-term decision-making (Kim 2012). For instance, the creation of scenarios in which urban regeneration targets can be adjusted to trade off diverse environmental, social, and economic costs and benefits can potentially be powerful engagement prototypes for decision-making, fostering the interest, involvement, and leadership of local stakeholders in planning processes (Dionisio et al. 2016).

Nutley et al. (2013) see another implication of SDSTs for decision-making in enabling evidence-based processes, allowing the revision of trends and targets, and having the potential to improve work functioning and quality. SDSTs allow for easier and faster data aggregation, analysis, and presentation (Nutley et al. 2013). Yet Eikelboom and Janssen (2017) emphasize that the choice of SDSTs influences decision-making in that it can yield different outcomes since, as Kim (2012) states, they are also social constructs that reflect a stakeholders' values and belief systems, and ultimately how problems are framed, and results interpreted. In addition, Kamps and Tannier (2008) argue that many SDSTs focus on the design and evaluation of possible urban solutions but that few focus on the evaluation and streamlining of the urban planning process itself.

This literature also supports that SDSTs are perceived as potential ways of better understanding wicked urban problems in urban areas as complex systems in line with a shift toward synoptic planning practices and the objective to increase participatory planning.

### Implementation of Urban Planning Tools

Despite considerable time, effort, and resources that are often spent on developing SDSTs (Uran and Janssen 2003; Rutledge et al. 2007), their implementation is often simply hindered by the tools being too expensive to buy, and/or time consuming, and/or complicated to understand (Loucks 1995). Thus, these issues can be showstoppers to the uptake and implementation of SDSTs (e.g., Bagstad et al. 2013). Furthermore, as Eikelboom and Janssen (2017) state, underlying values of stakeholders can result in different outcomes. Eyvindson et al. (2010) also see a challenge in accurately representing the preference of decision-makers in the use of SDSTs. These operational subjectivities (Vatrapu 2009) emphasize the need to make the information that informs SDSTs more explicit and less subjective in the implementation of SDSTs (Rounsevell and Metzger 2010).

Bagstad et al. (2013) explained another reason for the limited implementation of SDSTs, arguing that tools can vary significantly in their applicability to different locations and decision contexts, thus limiting their transferability and scalability. There is a trade-off to be made between scales of SDSTs: for example, a more generic SDST might be suitable at the national or regional scale but not at the local scale. SDSTs are in most cases not easily scalable, owing to a lack of generalization of inputs such as nonmonetary, social, and cultural perspectives across scales. The functionality of the systems is then not optimal in all cases (Nutley et al. 2013) if SDSTs are used in different contexts than initially used and/or intended. Attia et al. (2012) further mention that SDST results are often too complex and detailed, providing an excessive amount of information whose representation often lacks variety and visual qualities to be supportive to decision-makers. Bagstad et al. (2013) and Grêt-Regamey et al. (2017) similarly identify a large trade-off between complex, resource intensive tools with high accuracies and simple but more transparent approaches implemented by decision-makers. Campbell and O'Reilly (2005) refer to this as the "spatial science versus professional tool" dilemma.

With regards to this, Xu et al. (2018) emphasize the challenge of a lack of trust and communication between the SDST developers and end users; while Reed et al. (2013) argue that engaging stakeholders in the development is important for creating, maintaining, and progressively improving the relevance, consistency, and usefulness of planning tools grounded in local knowledge. Such engagement can also mitigate any uncertainty perceived by end users regarding the appropriateness of the model output to solve decision questions (Uran and Janssen 2003). Vonk et al. (2005), Vonk and Geertman (2008), and others have further identified a mismatch between the supply and demand of SDSTs, due to the tools being too generic, complex, and technology focused to be relevant for stakeholders. Vonk et al. (2005) explain the "implementation gap" by a lack of experience with PSSs, little awareness of PSSs, and low intention of stakeholders to use PSSs, which is applicable to SDSTs.

These challenges can be linked to the theory of sociotechnical interactions (Clarke et al. 2006; Vatrapu 2009) as outlined earlier and also stated by Williamson and Parolin (2012), highlighting the importance of trust and engagement to address challenges of subjectivity and technological intersubjectivity.

### Data, Technological, and Procedural Issues Promoting or Hindering the Uptake of Tools

Among the key challenges around the uptake of SDSTs are data issues. Availability and accessibility of data were identified as major challenges by, among others, Bagstad et al. (2013), English and Dale (1999), and Thompson et al. (2016). The latter reflect critically on the challenge of accessibility and availability, accuracy and consistency, manageability, and integration of data. The authors advocate for showing the potential of open data availability but also urge that greater access to information as evidence does not lead to better planning decisions on its own. Furthermore, information or data available always contains an element of uncertainty since it is often stored in different databases, which may make it difficult to access, manipulate, compare, and study it (Lombardi and Ferretti 2015). The application and performance of the models is limited by the quality and scope of the data (Herold et al. 2003).

Technological issues range from a lack of infrastructure and the need for training of stakeholders on the use of SDSTs due to unfamiliarity with the technology (Nutley et al. 2013) through to a lack of connectivity between different SDSTs developed based on different technologies and disciplinary perspectives (Attia et al. 2012). Thompson et al. (2016) see a challenge in capturing information resources that have the capacity to inform urban planning in a timely and accurate fashion.

Finally, procedural issues have been identified as a hindrance to the uptake of SDSTs. Beyond time and resource limitations (English and Dale 1999), strategic decision-makers often have only generic alternatives defined, which poses limitations to modelers who must translate effectively strategies into modeling language, often requiring further assumptions (Donnelly and Jones 2013; Lombardi and Ferretti 2015; Xu et al. 2018). This is linked with hurdles of communication and trust (English and Dale 1999), alignment of potentially conflicting priorities and too often a lack of value placed on data quality and availability (Nutley et al. 2013). Linking technological and procedural challenges, technology must also be perceived useful to be accepted as posited in the theory of sociotechnical interactions.

## Methodology

This paper takes a stakeholder perspective based on two methodologies. First, our analysis is based on conversations and engagement work with local councils and council-owned institutions around geospatial tools developed for Aotearoa New Zealand as part of the National Science Challenge 11 (NSC11) "Building Better Homes, Towns and Cities: *Ko ngā wā kāinga hei papakainga*." Second, information from the first methodology informed an online survey that was conducted among these and other stakeholders in the wider urban planning community.

### Stakeholder Engagement on Geospatial Planning Tools

Since 2016, the authors have been engaging with more than 25 stakeholders within local councils and other local planning authorities on the geospatial tools ENVISION and ENVISCION SCENARIO PLANNER (ESP) (Dionisio et al. 2016; Glackin et al. 2016). ENVISION is a web- and map-based SDSTs that integrates a range of types of spatial information about the built and lived environment from various sources (e.g., councils, census, urban plans, scientific literature, experts) to identify urban areas most likely to be responsive to stakeholder-defined criteria promoting urban regeneration, evaluate their redevelopment potential, and assess the economic viability of different urban regeneration scenarios [Fig. 3(a)]. Once data are integrated into the SDSTs, users can use sliders to adjust the selection criteria specific to an urban strategy and ENVISION will instantly identify which parcels match the selected criteria. Moving from the city to the neighborhood scale, ESP further enables the assessment of socioeconomic and environmental outcomes of different regeneration scenarios, through spatially modeling the allocation of residential, commercial, institutional, mixed-use, and infrastructure typologies [Fig. 3(b)]. ESP is a web-based SDST with 2.5D visualization. Using parcel cadastres for the developable area (exported from ENVISION or sourced elsewhere), users can amalgamate or subdivide parcels according to their urban strategy. Users can then "drag" built environment typologies (buildings, pathways, open spaces) onto the developable site or design new typologies. ESP then assesses the environmental and socioeconomic impacts of the designed built environment. Outcomes are revealed in graphical and numerical form to users. ENVISION and ESP are standalone SDSTs, but are designed to be used sequentially: once suitable parcels have been identified in ENVISION, they can be exported and then imported into ESP. The spatially explicit modeling outcomes can then be compared by experts and nonexperts and used to facilitate community engagement in decision-making processes.

ENVISION and ESP have been specifically adapted to the New Zealand context and further developed in collaboration with stakeholders, which distinguishes them from many other international SDSTs. They aim at usability by stakeholders and focus on visualization, for experts and nonexperts.

These tools equip New Zealand stakeholders with novel ways of modeling and examining potential trade-offs of their decisions on the environment and socioeconomics. While New Zealand's urban planning decision-support tools so far offer a predominantly market-driven perspective that strongly advocates for developers' interests in "business as usual" (BAU) approaches to redevelopment, our tools shed light on alternative regeneration scenarios. These tools offer novel ways to define, create, and assess alternative urban regeneration scenarios, which are being made available through continuous better integration of spatial data sources, geospatial technologies, and information about the built environment. This has the potential to provide urban planning practitioners with evidence and visualization material. No such research-based, publicly funded, practice-focused, and easy-to-visualize tools have been available to policy makers and urban planners for urban regeneration in New Zealand, while the requirement for evidence-based decision-making increases.

### Online Survey

This work and these conversations with stakeholders informed the design of the online survey. The survey was run online in June/July 2018 and contained closed and open-ended questions around the use, effects, opportunities, and challenges of (S)DSTs currently available to stakeholders. Since New Zealand's urban planning community is a well-networked community, an invitation to participate in the survey was circulated via email, social media, and the project's website among the authors' networks and official mailing lists of well-established planning networks. This snowballing method aimed at reaching a range of stakeholders. The survey was anonymous, but survey respondents identified whether they worked as urban planners, analysts, advisors, or strategic decision-makers primarily within local councils (9), council-owned institutions (1), a consultancy (1), and a private company (1). In order to place the survey responses into context, the survey also asked participants to state toward which urban outcomes they were currently planning (for results, see Fig. 1). Since we focused on the role of survey respondents, their demographic background was not reported, although some PSS literature demonstrated that those factors might affect PSS uptake (e.g., Williamson and Parolin 2013).

## Case of Aotearoa New Zealand

Planning stakeholders currently see key opportunities for New Zealand's urban planning and challenges as listed in Table 1.

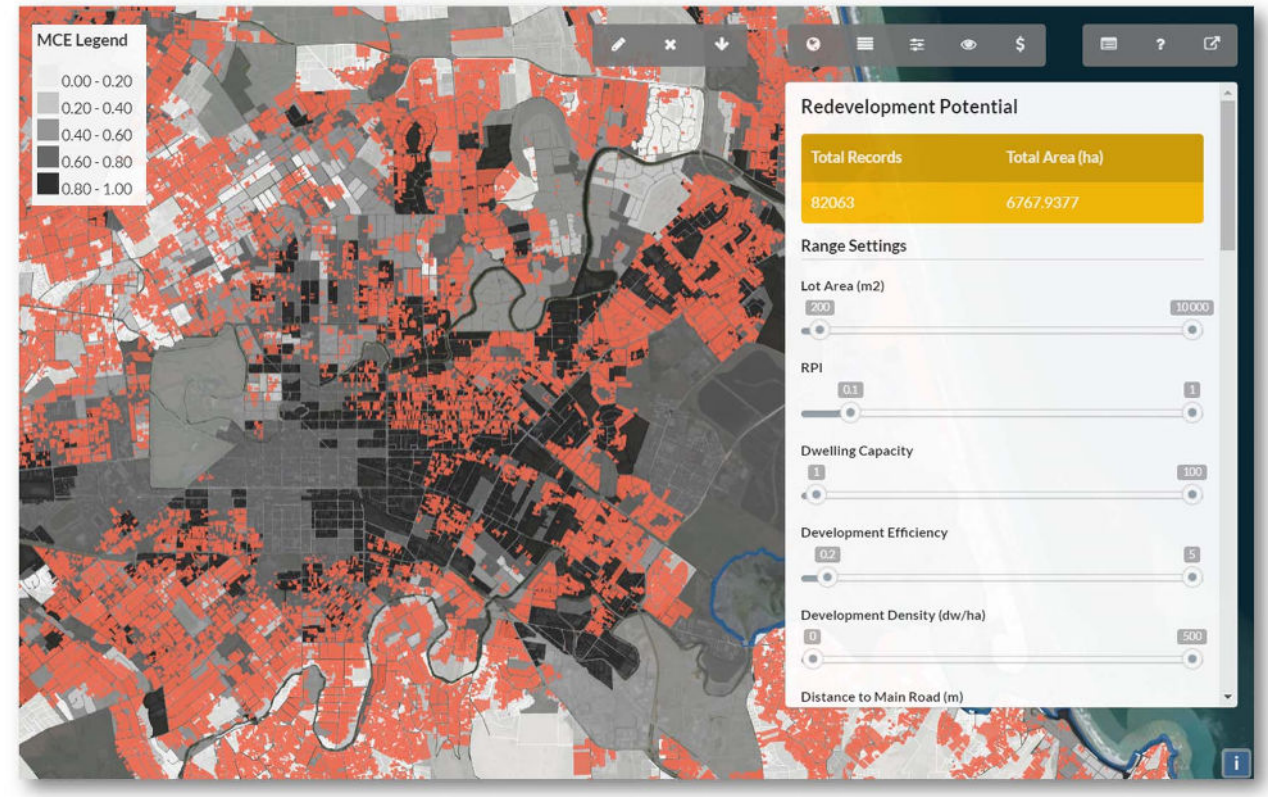
With advanced technology and increased societal interest in planning comes the opportunity for increased community involvement in the decision-making process. This development is, however, challenged by strong "NIMBYism" ("Not in My Back Yard"), where people object to planning ideas aimed at benefiting the wider community but likely to affect their own locality and interests.

Advances in technologies, such as in the field of renewable energies and the housing sector, allow also New Zealand's cities to seek more sustainable uses of resources such as (natural and urban) land. While the Resource Management Act (RMA) aims at "mitigating any adverse effects of activities on the environment" (New Zealand Legislation 2018), aligning planning practices with the RMA and making "proper" use of it is a complex task for stakeholders.

Another widely mentioned prospect to improve urban planning outcomes is "big data." Information about the built and natural environment, citizens' behavior, revealed preferences, and other spatial patterns can drive the planning of cities that contribute to urban wellbeing and quality of life for residents. However, access to fit-for-purpose (spatial) data is in many cases a barrier toward leveraging the potential of such data for improved decision-making.

Existing developed areas offer the potential to be used more efficiently by linking land development with more-efficient transport strategies. The opposite trend, however, is reported to be aggravated by a lack of awareness among residents about the costs induced by travel behavior and residential location choices.

Land availability both on fringes and in urban centers poses opportunities for land amalgamation to develop neighborhoods with




(a)


(b)

**Fig. 3.** (a) ENVISION, a SDST to identify urban areas responsive to specific user criteria for urban regeneration; and (b) ESP, a SDST to model urban regeneration scenarios and assess their environmental and socioeconomic impacts.

an increased demographic mix. This opportunity is opposed to current practices of developments at the subdivision scale. However, stakeholders mention a lack of remedies to curb urban sprawl as a key challenge to achieving such community-focused development.

This links to another opportunity identified by one of the survey respondents: Urban planning can support the development of local communities and initiate "place making," yet political expectations are often pointing in diverging directions and stakeholders experience a "political pushback on change."

Overall, stakeholders' view on current opportunities and challenges is that there is a good understanding on *why* change is required (e.g., to mitigate air pollution) and *what* needs to be done (e.g., more efficient transport); yet a better understanding of the *where* and *how* is required to achieve it. The following section analyzes how SDSTs

could help (or hinder) addressing these opportunities and challenges by looking at what SDSTs are used among New Zealand's urban planning community, and why.

### *Interaction between Urban Planning Tools and Decision-Making in New Zealand*

#### Taking Stock of SDSTs among New Zealand's Planning Community

Stakeholders use a wide range of (S)DSTs. Examples are the proprietary GIS software GeoMedia; the open source web tool Streetmix; the openly accessible Property Search (Christchurch City Council 2019) tool as part of the Christchurch District Plan provided by the Christchurch City Council; web maps such as Canterbury Maps (Environment Canterbury 2019), a joint data sharing initiative by several regional councils; a proprietary computerized land-use planning tool called SmartMap (SmartMap 2019); and 3D city design software such as Esri City Engine; and other Esri-based software. Some stakeholders are using ESP (GRI 2019) funded by the NSC11 (25%). A nonspatial, Excel-based tool frequently mentioned by local authorities is the Development Feasibility Tool (MBIE 2019) provided by the Ministry of Business and Environment to determine how much development capacity would be feasible for a developer to develop. Interestingly, a respondent also stated that "emotional intelligence" based on relationships with agencies and people is a "tool" that is widely underrated and should be mentioned explicitly in this context. This reflects well the attitude of a large group of stakeholders toward computerized decision-support tools, as also captured during engagement work and conversations with stakeholders prior to the design of the survey. This is not surprising, given that evidence-based decision-making is encouraged in New Zealand, yet the choice and use of SDSTs is voluntary.

**Table 1.** Key opportunities and challenges in urban planning as identified by stakeholders in New Zealand

| Opportunities | Challenges |
|---|---|
| Community involvement | "NIMBYism" |
| Sustainable uses of resources | Alignment and use of RMA |
| "Big data" | Access to high-quality data and use of them |
| More efficient use of existing developed areas based on more-efficient transport | Awareness of costs resulting from travel behavior and residential location choices |
| Increase demographic mix for developing neighborhoods, not subdivisions | Lack of remedies against urban sprawl |
| "Place making" | Political expectations |
| Good understanding of the *why* and *what* | Better understanding of the *where* and *how* |

#### Current Key Uses of Tools in New Zealand

To analyze how tools could help addressing the identified opportunities and challenges, the current key uses of SDSTs were explored (Fig. 4).

First and foremost, such tools are reported to support stakeholders in providing evidence for decision-making. Even though "emotional intelligence" (a survey respondent) proves to be a "tool" on which many stakeholders seem to rely heavily, SDSTs can provide a more formal, structured, and robust approach toward informed decision-making. Findings retrieved from SDSTs are based on expert user inputs, which can be made visible to parties involved in the decision-making process. This increases transparency and can expose underlying assumptions and rationales, and can allow a documented path toward decisions, which can be repeated multiple times with similar findings.

Another key purpose of SDSTs in New Zealand's urban planning is explanatory analysis. With the help of SDSTs, stakeholders are able to explore alternative developments, trade-offs, and alternative pathways without actually needing to implement them. Thus, even with limited resources, new ideas can be tested. These can then initiate further conversations and inform discourses. Along the same line, scenario modeling is a prominent use of SDSTs in New Zealand's planning community.

Finally, SDSTs are widely used for "storytelling," that is to convey the rationale of specific planning approaches and to communicate the narrative about the (learning) process. This is reported as particularly useful for communication between experts and nonexperts in the decision-making process or for the demonstration of use cases. For instance, a local council stakeholder sees the use of ESP as means to tell the environmental side of the development story and to convince others of more environmentally sustainable alternatives to the BAU.

#### Key Long-Term Objectives of Using Tools in New Zealand

The previously mentioned key uses of SDSTs in New Zealand ultimately aim at exploring alternatives to the BAU, reviewing targets and trends, facilitating collaboration between parties involved in the decision-making process, and more efficient communication in the long term (Fig. 4).

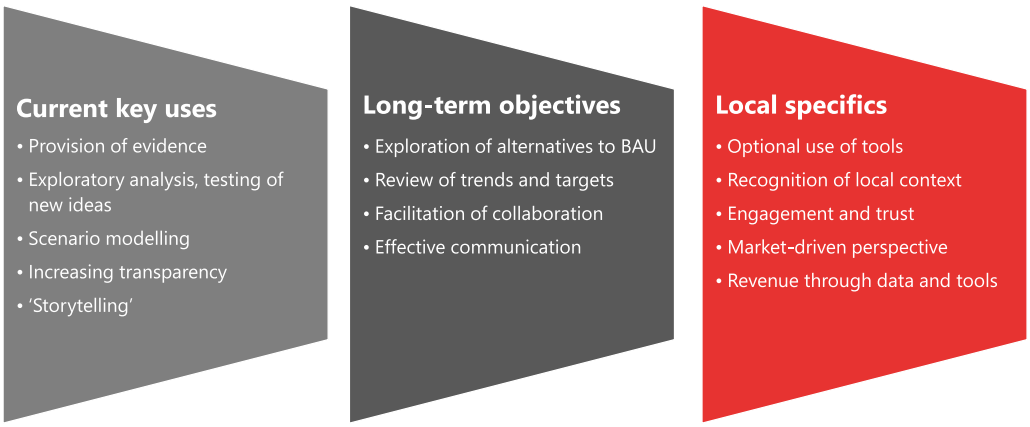



**Fig. 4.** SDSTs and decision-making: the key purposes for using SDSTs in New Zealand's planning community, key long-term objectives identified by stakeholders and local specifics that influence the adoption of SDSTs in New Zealand.

SDSTs can help play through alternatives to the BAU in terms of alternative urban outcomes and alternative ways of making decisions. Stakeholders are often locked into the BAU and anticipate that new tools can demonstrate alternative pathways. In the example of ESP, a neighborhood approach toward community responsive development can be explored through, for instance, lot amalgamation.

Good planning for urban development relies on knowing population trends, growth forecasts, and other trend analyses. SDSTs have the potential to provide evidence for these and inform on the effects of policy intervention. Stakeholders' long-term perspective is, therefore, in many cases to review such trends and targets based on information provided by SDSTs.

Further, tools are seen as a means of fostering collaboration, notably through their potential for more-effective communication between multiple actors involved in the decision-making process. Spatial visualization of planning scenarios, graphical representation of results, and disclosure of decision criteria used within the tools are sought to reduce friction in the process. SDSTs are seen as an opportunity for more community participation in the planning process, which is reported to be often more difficult with conventional nontransparent practices.

### Specifics of New Zealand's Urban Planning and Tools Landscape

Some of these uses and objectives have also been mentioned in the international literature, as outlined in the "Introduction" section and further discussed in the Discussion, yet these are embedded in New Zealand's urban planning landscape with its local specifics that influence the interaction between SDSTs and decision-making processes. The key ones are listed in the "Local specifics" portion of Fig. 4 and explained in the following.

First, the use of SDSTs is optional for stakeholders in New Zealand as far as decision-making processes comply with policy. For instance, stakeholders are committed to evidence-based decision-making; yet how this is achieved is mostly left to stakeholders.

Second, recognition of local variations and the local context is perceived as highly important among New Zealand's stakeholders. Planning priorities, strategies, resources, cost structures, characteristics of the built environment, and the multiple stakeholders involved in the planning process vary across urban areas in New Zealand. While it is feasible from a technological perspective to adapt a tool that was originally developed tailored to the needs of New Zealand's largest urban area, Auckland on the North Island (about 1.6 million inhabitants), to actually fit the local context of Christchurch, New Zealand's third largest urban area located on the South Island (about 380,000 inhabitants), from a social perspective, stakeholders' acceptance that such a tool sufficiently aligns with needs of a smaller city such as Christchurch is challenging. SDSTs developed elsewhere, for instance such as in the case of ESP in Australia, require engagement work and effort to transfer the tools successfully to the New Zealand (local) context.

This leads to another apparent local specific which comes into play when analyzing how SDSTs may affect decision-making in New Zealand, and vice versa: the importance of engagement and trust in a well-networked community. Engagement between stakeholders in the planning process renders it possible to establish trust, which is more often than not the key currency among New Zealand's community with respect to both tools and data.

Fourth, New Zealand's urban planning decision-support tools so far offer a predominantly market-driven perspective, which strongly advocates for developers' interests in BAU approaches to (re)development. This reflects the prominent role developers play in New Zealand's urban planning.

Finally, tools and also data are prevalently seen as a source of revenue. SDSTs constitute an opportunity to generate revenue to local authorities and consultancies. The relatively small landscape of spatial tools, software, and expertise encourages a competitive environment in which a culture of sharing of tools and (spatial) data often takes a back seat.

## *Challenges for the Uptake of SDSTs in New Zealand*

In our second research question, we asked stakeholders about the main challenges they face with regard to the use of SDSTs (Fig. 5).

The most prominent challenge is stakeholders' awareness of available tools. As basic as it seems, stakeholders do not have a comprehensive view of the landscape of tools and often get to know about tools only by word-of-mouth recommendation. Once an available tool is identified, however, many are not seen as appropriate for the local context, linking to the local specifics as outlined above. In line with the science-policy tension of tools or models as referred to by Bagstad et al. (2013), Grêt-Regamey et al. (2017), Williamson and Parolin (2012), or others, many tools are easily dismissed by stakeholders as being too complex for their purpose. Likewise, SDSTs designed for the national planning context or other urban areas are often perceived as not being appropriate to serve stakeholders' local needs.

In addition, existing SDSTs require information from a wide range of sources and experts of various disciplines, such as planners, developers, and researchers, which are not easily accessible or integratable into the tools. This is further aggravated by a lack

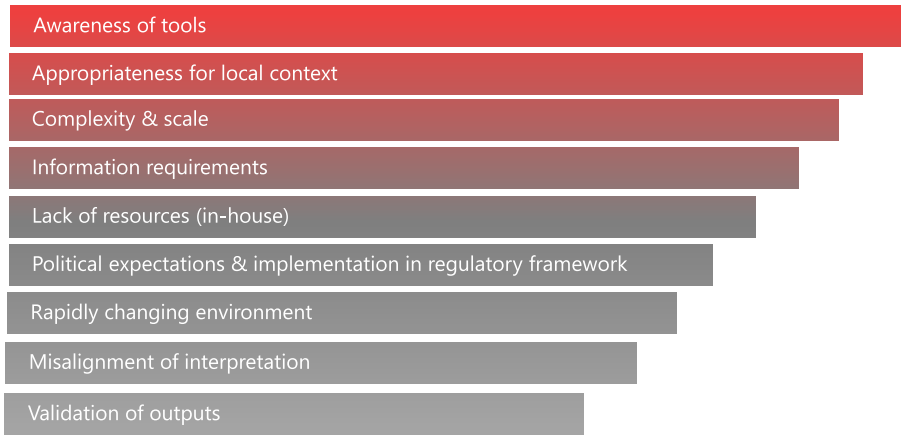



**Fig. 5.** Key challenges for the adoption of SDSTs among New Zealand's urban planning community as identified by stakeholders.

of resources inside local authorities or other local stakeholders. Few stakeholders have the required capability to work with spatial tools or data, the time to receive sufficient training to work with the tool or other resources to apply SDSTs to their local practice.

The use of tools aims at supporting the decision-making process. If, however, tools are not well aligned with political expectations or the regulatory framework, they pose extra workloads to stakeholders in order to be implemented into local practices. Survey respondents demanded a better alignment of available tools with the regulatory framework, such as the RMA. For instance, the terminology, planning and assessment criteria, and information requirements are all too often misaligned between tools and the RMA.

Urban areas as well as political planning visions are changing rapidly, which is challenging for tools to be up to date and well aligned with the latest changes. Stakeholders, therefore, express difficulties in keeping up with the changing environment of tools and having access to tools that align well with these.

Even though the use of SDSTs aims at increasing transparency and rendering it possible to make informed decisions, the interpretation of the results acquired from the tools still often leaves room for misalignment due to user subjectivity. For instance, indicator-based analyses as in ENVISION provide a basis for assessment, yet interpretation of these is still up to decision-makers. Finally, stakeholders express skepticism toward some outputs of SDSTs, in particular in the absence of means of output validation or in case of limited established ties between the developer/researcher of SDSTs and end users and, therefore, a trusted relationship.

### How Data, Technological, and Procedural Issues Promote or Hinder the Uptake of Tools in New Zealand

We now turn to a more detailed analysis of specifically how data, technological, or procedural issues promote or hinder the adoption of SDSTs.

#### Data Issues

The availability of fit-for-purpose data about the built environment is a key challenge. Sixty percent of survey respondents state that information availability or quality very much pose limitations to their work, while 30% feel that data issues limit their work to some extent, and only 10% report not to face any data-related challenges. While more and more data are generated on urban areas, their accessibility, integrability, and suitability for SDSTs are challenged by the multitude of data sources, formats, and stakeholders involved in the lifecycle of spatial data (Schindler et al. 2018).

The main reasons for such data issues given by stakeholders are of both technological as well as social nature.

The technological reasons are related to the completeness and timeliness of data, and actual access to the data. Static data-dependent SDSTs, such as ENVISION, require frequent (manual) data updates, as they are otherwise quickly outdated and of limited use for decision-making. Even though (spatial) data might be available, stakeholders within New Zealand's spatial planning community often express difficulties accessing fit-for-purpose data due to reasons discussed in Schindler et al. (2018). Mention has been made by stakeholders that an important component of accessibility is also the discoverability of data required for use in SDSTs. This is, on the one hand, due to the multitude of data platforms and incomplete metadata; yet, on the other hand, it is also due to the case-by-case data sharing practice based on individual social relationships rather than widely used sharing platforms.

Reasons of social nature are reported to be more eminent. For instance, the skills to work with spatial data (and other spatial methods in general) are listed on New Zealand's skill shortage list. This capability issue is also apparent in the survey responses. In particular within local authorities, few provide the skills for generating, manipulating, and integrating notably spatial data. Further, in case multiple datasets could be used for an urban planning task, stakeholders see the challenge of choosing the dataset that is most fit-for-purpose. This challenge arises again due to an often-limited experience of working with spatial data.

Above all, data sharing in New Zealand heavily relies on trust between data custodians and data users and is often based on established relationships. This might be rooted in the small size of the country and its relatively well-networked community, often with personal relationships between data providers and users, which likely exposes uncertainties, inconsistencies, and discrepancies associated with information more easily.

These data issues experienced by stakeholders within the sociotechnical system hinder the adoption of SDSTs, notably data-hungry SDSTs such as ENVISION (whose data requirements range from demographic data, to cadastre data with parcel characteristics and accessibility measures and zones of natural hazards).

#### Technological Challenges

There are also technological challenges that hinder or promote the uptake of SDSTs in New Zealand.

The language of SDSTs and policy practice usually differs. Thus, translating planning strategies into SDSTs likely introduces friction, which requires experience and bridging conversations. An example is the translation of policy guidelines or planning strategies into scenarios to be modeled within ESP; that is, to break down aggregate targets for housing provision stated in policy strategies into types and precise locations of these developments.

Local councils and other local stakeholders often depend on consultancies to conduct their feasibility studies, or spatial analysis due to a lack of in-house capability to develop (or work with) spatial tools. This creates a strong dependency on outsourcing such tasks. In other cases, the research identified a strong favor toward proprietary solutions based on proprietary software (e.g., Esri software or products developed by consultancies). These provide either better opportunities for revenue, or ease of access and use, and potential for customization. Thus, technologically savvy tools are more likely promoted since they promise a source of revenue. Instead, setting a focus on tools that initiate collaboration and conversations and are flexible to respond to local needs promotes the uptake of SDSTs.

#### Procedural Challenges

Finally, we identified procedural challenges in relation to SDSTs in New Zealand's planning community.

Predominantly, tools are chosen that seem to advocate for desired outcomes or are defined by decision-makers in senior positions. This might promote the adoption of one tool over another simply because of procedural issues. In addition, the New Zealand spatial planning framework is quite strict with regard to regulated documentation procedures, which tends to hinder the uptake of new tools and changes in local practices. This also implies that available, but infrequently used, tools must be better aligned with regulatory frameworks and facilitate a link to the currently fragmented decision-making process. Stakeholders take note of limited collaboration between developers, planners, researchers, and decision-makers, which too often hinders the exchange of cutting-edge information, knowledge about tools and ideas, and the sharing of data; at the same time, many SDSTs induce a dependency between these groups of stakeholders, for instance through their information requirements. Yet examples exist of a successful collaboration between a larger and

its smaller neighboring councils for a joint development of a SDST, which advanced the development and use of a tool (aforementioned Canterbury Maps).

## Discussion: Local Context Matters

### Lessons Drawn from the Developed SDSTs (ENVISION and ESP)

We find that users gain a deeper understanding of trade-offs to be made in planning with the support of SDSTs. For instance, the geospatial tools developed as part of the NSC11, ENVISION and ESP, provide support ranging from financial/environmental decision criteria to developer viability/community acceptance. By modeling the impacts of various regeneration scenarios visually and at various urban scales, and facilitating evidence-based conversations with stakeholders, the spatially explicit web-based tools contribute to users' learning about (complex) urban systems. By analyzing trade-offs from the building to the neighborhood scale, the case study SDSTs provide stakeholders with a wider perspective on potential outcomes, including unexpected outcomes due to the complexity of the SDST algorithms reflecting the complexity of urban systems. Outcomes are unclear a priori, and ENVISION and ESP can help with understanding interdependencies and trade-offs between the environmental and socioeconomic perspective on impacts of the built environment. Yet SDSTs still limit the insights on perspectives, which have been considered in their algorithms, while some aspects potentially relevant to urban planning practitioners might not (yet) be included, and therefore limit outcomes. The geospatial tools bridge research and practice through stakeholder engagement to facilitate an adequate uptake and adoption of the tools, while enhancing the collaboration potential between local planning stakeholders. Thus, the implementation of SDSTs must consider potential technological intersubjectivity, regarding the interactions between users and tools, and the decision-making processes informed by such interactions (Vatrapu 2009). Yet it has been apparent that trade-offs have to be made to incorporate cutting-edge research, while facilitating practicalities to address stakeholders' local needs. This finding is in line with, for instance, Grêt-Regamey et al. (2017).

Further, we expose the challenge for systems defined within national frameworks to address local needs as also found by Bagstad et al. (2013). We go further by stating that despite stakeholders' understanding of the potential of the tools to improve the performance of decision-making, extensive stakeholder engagement and tailored support are needed to ensure the uptake of spatial decision-support tools in local practices. Research about the importance of establishing trust and effective communication (e.g., English and Dale 1999) in line with the theory of sociotechnical interactions (Clarke et al. 2006) have been integrated in the way ENVISION and ESP have been developed and implemented in alignment with stakeholders, increasingly reflecting their local needs in flexibly designed SDSTs. This demands specific resources from both stakeholders and researchers to be accommodated in urban planning workflows. ESP also aims specifically at supporting stakeholders in translating often-generic planning alternatives (Donnelly and Jones 2013), defined by strategic policy-makers or planners, into transparent and visual simulation scenarios through a supportive graphical translation interface.

The tools ENVISION and ESP explicitly counter the trend of revenue-seeking SDSTs in New Zealand and the resource-related challenges described by others (e.g., English and Dale 1999; Bagstad et al. 2013), as they are publicly funded. What is more, the project puts emphasis on the engagement, building of trust between researchers/developers of the tools and end users, and facilitation of conversations that support an adaption of the tools considering the stakeholder needs. The tools represent an interdisciplinary approach initiated by researchers to bridge siloed organizational practices to tackle some of the identified challenges. In particular, the spatial tools can be seen as an attempt to move from a technological approach to a *sociotechnical* approach, and to initiate a *spatial* sociotechnical approach (further discussed in the section "Beyond the Case Study: Decision-Making in Spatial Sociotechnical Systems") flexibly integrating some local specifics and spatial visualization.

Yet work with the tools also shows that transferability of tools from one context to another is not about simply tweaking the tools technologically to accommodate stakeholders' local needs, but is mostly about gaining the stakeholders' acceptance of the new technology through engagement and establishment of trust. ESP and ENVISION, for instance, have been transferred from their original Australian context to New Zealand. From a technological perspective, it required few adaptations, which were mostly data-related; yet it still requires ongoing effort to receive institutional recognition from local planning authorities, and to ensure the tool's uptake in local practices, acknowledging their fitness to particular local contexts.

Further, the developed SDSTs, ENVISION and ESP, have been initiated as a response to the planning paradigm shift toward increased synoptic and participatory planning in New Zealand. This is reflected in their design around spatially visual scenario assessment targeted at expert and nonexpert users. Although stakeholders use the SDSTs in a synoptic account, their current use as participatory planning tool is limited in most cases to the expert level. This also highlights the challenge of SDSTs being designed with a particular tool in mind that might well differ from its actual use, in some cases resulting in an unsuccessful SDST. Another limitation in the implementation of these tools is that often stakeholders seek support within BAU processes, while there is less interest in exploring alternative urban regeneration scenarios and methodologies, or to advance the processes of decision-making in planning. This reemphasizes the need for continuous engagement during the development phase of the tools.

### Recommendations for Aotearoa New Zealand

Stakeholders see opportunities to explore new ideas and attempt to identify alternatives to the BAU by using decision-support tools and to increase collaborations among stakeholders. Yet the analysis reveals a current focus on the development of technologically savvy SDSTs in New Zealand's urban planning community also due to the revenue-seeking nature of the tool developments (i.e., tools are developed to generate revenue to the provider). However, the case study and review of international literature indicates that, instead, a spatial sociotechnical systems approach would be beneficial. Such an approach would be critical to ensure that adequate resources are allocated for necessary technological advances that aim to facilitate debates in urban planning, instead of spending considerable amounts of public budgets in cutting-edge technology that does not show any prospects to reach the wider public for involvement in the decision-making processes. As Allen Gunn stated: "Technology is for building and strengthening relationships. It is not a replacement for them" (Thompson 2015).

Like many places, New Zealand needs flexible tools that are easily transferable across locations but still address local needs of stakeholders without the need for individual new tools. This would especially benefit smaller councils with limited resources to develop their own tailored SDSTs. Adequate technological solutions are

required to ensure such flexibility, but this requires stakeholders across locations and organizations to be involved in the development processes. On the one hand, it is necessary that stakeholders establish trust toward the SDSTs, and on the other hand, SDSTs need the ability to sufficiently recognize diverse local contexts. Reducing fragmentation across SDSTs development and use through engagement and trust in a well-networked community, such as New Zealand, can support a balanced system of interdependent and efficient SDSTs in urban planning. Even though tools might technically be transferable from place to place, stakeholders' perception of a tool's suitability and adaptability to recognize the local context might still hinder the uptake. Stakeholder engagement is essential as the social dimension to ensure integration in local practices.

One way forward could be, from a governmental perspective, to incentivize collaboration to counteract revenue-seeking local practices. In the data space, for instance, Glass and Schiff (2017) showed how an intervention on the revenue from data changed local practices. In a similar vein, central government could set an example by restructuring government-related development and use of SDSTs or by funding SDSTs as in the case of the tools developed within the NSC11.

### Beyond the Case Study: Decision-Making in Spatial Sociotechnical Systems

This article argues for conceiving urban planning decision-making in a spatial sociotechnical system, recognizing interactions between SDSTs, spatial data, and the local context. Grounded in the synoptic and participatory planning practice and the understanding of urban areas as complex systems, SDSTs support planners in tackling wicked urban problems. Yet, the sociotechnical interactions intertwined with a local context pose major challenges.

Urban decision-making is shaped by tools, data, and the local context, as depicted in Fig. 6 (circles), which in turn are interconnected and exposed to external trends (outer arrows). For instance, research and technology advance urban planning tools to respond to global trends and shifts in planning paradigms. Data are influenced by similar trends and are embedded into international data standard frameworks. The local context is affected by local factors such as sociodynamics, intersubjectivity, and public participation, and by global trends. This paper exposed parallels between challenges around tools and data, embedded into the local contexts.

In addition to such external factors, the spatial sociotechnical system is informed by interactions between tools, data, and local context (see dashed circle in Fig. 6). Tools have data requirements, while tools direct data collection and management, and therefore affect the data life cycle. Data must be made available to the tools (and their purpose) in mind, just as the tools must be developed with consideration of the data landscape. Tools are also shaped by the local planning vision, paradigm, culture, and belief system, while they in turn coin places through advocating for certain urban outcomes based on the generated evidence and knowledge. Finally, the data integrated in tools are about places and depend on local practices and priorities; in turn, information generated through data about a place also informs local practices. Thus, challenges of having tailored SDSTs that are successfully implemented by urban planning stakeholders are embedded in the spatial sociotechnical system. Tools might help with framing the problem and defragmenting the decision-making process if designed and embedded well into the spatial sociotechnical system,

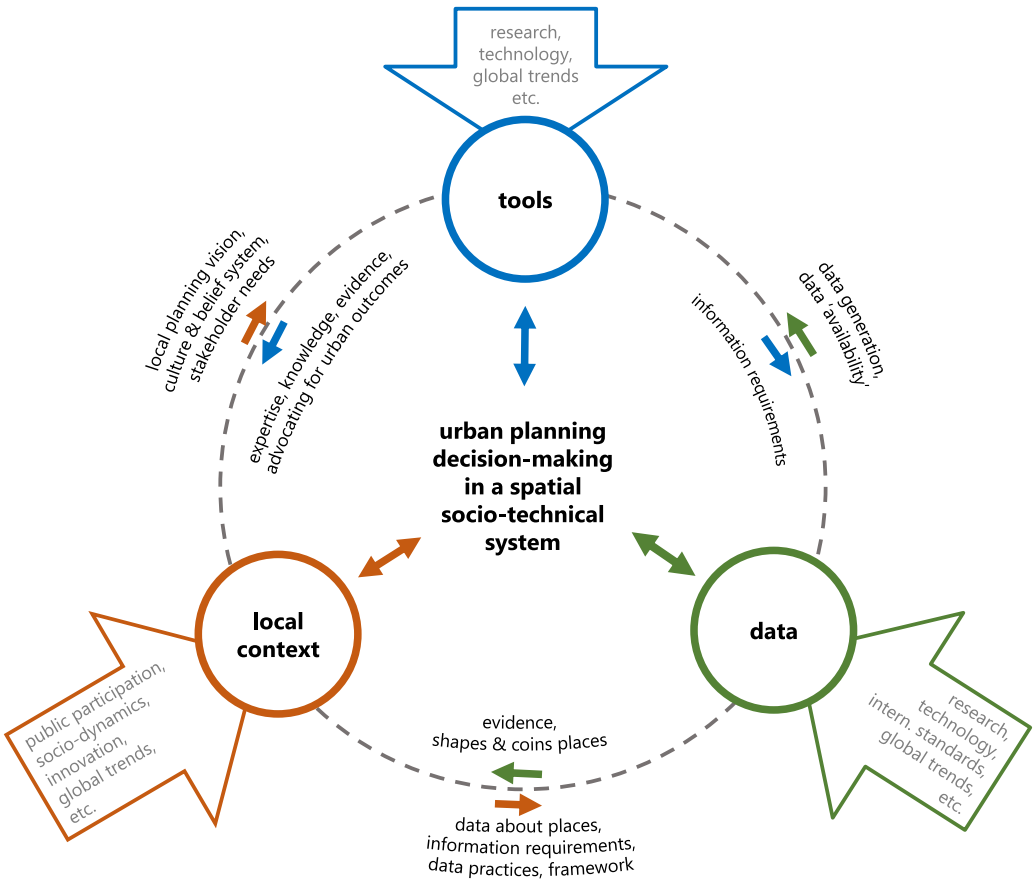



**Fig. 6.** Urban planning decision-making in a spatial sociotechnical system where data, tools, and place interact.



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while considering local specificities in the tools functionality and integrated data.

Even though it seems from this discussion that every locality has to identify its own tailored SDSTs to best respond to its local sociotechnical system, ideally, SDSTs that are flexible enough and have the potential to be transferable will be better suited to greater use, and are thus recommended. Taking the analyzed spatial sociotechnical systems approach helps with finding a balance to the sociotechnology, scale, and complexity tensions in order to develop successful SDSTs with the support of stakeholder engagement.

## Conclusion

This article analyzed which lessons can be drawn from New Zealand's urban planning for others on (1) how spatial planning tools might influence decision-making; (2) the challenges toward the appropriate adoption of spatial tools; and (3) how data, technical, and procedural issues may influence the adoption of tools in planning practices. It contributed an integrated view drawing from literature on complex systems, theory of sociotechnical interactions, and synoptic planning. The paper has exposed the link between challenges around urban planning tools and spatial data. Stakeholders see opportunities to explore new ideas and attempt alternatives to the "business as usual" by using decision-support tools and to increase collaborations among stakeholders. Yet the key challenges identified are stakeholders' awareness of the availability and value of SDSTs, and the appropriateness of tools to the local context.

Some of the challenges around SDSTs, as identified in this research, can be found in the international literature, as they are to some extent transferable from one case study to another. Yet the main local specifics of New Zealand are that the local context is perceived to matter in particular, and that for the well-networked community engagement and trust are exceedingly important. This research highlighted the current focus on providing and using technologically savvy tools driven by a revenue-seeking perspective toward SDSTs and data in New Zealand. It argued instead toward a focus on SDSTs that initiate conversations and collaborations built around engagement and the establishment of trust in a well-networked community, which can also be beneficial in other contexts outside New Zealand.

Going further, the research highlighted the need for viewing spatial planning decision-support tools in a spatial sociotechnical system, integrating tools, data, and local context to better align tools with regulatory frameworks and planning processes. Local context matters in this systems approach to promote the uptake of decision-support tools. SDSTs change the way decisions are being made in urban planning and can play an important role in shaping future cities. Yet decision-makers must be aware of challenges around SDSTs, such as technological and user subjectivity, and view SDSTs in a wider, spatial sociotechnical system to fully leverage their potential and ensure improved urban outcomes adequately considering the local context. Furthermore, stakeholder and end-user engagement must also be considered during development and improvement of SDSTs, to ensure that the tools can be flexible, appropriate, and efficient in addressing diverse local contexts.

This research has been conducted through the lens of the work framed within the NSC11 and might therefore represent a selective stakeholder view. Yet this perspective is in many respects confirmed in conversations in the wider community. Future work will aim at a longitudinal survey to capture potential changes in the use and role of SDSTs in New Zealand.

This research is grounded in the theoretical framework of the theory of complex systems, sociotechnical interactions, and synoptic planning practices. Viewing the research questions through different lenses, such as a law or even more cultural perspective, might yield additional insights into the SDST landscape and its challenges. This could be an avenue for future research.

Based on this research, many other avenues for future work arise. Addressing the key challenge of stakeholder engagement calls for further development of engagement strategies, establishing a working relationship between developers/researchers and stakeholders, and develop tools in continuous conversation to ensure tools fit stakeholder needs. Further strengthening the local applicability of the tools and applications in various urban settings emerges as key priority for future work.

## Data Availability Statement

Some or all data, models, or code generated or used during the study are available from the corresponding author by request, including access to ENVISION and ESP and the survey.

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