Improved Modelling for Urban Sustainability Assessment and Strategic Planning: local government planner and modeller perspectives on the key challenges

Andre Brits[1]
Matthew Burke[2]
Tiebei Li[2]

[1]School of Environment, Griffith University
[2]Urban Research Program, Griffith University

Abstract

Many technical and modelling tools are available to support the strategic assessment of land use and infrastructure policy proposals in local government. However, there remains a lack of guidance and confusion as to how modelling may be integrated into the policy- and decision-making process or how to practically set-up participatory model-building with practitioners. Although major advances have been made in modelling in recent decades several unresolved implementation issues remain in practice. This paper provides the results of a panel survey exploring what planners and modellers believe to be key modelling implementation issues, their perceived importance, and a set of modelling requirements. The results suggest planners generally feel they do not understand models and the modelling process, and that modellers, in turn, feel they don't always understand policy development and decision-making. Problems of data preparation were viewed as the most important challenge. Ensuring leadership and management support and initiatives aimed at improving communication and the confidence of participants were perceived as key requirements. Limited resources, leadership support and a lack of education are some of the challenges that are perceived to be important before planners and other government officers can take advantage of modelling.

Introduction

In recent years climate change and other urban growth considerations have put sustainable urban development at the forefront of strategic policy discussions in Australian cities (Commonwealth of Australia, 2011). The environmental agenda has engendered the need for employing sustainability assessment and modelling of urban systems to assist urban planning and policy development. Urban systems emerge from the complex interactions of three interconnecting and overlapping primary systems: the environment, the economy and society. The resulting complexity creates problems identifying the causes of urban problems and how best to address them without creating unintended consequences. Land use and infrastructure planning has traditionally addressed problems with policies regulating the location and intensity of urban activities, often based on assumptions about urban and environmental dynamics that are rarely revisited (Alberti, 1999; Neuman, 2005). A key challenge of planning for urban sustainability is to understand the dynamic multi-scale and multi-level relationships between different social, economic and environmental systems in a local or regional context. The sustainability literature has acknowledged the central role of modelling

instruments in gaining an improved understanding of the dynamics and interrelationships between social, economic and ecological systems (Weaver and Rotmans, 2006; Weaver and Jordan, 2008). We seek to contribute to this imperative by exploring what planners and modellers perceive to be key modelling implementation issues, their importance, and how they think these may be lessened by introducing a set of modelling requirements.

In this paper we focus on the role and use of modelling to support strategic planning and the assessment of land use policy options, prior to implementation. Despite significant progress towards the development of computer models to support land use planning, their use is far away from being trivial or the norm. The paper explores these modelling challenges, using them to inform the development of a set of modelling requirements to improve the use of modelling in strategic planning and the assessment of policy proposals. Views from a set of workshop panel respondents indicate that implementation of these requirements is likely to improve the level of confidence of planning practitioners to use computer models to support planning and assessment practices.

The term modelling is used here to indicate mathematical models implemented on a computer and designed to analyse and forecast the development of urban or regional land use systems (Wegener, 1995). The type of modelling instruments considered in this study do not provide detailed realistic visual representations of urban environments through three-dimensional (3D) modelling or illustration (e.g. *CommunityViz*). Rather, the types of modelling considered are those that provide abstract representations similar to those found in geographical information systems (GIS) and are mostly dedicated to planners' analytic, forecasting, or design tasks. Using the categorisation of selected planning support systems (PSS) by Klosterman and Pettit (2005, p478), the type of models considered in this study are those that primarily focuses on the task of land use / land cover change. These models include the use of techniques such as agent-based modelling (e.g. *UrbanSim*), rule-based modelling (e.g. *What if?*) and cellular automata (e.g. *SLEUTH*). Although increasingly coupled with land use models (see Nicolai, 2011), transport models are excluded from the study. Australian examples include the work of Pettit *et al.* (2008) in Mitchell Shire, Victoria, and Chhetri *et al.* (2007) in South East Queensland. Detailed information on specific models, their strengths, weaknesses and major applications are not included in this paper. The paper concludes reflecting on how the insights gained from planners and modellers can be used to inform

processes and solutions that aim to enhance better use and integration of modelling in planning practice.

Modelling Implementation Issues in Planning Practice

Land use change models are useful in helping evaluate alternative futures and to explore the possible consequences and impacts of those alternatives (US EPA 2000, p7). But why are they not being used as planning supports more often? And are there specific problems in how land use change modelling and broader strategic planning activities interlink?

Matthews *et al.* (2007) state that models have played a major role in land system science in undertaking structured analysis of complex interactions within the land system. Where real-life experiments are not possible, models provide artificial experiments to explore system behaviour, i.e. as a computational laboratory. In addition, models enable ex-ante assessments of policies and provide input to the planning process (Helming, *et al.*, 2011b).

Land use models that simulate the decision-making behaviour of households, businesses and developers have been developed, but these are seldom applied in a policy and planning context (Verburg *et al.*, 2006a,b) with limited exceptions (Gaube *et al.*, 2009). Though widely adopted and of significant benefit, the limitations of land use models are well documented and include aspects such as their excessive data requirements and complicated nature (Lee, 1973, 1994; Timmermans, 2003; Brugnach *et al.*, 2007; Harding, 2007 and Waddell, 2010). The advent of the "information age" has increased the availability of data, stimulated the growth of GIS and related technologies and greatly expanded access to computing. Today, there is much less questioning about whether to use urban models, but much more about when to do so, the appropriateness of a model system and how to improve the confidence of planners in model use. The role and potential use of models in rendering planning support are also well documented (Klosterman, 1998; Harris, 1999; Brail and Klosterman, 2001, Vonk *et al.*, 2005 and Geertman, 2002, 2006). However, there is good evidence to suggest that the place of computer modelling in planning practice remains problematic after four decades of efforts in bringing the two fields closer together. This is evident when studying the Planning Support System (PSS) literature. A common theme is that planning practitioners remain uncommitted and have never fully embraced the use of models. Geertman (2006, p863) suggests this neglect is remarkable against the background

that planning support instruments are increasingly finding their way from the scientific community into the marketplace and planning tasks characterise themselves increasingly by their growing complexity. He lists a number of reasons for this apparent neglect. One of the reasons is that planning-support instruments, such as computer models, do not readily fit the changing needs of the planning profession in that they are far too generic, complex, inflexible, incompatible for most planning tasks. In addition, the professional education and training of planners in the innovative application of models remains at a rudimentary stage.

The problem is further compounded by the variety of planning theoretical perspectives applied in local government, from rational planning and the use of expert orientated instruments (Jenkins, 1978; Downs and Larkey, 1986) to more collaborative planning where facilitation of "reasoning together" appears to be the medium for processing information and generating knowledge (Healey, 1997, 1999).

Meanwhile, there is a growing realisation of the importance of regional and supra-regional factors, such as economic globalisation, international migration and climate change, all of which can have very specific local effects. Land use and transport change are themselves issues spanning the local-to-global spectrum, so that changes at one geographic scale may have significant repercussions at several other scales and times. At a city level, urban growth cannot be addressed by one community without direct implications for several others (Calthorpe and Fulton, 2001). Proponents of regionalism have developed these kinds of arguments in great detail and show that local autonomy by local governments and, along with it, the idea of local area planning are to a large extent illusionary concepts (Calthorpe and Fulton, 2001), all of which adds to a renewed interest in the development of long term strategic plans for major capital cities (Council of Australian Governments (COAG) Reform Council, 2011) backed by large-scale urban growth models (Au-Yeung, *et al.*, 2010).

Planning for urban sustainability often requires a combined approach, involving both the use of expert orientated instruments and the active participation of a variety of disciplines in planning activities. In such circumstances there is a need for more integrative approaches that combine disciplines, planning theoretical perspectives and modelling instruments.

One such emerging approach, where the use of modelling instruments are considered central to the process, is Integrated Sustainability Assessment (ISA). ISA is a cyclical, participatory

planning and policy assessment process, and includes steps of scoping, envisioning, experimenting, and learning (Weaver & Rotmans, 2006). Experimentation involves, amongst other things, the use of modelling instruments to simulate the likely implications of policy options (scenarios). Lotze-Campen (2008) conducted a detailed review of existing modelling tools for sustainability assessment and concluded that model integration from the perspective of ISA is still in its infancy and that the ultimate test of model applicability for the challenging tasks in ISA can only be achieved through intensive stakeholder involvement.

Based on empirical material from recent studies on the use of models in stakeholder dialogues (see Antunes, et.al., 2006; Van den Belt, *et al.*, 2010; Te Brömmelstroed and Schrijnen, 2010; Olsson and Andersson, 2007) two central problems are identified: (a) models are laden with choices and thus depend on the assumptions and priorities of modellers and (b) the ability and willingness of planners to criticise or accept modelling results. Recognised factors likely to influence planners' acceptance of model derived results include issues at stake, planners' ability to criticise model derived information, and their trust in the modellers that have developed or applied the models. Methods and frameworks that can account for and respond to these problems are required. In this regard, Geertman (2006) developed a conceptual framework, which constitutes crucial factors that influence the potential planning support roles of instruments, such as computer models. Using known theoretical planning traditions he suggests that factors such as the content of the planning issue at stake; the profession and working habits of planners; the specific characteristics of data and models available; the dominant planning and policy development style and political context - all influences the potential support role that modelling plays.

In Australia, Pettit and Pullar (2004) used land use modelling approaches, as part of a decision support framework, to formulate and assess a range of land use planning scenarios for a growing coastal area of Hervey Bay. Yet few studies have investigated the conditions for their practical application. Vonk *et al.* (2005, pp916-917) explored some of these concerns in an international survey of planners using various planning support systems (PSS) (a term which bring together the functionalities of geographic information systems (GIS), models and visualisation, to gather, structure, analyse, and communicate information in planning). They found that there were three key barriers to adoption: 'experience [of the system] within the planning organisation', 'user friendliness' and 'users' awareness of [the] potential of planning support systems'. In addition, the quality and the accessibility of the

input data were seen by planners as insufficient, and organisations weren't providing enough implementation support for these systems (Vonk *et al.*, 2005, p916). The same researchers then looked at how geospatial planning support systems were being adopted by planning organisations in the Netherlands, interviewing geo-spatial officers, planners and managers within these agencies. They found that failure to disseminate and take up these systems was viewed as relating to the attitude of management, the social organisation of the (end) users, the awareness of the potential of the systems, and implementation support. Only informal adoption pathways were generally employed across the planning organisations (Vonk *et al.*, 2007, pp750-752). Pettit *et al.* (2008, p451) explored the adoption of the *What-If?* planning support and modelling system in the Mitchell Shire in Victoria, Australia, finding that planners struggled to understand the tool, and that there were needs in support for and evaluation of similar tools.

Te Brömmelstroet and Schrijnen (2010) looked at the adoption of a modelling and forecasting tool in the Municipality of Amsterdam, undertaking surveys of both the modellers and planners involved. They found that a more complex and involved process of dialogue between the planners and modellers in developing the modelling supports led to shared understandings and the development of a common language, and a more 'user-oriented support system though they provide minimal information on the remaining challenges faced by each group (Te Brömmelstroet and Schrijnen 2010, p17). Williamson and Parolin (2012) used actor network theory to explore planning support systems employed in three applications in New South Wales. Where there was a strong link of the system to explicit policy or planning legislation, there was greater success in linking planners and modellers. Adoption and use could be hampered by actor network instability in the form of the departure of a key focal modeller, situations where a whole network relied on a single modeller or networks without consistent funding for the modelling systems and their on-going maintenance and support. The researchers also noted all three of their cases did not include project evaluations and feedback loops to support improved research and development of such tools (Williamson and Parolin 2012, pp82-83) which limits our capacity to improve practice.

This research literature opens almost as many questions as it answers. Only some of the requirements that are needed to ensure that models can be used as valuable tools in planning and policy assessment practices are known. And we know less about how Australian planners

and modellers view the main requirements for improvements in how models are framed and used in planning practice.

Aims, Approach and Methods

To respond to these questions, our research agenda is experientially developing and using with practitioners a computer model instrument to assist in planning and assessment practice. The introduction of a new model instrument in a local government faces a number of issues.

The intent of the work reported in this paper was to identify how Australian modellers and planners conceive of these issues and, in response, what they perceived to be the most important model implementation requirements. The approach for the introduction and use of a model instrument in local government planning practice is based on key conceptual and theoretical insights drawn from the systems theory, planning support systems (PSS) theory, impact assessment and modelling literatures, scoped to the problem of land use policy assessments for urban sub-regions of large Australian cities. A design-based research (DBR) study is undertaken that "blends empirical research with theory-driven design" (Design-Based Research Collective, 2003, p5). Research and development take place through continuous and iterative cycles of design, enactment, analysis and redesign. One local government is used for the research, based on the limited resources available to the project and the very large effort required for data gathering, model development, and workshop exercises.

This paper explores the initial insights of a panel who participated in three workshops, each between one to three hours long, held over a period of two months during 2011. Workshop participation was entirely voluntary and the panel comprised nine planning practitioners (1 transport orientated, 3 land use, 2 social, 2 infrastructure and 1 from environment) and three land use modellers from one local government, who had varied experience in developing and using models to aid policy development. After being briefed on the research project and its objectives, the panel were involved in a series of workshops. During the first phase of the workshops, participants were tasked with exploring the issue of "improving the confidence of planners in the use of models to support policy development". The end result produced a list of reasons for this apparent lack of confidence. Next, the panel was tasked to write down those modelling issues they consider as most important to resolve. The workshops concluded with a consolidated list of modelling issues.

A total of 17 modelling issues were identified by participants. These modelling issues informed the design of the first questionnaire. Next, the panel was tasked with completing a structured questionnaire, rating the importance of the 17 modelling issues on a scale from 1 (unimportant) to 5 (critical importance). The results of the first questionnaire informed the next cycle of workshops. Using the results of the first questionnaire, the panel was tasked with coming up with solutions for each of the modelling issues. These solutions were incorporated in the design of a second questionnaire. The second questionnaire contained the modelling issues and for each issue, a corresponding list of modelling requirements (solutions). A total of 31 modelling requirements were listed, 7 of these listed more than once, due to their cross-cutting nature and potential contribution to help alleviate more than one issue. Next, the panel was tasked to rate the likelihood of each requirement making a contribution towards resolving the modelling issue on a scale from 1 (no contribution) to 5 (significant contribution).

Besides the panel, both surveys were circulated to other practitioners in the local government, with four responses received (1 from transport, 2 from land use and 1 from environment). A total of sixteen responses were received. Although the sample size is too small to provide robust statistical analyses, the responses provide useful indicators of user sentiments. We focus in this paper on the key issues identified and a summary of the modelling requirements by the respondents. There is one limitation with the structure of the survey: though we were keen to identify the importance of disaggregate issues, some respondents reported finding it difficult to rate individual issues and felt that some issues perhaps might have been better grouped and then rated, though this is not believed to have affected the results obtained.

The Case Study Area

The research was conducted in Logan City, South East Queensland. Logan City Council is currently the sixth largest local authority in Australia with a current population of just over 280,000 (ABS, 2011) and with substantial residential, commercial and industrial areas. Logan City is projected to increase its population to over 452,000 people by 2031.

The urban settlement structure, form and function differ across Logan City, consisting of dense suburbia in the northeast through to small towns and rural villages in the southwest.

For Logan City, where an abundance of broad hectare land is available, deciding on whether to add new urban land or to intensify existing urban areas remains an important planning consideration.

Land use modelling plays a central role in projecting future demand for infrastructure networks and services in Logan City. In this regard, Logan City uses a development projections model[1] that projects the amount of residential and non-residential land required to satisfy target estimated residential population and employment totals. Model results, together with a set of standards for the delivery of infrastructure and services, are used to inform the development of a Priority Infrastructure Plan (PIP). The model is a rule-based land use allocation model (i.e. it does not include endogenous price signals or an explicit supply process), which leaves the door open for model results to be manipulated to support already decided upon policy positions. Involvement of planning practitioners in the modelling process is limited to the supply of key land use planning assumptions (e.g. existing level of development, physical constraints of land and scale of future development) and the assessment of model results (e.g. estimated resident population, jobs, residential and non-residential growth). As a consequence, it appears that management support and the use of the model by planners remains "marginal" with a single purpose and does not render ongoing planning support[2].

Workshop Panel Responses

To investigate perspectives around modelling, the study held a series of workshops with planning practitioners and modellers. This involved 1) identifying key modelling issues, 2) rating the importance of dealing with these issues, and 3) developing a set of modelling requirements.

1. Identification of Key Issues

[1] The development projections model, including its associated planning assumptions, has been documented by Logan City Council. At the time of writing the outputs were considered confidential, and only likely to be made public when a new Planning Scheme is released for public consultation.

[2] These are perceived limitations that were observed by the authors and do not reflect in any way the views or opinions of any member of staff at Logan City Council.

During the first phase of the workshops, participants were tasked with exploring the issue of "improving the confidence of planners in the use of models to support policy development" Workshops concluded by asking each participant to write down the issues they consider as most important. The end result of the workshop discussions produced a list of reasons for this apparent lack of confidence. These issues or challenges are summarised below.

The first set of issues related to professions and institutions. It was found that *planners (in general) do not understand models and the modelling process.* Participants felt that poor integration of modelling in the policy and decision making process was due to poor communication between planning practitioners and modellers. In particular, there was a need to simplify explanation around what questions the model can potentially answer and the strengths and limitations of the model, such that planning practitioners and other non-technical stakeholders could understand why it has been designed in a certain manner. During the workshop, it was agreed that this situation was mainly a consequence of a poor understanding of computer models on the part of planning practitioners. *Modellers, in turn, do not always understand the policy development and decision making process*. Modellers often had a limited understanding of key policy-making processes that planning practitioners are required to facilitate, and the types of decisions they have to make. Greater clarity was needed on the role of models and how their results were being used and interpreted. This included issues such as how well the model has been shown to match reality, what its restrictions were, and even how to express modelling concepts to a wider audience. *There are fragmented organisations.* The fragmented nature of many local government services was seen as another hurdle to effective modelling processes by modellers. More often than not, a modelling process leads to a question that requires different departments from the same local government to be involved. *Project management* raised concerns. Participants recognised one consequence of lengthy and expensive modelling projects is the necessity for strong project management skills. Participants agreed that a greater emphasis should be placed on developing the simplest possible (but functioning) version of a model, on getting that well documented and on producing outputs containing illustrative results within the project budget and timeframe. And there were *constantly changing participants*. Those in the workshop recognised that the somewhat voluntary nature of participation and the potential for changes in personnel during a lengthy modelling project can disrupt a successful modelling and dialogue process.

The second set of concerns were modelling concerns, per se. There were concerns about *model accuracy*. When it came to the meaning of model validation or level of certainty achieved, planning practitioners were keen to confirm that they knew and accepted that a certain amount of uncertainty is and will always surround model prediction. What, however, was missing was more information on the level of uncertainty of any model result or outcome and how this arose from the limitations or assumptions of the model. *The flexibility of models* was questioned. Modellers felt that we continue to see improvements in theory, in empirical methods, in software development and in data. But models and software platforms that are too rigid become a serious constraint, and limit applicability. Modellers felt that different users will have different data and needs, and it is clear that models need to be adaptable to these conditions if they are to be widely used. A flexible model design means the ability to make changes to the model with minimal disruption. Modularisation of models was viewed by modellers as one of the key factors in ensuring that a model maintains its flexibility and longevity. *Changing models* create problems. Practitioners were unhappy with models changing throughout a project, such that different results could be produced from the same set of assumptions and input data. What practitioners really wanted was "one model" allowing an answer to be associated with a specific model version and some measure of uncertainty or confidence indicator.

Participants wanted *behavioural validity*. That is, they felt that for a model to be credible for use in government, it must have sufficient 'common sense' or behavioural validity of how the world works to be believable as an independent tool, within a clearly defined scope of applicability. Models that lack any form of behavioural and theoretical foundations cannot pass the credibility test, and are not ultimately useful in supporting the assessment process. Participants sought *empirical validity*. It was argued that models must be tested against observed data in order to assess their empirical validity. That is, no matter how much or little common sense a model might have, it is not useful unless it can respond to input assumptions and make predictions that reasonably well correspond to observed reality. This is the process that some refer to as model validation. Participants felt that many models do not go through any form of local validation, and leave it to the stakeholders to simply believe the results. More often than not, new modelling instruments do not go through any form of local validation as a way to provide the necessary "proof" that the model system does indeed reflect the local reality experienced by most participants. *Models had to be without bias.*

Participants wanted models able to withstand scrutiny from this perspective. They also had to have *ease of use.* Beyond the conditions outlined above, respondents noted that if a model is too complex to explain, it also will ultimately not succeed in practice. In addition, participants felt that if it requires a modelling expert to provide extensive and ongoing support, with no building of capacity to use and modify the model system by its users, it will be far less compelling than a model that accomplishes this aim.

The next set of problems related to resourcing. Participants noted challenges in *data preparation*. Probably the most daunting problem in implementing a model remains input data. In a study on the use of disaggregate models with aggregate data, Patterson *et al*. (2010, p8) said that "in order to understand the data requirements and how these requirements need to be overcome, a basic understanding of the model system [in this case UrbanSim] is needed."

Notably, participants highlighted two key data issues: first, the scope and size of the base year dataset that needs to be prepared and secondly, data quality, especially in those instances where micro (disaggregate) data are absent and need to be derived from aggregated datasets. Participants noted *time constraints* arguing there was often not enough time to model. They also highlighted the limitations implicit in the process of using modelling during stakeholder participation, due to time constraints placed on group learning and decision making. These problems in turn related to limited *budget.* The construction of an integrated model, of a quality suitable to be used to support important government policy decisions, can be an expensive and time consuming exercise. Participants recognised the importance for modellers to be open about just how expensive such models are to build, so that they can help ensure that government do not embrace such projects with unrealistic expectations. *Computational requirements* raised concerns. Traditionally, large scale models required large computers to run and in addition, required run times extending over several days to simulate basic urban behaviour changes. Advances in computing power and speed have contributed significantly in the last few years towards scaling down running time. Ultimately, several factors will influence computational requirements, ranging from the size of the study area, the geographical unit of analysis (e.g. grid cell-, parcel- or zone-based) and whether the database structure of the model allows parallel processing of data. The modellers felt that careful consideration of these aspects is required, prior to the implementation of a model.

The findings of the workshops were compared with the literature and one of the issues earlier hypothesised as a key concern had been omitted by participants. This may be described as '*Differences in knowledge and local experience between participants*', which was noted by Te Brömmelstroet and Bertolini (2008) as a major factor in soliciting information, building and reaching consensus during a modelling process. They ascribed these differences to the gap between tacit and explicit knowledge between land use and transport planners. Explicit knowledge is characterised as easily codified, formalised and expressed in words and numbers. Tacit knowledge on the other hand is deeply rooted in action, meaning and personal experience in a specific context. Scientific instrumental rationality still seems to be the predominant paradigm when it comes to transport planning. Transport planners tend to use more quantitative information and tend to focus more on general theories and computer models, whereas land use planners tend to use more qualitative information, work in more communicative settings and often have a background in design or the "soft" social sciences. The real issue may be less whether qualitative or quantitative epistemologies are more or less correct, than whether some combination of them can be used to provide sufficient behavioural and empirical validity to become useful as a basis for facilitating discussion. This issue was added to the set of challenges facing modelling for the next phase of the research.

2. Importance of these Modelling Issues for Resolution in Planning Practice

Table 1 summarises the perceived importance of modelling issues by planning practitioners and modellers respectively, with the average rating of planners indicated in decreasing order of importance.

Table 1: Comparative Importance of Modelling Issues by Planning Practitioners and Modellers

No.	Modelling Issue	Average Rating	
		Planners[3]	Modellers[4]
1	Data preparation (models are too comprehensive)	4.8	4.7
2	Modellers do not understand the policy	4.6	4.3

[3] Results are based on a sample size of 13 planning practitioners only

[4] Results are based on a very small sample size of 3 modellers only.

	development and decision making process		
3	Not user friendly: Planners do not understand models & the modelling process	4.4	4.7
4	Models are not known	4.5	4.3
5	Models are too rigid	4.5	4.7
6	Modelling projects difficult to manage	4.2	3.7
7	Empirical validity	4.2	3.3
8	Model results are not credible	4.2	4.0
9	Not user friendly	4.1	4.3
10	Behavioural validity	4.1	3.7
11	Models are biased	3.8	3.0
12	Too expensive	3.8	3.0
13	Fragmented organisations	3.5	4.0
14	Time constraints - not enough time to model	3.6	4.0
15	Changing participants	3.3	3.7
16	Computational requirements high	3.2	4.3
17	Differences in knowledge & experience of participants	3.1	3.0

All of the issues included in the table received an above average importance rating of more than 3. The respondents perceived all of these issues as important considerations when modelling in government settings. Of highest priority, it is clear that data preparation is perceived as of most critical importance, followed by a lack of understanding by planners of models. In addition, modellers' lack of understanding of the policy development process, the problems of changing models and the flexibility of models were also seen as more important considerations. Differences in the knowledge and experience of participants in modelling were perceived as of lesser importance.

In addition to the above modelling issues, respondents felt that there is (generally) insufficient investment in model design and specification, which leads to the following consequences:

- Sub-optimal design, which becomes difficult to maintain as modelling progresses.

- Insufficient understanding of the nature and scope of the problem. This relates both to modellers' apparent lack of understanding of the policy development and decision making process and planning practitioners' failure to reach consensus and agree on the nature and scope of the problem.
- Generation of unreliable and/or inadequate model results, which contributes to a loss in legitimacy and management support.
- Planners find it difficult to translate their requirements into a "modelling language". This becomes especially apparent when planning practitioners are expected to provide input into model design and specification. A lack of an intermediate language (interface) and poor dialogue between planners and modellers further exacerbates the problem.
- Assumptions included in the model may be incomplete and inaccurate. In some cases, these assumptions may be valid for a certain time period, but are not reviewed as new information becomes available and documented properly to inform model refinement.
- Limited understandings of the time and effort required to build, prepare data, use and maintain a model.
- Problems sustaining institutional capacity and management support, especially where officers are expected to maintain operational models.

3. Modelling Requirements

The study next developed a set of ‘modelling requirements’, which are responses that could potentially be used to resolve or moderate the previously identified modelling issues. Table 2 contains a summary of these requirements. Workshop participants were asked to rate the likelihood of each requirement making a contribution towards resolving the modelling issue on a scale from 1 (no contribution) to 5 (significant contribution). Table 2 summarises the perceived importance of the modelling requirements, in decreasing order of importance as perceived by the panel of 16 participants.

Table 2: Comparative Assessment of Responses to the Modelling Requirements

No	Modelling Requirement	Average Rating

1	Ensure leadership & management support.	4.6
2	Record decisions around model changes & underlying assumptions.	4.4
3	Limit the initial list of questions to be modelled.	4.3
4	Present early on examples of model results to improve communication.	4.3
5	Appoint a mediator to interface/translate between planners & modellers.	4.3
6	Define a validation method, based on feasibility, local context & support.	4.2
7	Apply full lifecycle costing to the modelling instrument	4.1
8	Implement model instrument use early on in the planning process	4.1
9	Apply modelling procedures (steps) that are logical to practitioners.	4.0
10	Maintain documentation to sustain model use & future enhancements.	4.0
11	Communicate model results with associated uncertainties	4.0
12	Communicate the theoretical foundations of the modelling instrument.	4.0
13	Select stakeholders to purposefully participate in the modelling process.	4.0
14	Associate model changes with a model version & model results.	3.9
15	Select an appropriate model system with a proven track record.	3.9
16	Define uncertainties around model specification, validation & results.	3.9
17	Justify the extent of the study area to be modelled.	3.6
18	Explain the rationale behind various policy options to modellers.	3.6
19	Communicate the strengths & limitations of the modelling instrument.	3.4
20	Develop a modelling project plan as a basis for reporting to stakeholders	3.4
21	Validate initial cost with similar modelling projects elsewhere.	3.4
22	Select an easy to use modelling instrument that fits the purpose	3.3
23	Conduct quality tests & validate derived data, prior to running simulations.	3.2
24	Determine confidence of stakeholders in the model results.	3.1

From the responses, ensuring leadership and management support for a modelling project were perceived to provide the highest contribution to meeting the modelling issues. Model requirements aimed at improving decision-making, communication and the confidence of participants, prior to the start of model design, development and implementation, all received high ratings. These include the need to develop a project plan, collecting data in advance, and applying lifecycle costing to the modelling exercise. But central to all of this is the need to appoint/nominate a mediator that can serve as an interface/translator between planners and

modellers, preferably someone with extensive experience in model development and planning in government.

Conclusion

Debates on the value of modelling in planning practice are not new. Throughout this debate, however, the scientific community and modellers have developed techniques that have improved the predictive abilities of models. These efforts have added to the array of modelling instruments potentially available to planning practitioners. However, it needs to be asked whether planning practice is indeed better off today because of these recent advances in modelling practice and technology? There is good evidence to suggest that the place of modelling in planning and sustainability assessment practice remains problematic after four decades of efforts in bringing the two fields closer together. This is evident when studying the Planning Support System (PSS), integrated assessment and modelling literatures

Our results suggest that in the Australian urban modelling context, the view of modellers and planning practitioners are much in line with the international literature in terms of what are the key challenges confronting such activities. What was perhaps more noteworthy was the ratings given by the panel members and the significant emphasis they placed on data preparation and on mutual understandings between planners and modellers of each other's domains, as the most important modelling challenges. This suggests that, firstly, the ever-present problem of data availability and useability remains a concern, at least for this cohort when considering urban modelling at the local scale. Secondly, it appears collaborative, participative modelling approaches, that generate mutual learnings between planners and modellers, are a likely way forward for improved urban analysis. Admittedly, the panel involved only one group of practitioners from a single large local government authority, but the study findings suggest that improved models derived from the academy may not translate into better practice in the field, unless the procedural dimension of modelling activities is improved.

The ultimate test of model applicability for the challenging tasks in planning and sustainability assessment can only be achieved through stakeholder involvement. This requires a continuous, participatory process of social learning. Model experts have to make the underlying assumptions, functions and results of their tools as transparent as possible.

Planning practitioners and stakeholders need a minimum level of training to understand basic functionalities and model outcomes as well as the possible consequences of underlying structural choices and paradigms. We suggest this training may involve exposing university planning students to urban models, professional development activities for graduate planners, as well as training within agencies. Stakeholders must also become aware of the trade-offs between model specialisation and integration. Models with broader thematic coverage required for planning and sustainability assessment may not at the same time provide all the levels of details expected by a single stakeholder.

Finally, for the integration of modelling activities in planning practice to be successful, we claim that a shift in attitude within both the modelling and the planning communities are needed. To modellers, this means making models more understandable and improving the measurement and communication of uncertainty and model limitations, promoting the use of models as communicating, learning and exploratory tools. For planners this means a shift in perceptions, to view modelling not as a way of achieving certainty but as a device to inform planning and policy development in an uncertain world.

The results of this study are informing the development of an urban sustainability assessment framework. The framework will show how strategic planning, multi-agent based modelling and stakeholder participation can be integrated into a framework to structure policy making on land use and infrastructure delivery. The next cycle of case study work will use a modelling instrument to analyse policy scenario options with planning practitioners as part of the framework development.

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