Embedding Urban Growth Modelling in Planning Practice

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Abstract: In recent years, local government land use planning practices have evolved from conventional land use planning to include integrated urban growth and infrastructure management approaches. Urban growth models are increasingly being used to inform the decision-making process and infrastructure planning practice. However, models tend to be non-market based and generally "once-off" applications with a single purpose, rather than dynamic applications that render ongoing planning support. As a consequence, management support and the use of these models by planners remain marginal. UrbanSim is a software-based model system that treats urban development as the interaction between market behaviour and government action and has been under development since the late 1990s. A number of papers describing the application and inherent workings of UrbanSim have appeared in the formal and grey literatures, but the way in which UrbanSim gets embedded in planning practice has remained largely ignored and poorly understood. Based on data from a case study implementation of UrbanSim in Logan City, this paper describes how UrbanSim is applied for use in Australian planning practice. Summary outputs of an UrbanSim model are provided, but the main focus of this paper is how the model system and outputs are perceived by planning actors. Findings suggest that a technical focus is insufficient to improve the implementation of the model. The key obstacles are centred more towards "soft issues" such as a lack of transparency and poor connections to the planning process. The paper concludes with a discussion that offers potential remedies for these shortcomings.

1. Introduction

The integration of infrastructure and land use planning presents difficult decisions when planning for urban growth. Large single owner development areas involve little, if any, identification of privately owned land for infrastructure requiring acquisition by government to the extent that it impedes future development of the property (e.g. greater than 50% acquisition). In comparison, government undertake the lead planning role in areas with high land ownership fragmentation that can involve acquisition of entire properties (e.g. urban infill and redevelopment). It is in this latter context that the integration between land use and infrastructure planning are often absent, which in turn produces suboptimal and often unviable plans, ideas and concepts. Common weaknesses include a failure to provide sufficient detail on the infrastructure requirements of the land use plan, insufficient evidence that the market is willing or able to take responsibility for delivering relevant infrastructure requirements, in some cases leading to overly optimistic and/or unrealistic land use plans with a narrow conceptualisation of infrastructure requirements. Generally, once a plan has been adopted, the process of developing or amending an infrastructure plan commences. The problem arises when subsequent market behaviour and revenue flows contradict the policy intent reflected in the land use plan.

Several barriers seem to explain this lack of integration. These may be roughly divided into institutional / procedural obstacles (i.e. separate planning institutions and financial arrangements) and substantive differences (i.e. different planning objects, different time horizons)(Curtis and James, 2004; Hull et al., 2006). As far as substantive barriers are concerned, general insights and suggestions for improvements have produced a host of indicators and instruments that attempt to bridge the divide between land use and infrastructure planning, often based on integrated land-use-transport (LUT) models (Geurs *et al*. 2006, Waddell, 2010).

This paper discusses the results of research into improving model use in planning practice. The research forms part of a broader research agenda into the development of an Urban Sustainability Assessment Framework, where modelling activities form an integral part of Framework application. 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 (see Couclelis, 2005; Geertman 2006; Vonk *et al*, 2005), impact assessment and modelling literatures, scoped to the problem of land use policy assessments for urban sub-regions of large Australian cities.

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 does not provide detailed realistic visual representations of urban environments through three-dimensional (3D) modelling or illustration (e.g. *CommunityViz*). Rather, the type 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. 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 beyond the scope of this paper.

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. PSS is a term which bring together the functionalities of geographic information systems (GIS), models and visualisation, to gather, structure, analyse, and communicate information in planning. A common theme is that planning practitioners remain uncommitted and have never fully embraced the use of models.

In Australia, Pettit and Pullar (2004) used a range of 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). 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). 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.

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, particularly in planning 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. The lack of model use by planning practitioners produces several questions: why are existing model instruments not used/usable in planning practice? What context-specific demands for information support are important? How can existing modelling instruments be improved?

2. Aims

In response to these questions, the research agenda involves adapting and using with practitioners a modelling instrument. A design-based research (DBR) study is undertaken that "blends empirical research with theory-driven design" (Design-Based Research Collective, 2003, p5). Previous case study work in 2011 involved a panel survey, which explored what planners and modellers believed to be key modelling implementation issues, their perceived importance and a set of modelling requirements. (see Brits, *et al*., 2013). This paper contains the results of the second cycle of case study work in 2013. The case study involved the application of a modelling instrument and a panel survey around three principle areas of interest: model use in planning practice; Urbansim as a modelling instrument and model results.

3. Case Study Area

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. The research was conducted in Logan City, South East Queensland. Logan City is currently the sixth largest local authority in Australia with a population of just over 280,000 (ABS, 2011). Land use modelling plays a central role in forecasting the future demand for infrastructure networks and services in Logan City. Logan City uses a development projections model[1] that forecasts the amount of residential and non-residential land required to satisfy target estimated residential population and employment totals. Model results inform the development of a Priority Infrastructure Plan (PIP). The use of the model by planners remains "marginal" with a single purpose and does not render ongoing planning support[2].

4. Method

Silva & Wu (2012) describe a variety of modelling instruments that could be employed by planners. UrbanSim was chosen for the study. The method of adapting UrbanSim is outlined below.

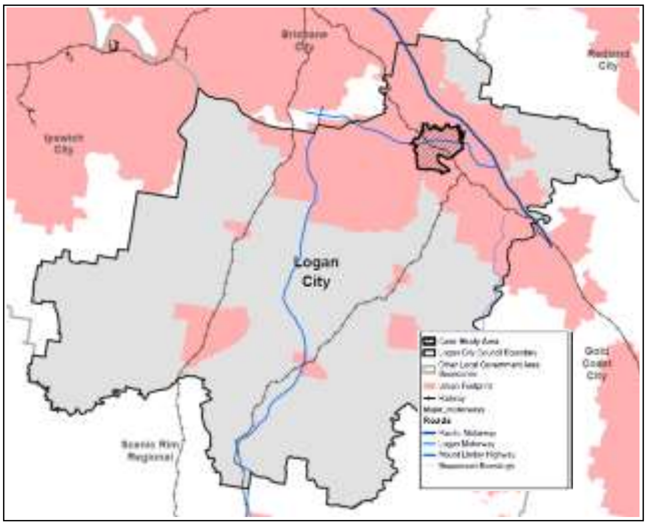
Adapting the UrbanSim

The process of adapting UrbanSim over two years involved data preparation, model estimation, validation, scenario development and forecasting. Designed by Prof. Paul Waddell of the University of California, UrbanSim is a rapidly evolving integrated transportation land use model system and has been under development since 1996. Licensed as open source software, a copy can be downloaded from www.urbansim.org. The model system has been implemented at several locations in the United States and more recently internationally (De Palma *et al*., 2005; Patterson *et al*., 2007,).

Data preparation

UrbanSim requires large amounts of detailed data. Using readily-available data and limiting the size of the area to be modelled seem most logical. Figure 1 shows the location and spatial extent of the modelling area. The area consists of the suburbs of Loganlea and Meadowbrook, comprising in total 6,400 parcels. Several land use policy options are under consideration for the future development of the area.

Figure 1: Modelling area



[1] The development projections model, including its associated planning assumptions, has been documented by the Logan City Council. Upon completion of this paper, these documents were considered as confidential, only to be released at a future date.
[2] These are perceived limitations that were observed by the author and do not reflect in any way the views or opinions of any member of staff at Logan City Council.

The establishment of a base-year database forms the backbone of UrbanSim. A base-year database contains a snapshot of the base information defining the initial state before the UrbanSim simulation. The relational database (MySQL) contains exogenous data, primary data, model coefficients, model specification and data classifications. Table 1 contains a simplified overview of the database tables according to data content. The research adapted the parcel-based version of UrbanSim, using the example data of Seattle as basis. Data preparation took four months and focused on "six" main tables, without which most models in UrbanSim cannot run. These tables are: parcel; buildings; household; persons, jobs and travel. UrbanSim contains several geographies for aggregation, analysis and visualisation. These include large area; zones; grid-cells; county and city. Cadastre data were obtained from the Department of Natural Resources and Mines, Queensland Government. Other parcel and building related data were obtained from Logan City Council.

Table 1: Table categorisation according to data content

Simulation Tables: ▪ Parcel ▪ Buildings ▪ Households ▪ Persons ▪ Jobs ▪ Travel data (zone to zone skims) ▪ Development project proposals (user defined / simulated)	Definition Tables: (a) Planning assumption / boundary conditions: ▪ Annual control totals for households and employment ▪ Annual relocation rates for households and jobs ▪ Target vacancies ▪ Plan types (land use zoning and precinct classes) ▪ Development constraints ▪ Building square feet[3] per job ▪ Demolition cost per square feet ▪ Velocity functions (b) Classifications: ▪ Building types ▪ Employment sectors ▪ Land use types (c) Templates: ▪ Development templates
Model Estimation Tables: ▪ Household location choice ▪ Home based employment location choice ▪ Non-home based employment location choice ▪ Real estate price	

Model specification and estimation

The individual model components of the UrbanSim must be specified. UrbanSim simulations rely upon three sub-models:

(a) Real Estate Price Model (REPM), a linear regression model, predicts the probability that a location will experience a real estate development event over a one year period, given the characteristics of the location and the market conditions.
(b) Household Location Choice Model (HLCM), a multinomial logit model, predicts the location choices of households from available (existing and vacant) housing units
(c) Employment Location Choice Model (ELCM), a multinomial logit model, predicts the location choices of jobs from available job spaces.

Each model is specified by defining a set of variables. These either directly reference values in the base data, or are calculated using data fields. Table 2 contains the estimation results of the three sub-models.

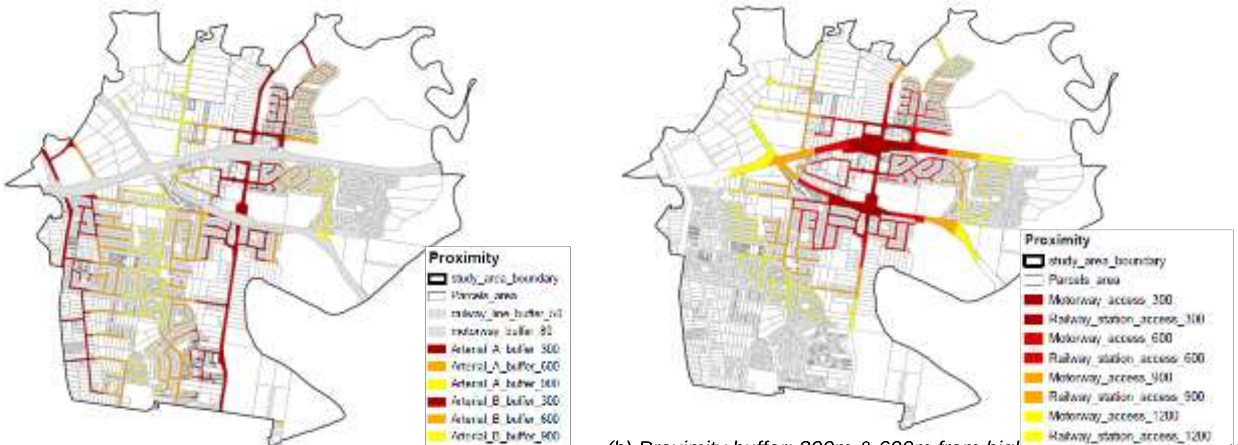
Real Estate Price Model (REPM) provides a key input to the land development, household and employment location choice models. Real estate price is modelled by using hedonic regression on attributes such as land use type (i.e. residential, retail, commercial, industrial land uses), site characteristics, access variables, neighbourhood and zoning characteristics. UrbanSim implicitly assumes that households, businesses, and developers are all price takers, and annual price and development adjustments help match aggregate supply and demand over time. Table 2 suggests that an increase in commercial floor area, total employment, population density, percentages of commercial and developed lands are associated with higher land prices, whereas the presence of industrial and open space within walking distance (600m) of a residential parcel are associated with lower land prices. Such signs are consistent with behavioural expectations.

[3] Adapting UrbanSim for Australia required the conversion of area from square feet to square metre and acre to hectare.

Table 2: Estimation results of sub-models for Meadowbrook

Variable	REPM		HLCM		ELCM	
	Coefficient	*t-stats*	*Coefficient*	*t-stats*	*Coefficient*	*t-stats*
housing cost	-	-	- 0.195	- 22.75	-	-
average income for households in zone	-	-	+ 3.19E-06	+ 8.51	-	-
acres of open space	-	-	+ 0.165	+ 7.56	-	-
distance to nearest arterial	-	-	+ 0.16	+ 6.89	-	-
distance to nearest highway	-	-	+ 0.0852	+ 5.88	+ 0.0566	+ 3.8
distance to nearest station	-	-	+ 0.23	+ 4.73	-	-
total land value	-	-	- 0.03	- 4.9	-	-
number of jobs	+ 0.256	+ 128.55	-	-	-	-
access to employment for households with one car	-	-	+ 0.721	+ 12.58	+ 5.22E-04	+ 1.84
% service sector employment within 600m	-	-	-	-	+ 0.1628	+ 7.82
square ft of commercial floor area	-	-	-	-	+ 0.04553	+ 76.79
square ft of industrial floor area	-	-	-	-	+ 0.0912	+ 137.44
population	-	-	+ 5.98	+ 13.58	-	-
travel time to district centre (on network, in a.m. peak period)	-	-	+ 0.029	+ 7.12	- 0.029	- 2.84
% industrial household within 600m	- 0.0178	- 24.15	-	-	-	-
% commercial household within 600m	+ 0.01588	+ 48.79	-	-	-	-
% developed land within 600m	+ 0.0245	+ 118.44	-	-	-	-
% open space within 600m	- 0.0129	- 52.66	-	-	-	-
population density (person / acre)	+ 0.0866	+ 92.78	0.0855	97.99	-	-

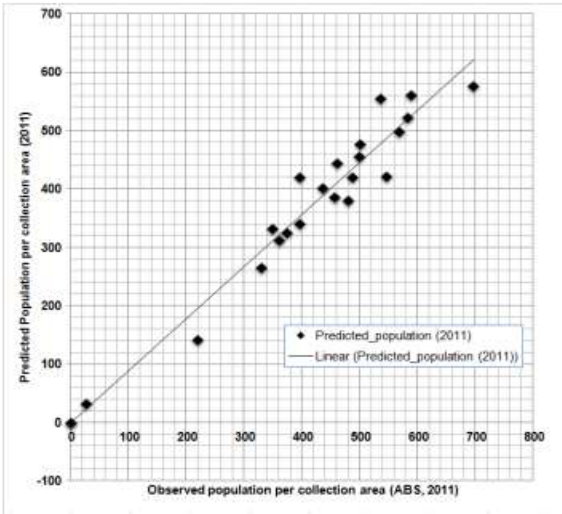
Figure 2: Model specification: access to arterials, highway and railway station



(a) Proximity buffer: 300m & 600m from main arterials

(b) Proximity buffer: 300m & 600m from highway and railway station

Figure 3: Model validation



Household Location Choice Model (HLCM) gets informed by two sub-models, a transitional model and a relocation model. The transitional model generates a list of households to be added to or subtracted from the set of existing households, due to demographic processes like ageing, marriage, divorce, births and deaths. The household relocation model generates vacant spaces when households are selected to move and adds all movers to the list of unplaced households. Although the probability that a household moves should depend on the relative attractiveness of alternatives, compared with the current dwelling, this presently is controlled by exogenous relocation probabilities, specified by the user. A probability rating between 0 and 1 is defined for each age and income category of household. Table 2 suggests that increases in housing and land costs and the share of land in residential use negatively impact a parcel's residential location utility, everything else constant. In contrast, variables such as income of current residents, open space, proximity to arterials and highways, accessibility to local employment, population and travel time to the district centre are predicted to have a positive impact on a parcel's utility. The positive signs on distances to arterials and highways and on the district centre travel times are not intuitive, but offset by the positive benefits of the jobs accessibility values of almost all locations.

Employment Location Choice Model (ELCM) is similar to its household location choice model. A transition model generates or removes the newly created jobs in each sector, depending upon the growth or decline of employment in that sector (compared with the previous year). Estimation results in Table 2 suggests that increases in commercial and industrial floor area, distance to the nearest highway, number of service jobs within "walking distance" (600m, Euclidean from parcel centroid) positively impacts a parcel's attractiveness. UrbanSim requires data on home-based jobs to run. However, Meadowbrook does not have such data, so this data set was manufactured by using a 2% of jobs per zone assumption. Estimates indicate a preference for larger, more expensive residencies close to arterial roads and highway. Although many parameters appear reasonable, others appeared to be at odds with actual trends because these job sites were randomly selected. This should not greatly affect the overall forecasts because only 2% of the modelled population works from home (Bayles *et al*. 2002).

Model validation

Model validation compares the performance of a model system or its components to data sources available relating to the observed state or actual conditions the model system is trying to represent. For validation, a baseline scenario for the years 2007 to 2011 was simulated. The time interval for each simulation was set to 1 year. Figure 3 presents the efficiency of the model in predicting the population at 2011. When comparing the predicted population with the observed population from ABS 2011 Census the model system produced reasonable results.

Scenario specification

UrbanSim is designed to simulate and evaluate the potential effects of multiple scenarios. A scenario is defined by UrbanSim as a combination of input data and policy assumptions to the model system. Two scenarios were developed to simplify comparison and presentation. Table 3 contains a summary of the two scenarios.

Table 3: Urban growth scenarios

Assumption	Scenario 1	Scenario 2
Description	Baseline / Business-as-usual	Increased Urban Compaction
Main policy consideration	Land use policy configuration as contained in the Logan City Planning Scheme (2006)	Land use configuration based on residential infill targets and TOD principles contained in the Loganlea Neighbourhood Plan (2011)
Base year	2006	2006
Simulation years	2007 - 2041	2007-2041
Annual population growth (%)	1,5%	5%
Annual employment growth (%)	1,5%	3%
Annual relocation rates for households	Low probability for all ages and income groups	Increased probability for relocating for ages 18-34 with moderate-high incomes
Target vacancies per building type	5% for all building types	5% for all building types
Land use (plan) types	Logan City Planning Scheme (2006)	Loganlea Neighbourhood Plan (2011)
Development policy constraints	Logan City Planning Scheme (2006)	Loganlea Neighbourhood Plan (2011)
Building floor space per job	Various	Unchanged
Demolition cost per building type	Constant for all building types @ \$50 / m^2	Constant for all building types @ \$50 / m^2
Velocity functions (construction schedules)	Various	Unchanged

The baseline scenario contains assumptions against which scenario two are compared. The land use configuration and policy settings contained in the Logan City Planning Scheme (Logan City Council, 2006) were used to develop the baseline scenario. Land use classes were translated to reflect the latest land use definitions of the Queensland Planning Provisions (Queensland Government, 2011). Scenario two contains the main policy considerations outlined in the Loganlea Neighbourhood Plan (2009-2031). Using transit-orientated development (TOD) principles, the Loganlea Neighbourhood Plan proposes increased residential development opportunities close to Loganlea station. The plan aims to facilitate the delivery of approximately 2,490 dwellings to accommodate some 5,730 residents by 2031, using a mix of high, medium and low residential precincts.

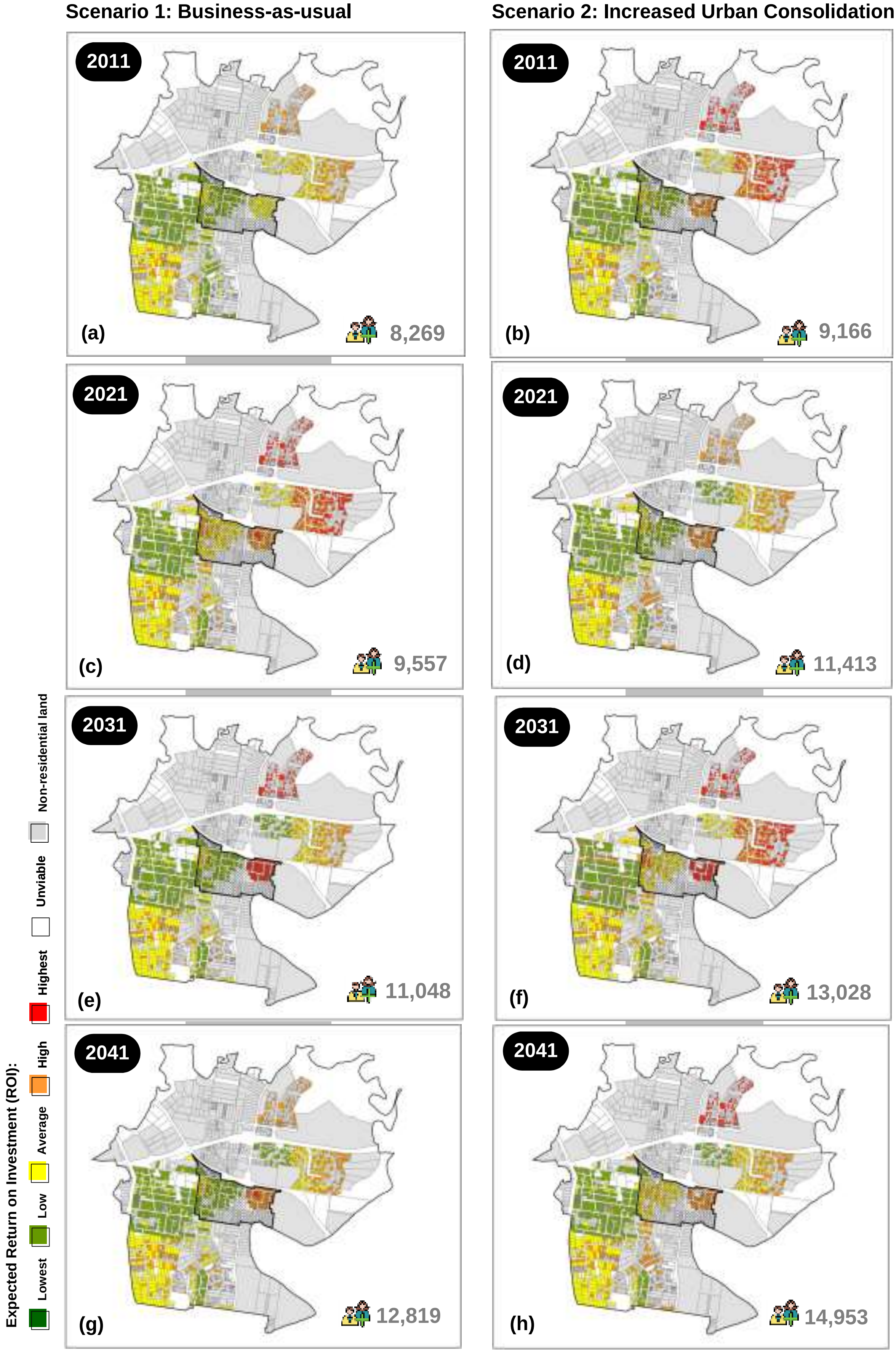
5. Summary results from UrbanSim

Figure 4 contains the simulation results for the two scenarios. The Loganlea neighbourhood planning area (darker hatched area) is shown for comparison. Only residential land uses are displayed. Non-residential land uses (industrial, commercial, retail, education, health, etc.) and areas that are undevelopable (e.g. flooding) have been greyed out to simplify visualisation of scenario results.

Scenario one suggests that, with the current land use policy settings, the expected return on investment across the entire Loganlea planning area will be the highest in 2021 (Figure 4c). In comparison, the introduction of higher residential densities in scenario two will delay expected higher returns on investment for the same area by almost 10 years, only to be realised in 2031 (Figure 4f). Noteworthy, are the higher returns on investment in surrounding areas (Figure 4b - north-eastern residential areas). It is only by increasing the population growth from 1.5% to 5% per annum, that a more favourable return on investment is achieved in the target planning area by 2031 (Figure 4f). Without a substantial increase in residential demand (well beyond the current population growth of 1.5% per annum), the area of compaction is unlikely to attract higher levels of investment by 2031.

The results are consistent with behavioural expectations in the area that are characterised by low residential densities, an abundance of developable land, low population growth and the demand for single detached housing. Scenario two succeeds in increasing the capacity over the long term by providing for an additional 2,134 equivalent persons by 2041. From the simulation results, it became evident that UrbanSim is useful in highlighting some of the spatial and temporal consequences of different land use policy options.

Figure 4: Predicted return on investment



6. Workshop panel responses

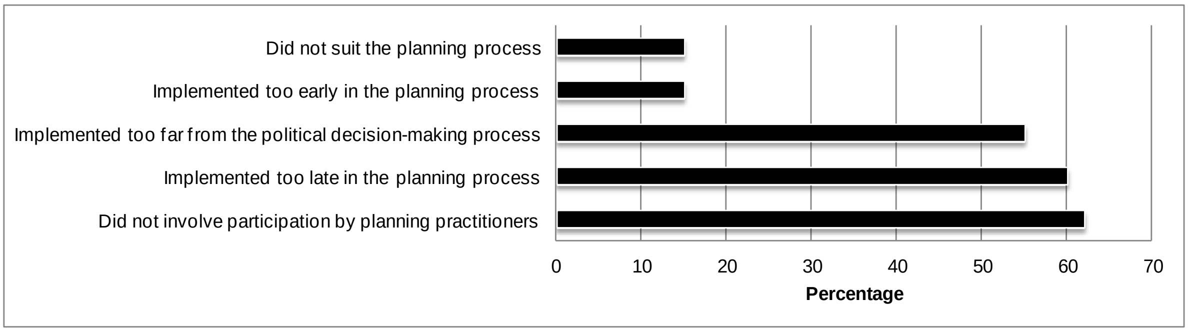
UrbanSim and the scenario results were presented to a panel of planning practitioners. Participation was entirely voluntary and the panel comprised sixteen planning practitioners (2 transport orientated, 7 land use, 2 social, 2 economic development, 2 infrastructure and 1 environment) from the local government, who had varied experience in developing and using models. The panel was asked to participate over a period of one month in one workshop event and informal interviews.

During the workshop, participants were tasked with completing a structured questionnaire. The first part of the questionnaire built a profile of those that were participating in the research. The second part asked questions around modelling in general and the third sought views on the use of UrbanSim in planning practice. Although the survey was anonymous, respondents were required to specify their primary work domain and their organisational group. For most statements, respondents could distinguish between "strongly agree", "agree" "neutral", "disagree" and strongly disagree". Open questions were mainly used to interpret the results and to provide in-depth justification of problems and possible solutions. Significant results are discussed below.

General views concerning modelling in planning practice

Figure 5 illustrates the level of agreement with statements that reflect views on implementing models in planning practice. The majority of respondents felt that modelling instruments are implemented too late rather than too early in the planning process and did not involve sufficient participation by planning practitioners. In addition, participants felt that modelling instruments are implemented too far from the political decision-making process. Only fifteen percent of respondents were supportive of the view that modelling instruments do not suit the planning process. The low level of concern with the modelling instrument contradicts continuing efforts by the modelling community towards improving there model systems. Rather, it confirms the widely held view of models being developed too far from planning practice and decision-making, not involving and providing practitioners with enough insight into crucial model relationships and model assumptions.

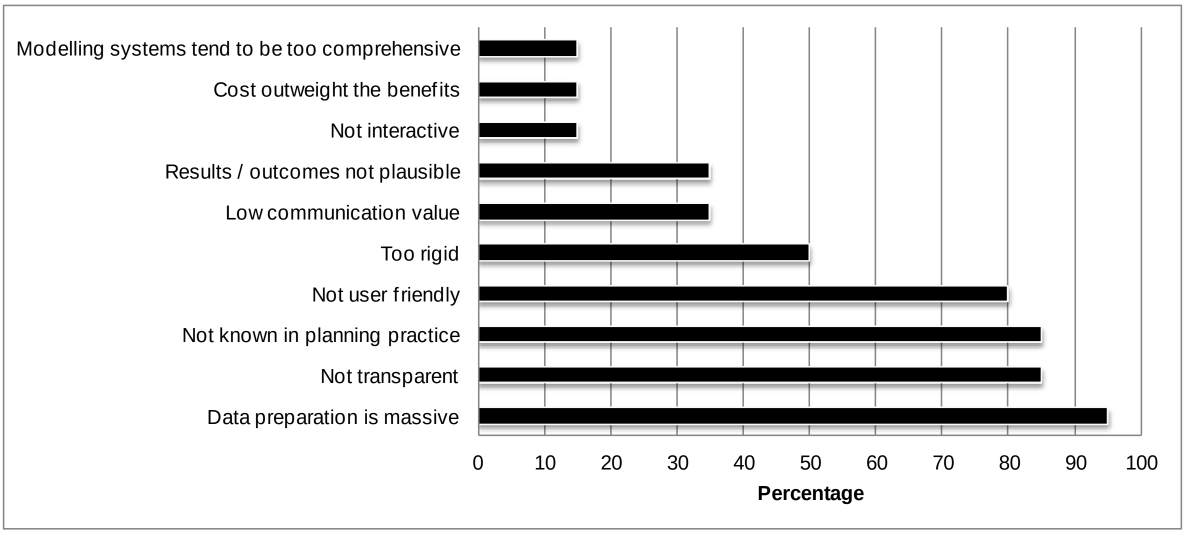
Figure 5: Implementation of modelling instruments in the land use planning process



Next the panel rated a list of known implementation bottlenecks (Figure 6). From the results it is clear that besides data preparation that remains to be seen as a major obstacle (95%), more than 80 percent of the respondents felt that available modelling instruments are unknown in planning practice and continue to be viewed by practitioners as not user friendly and not transparent. Off less significance were modelling results that are seen as not plausible (less than 40%), which contradicts the view that models tend to be not transparent (85%).

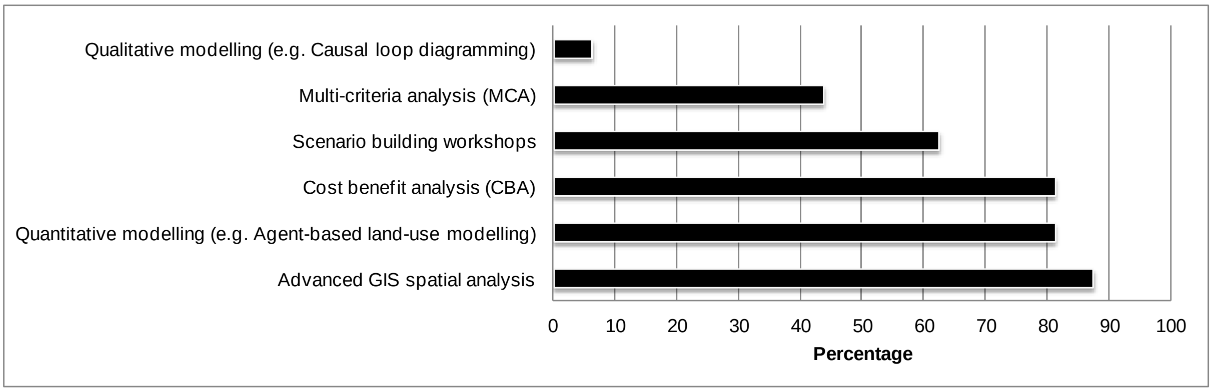
From follow up informal interviews it became apparent that it is not the technological qualities of the modelling instrument that is an obstacle, but rather soft problems around the adaptation of the instrument to the planner's demands (i.e. user friendliness, transparency and generally not known in planning practice) that remain a major bottleneck. Adding to the lack in transparency is the absence of making assumptions explicit and communicating calculation method(s) with model results in ways that planners can understand. This echoes previous research around the fundamental problems of computer models in planning, already recognised in Douglas Lee's "Requiem (1973) and recently explored by Vonk (2006 and Brömmelstroet (2010).

Figure 6: Bottlenecks to model implementation



The panel was tasked to select from a list of known planning support instruments what they considered to be useful in practice (Figure 7).

Figure 7: Planning support instruments



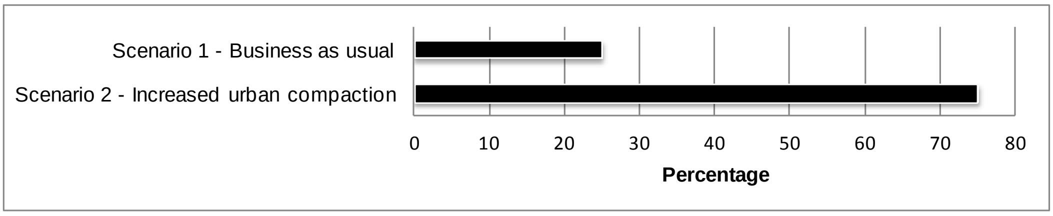
From the responses, more than 80 percent of the respondents felt that advanced GIS spatial analysis, quantitative modelling (e.g. agent-based land use modelling) and cost benefit analysis are useful. Causal loop diagramming, as an example of qualitative modelling, received the lowest score at 6 percent. A causal loop diagram is a simple map of a system (e.g. an urban system) with all its constituent components and their interactions. By understanding the structure of a system, it becomes possible to ascertain a system’s behaviour over a certain time period. (Lane, 2008). Investigations revealed that many of the participants did not know what causal loop diagramming is and its potential use. In addition, panel members indicated the importance to provide for better integration between planning support instruments.

Views concerning UrbanSim

A demonstration of the UrbanSim was done followed by a presentation on the results of the two scenarios. The panel was tasked with completing the third part of the questionnaire. Part three included statements around the scenario that most appealed to the panel; planning activities potentially benefiting most from the model; performance of UrbanSim; and aspects likely to increase the confidence of planners to use UrbanSim more often (Figures 8-11).

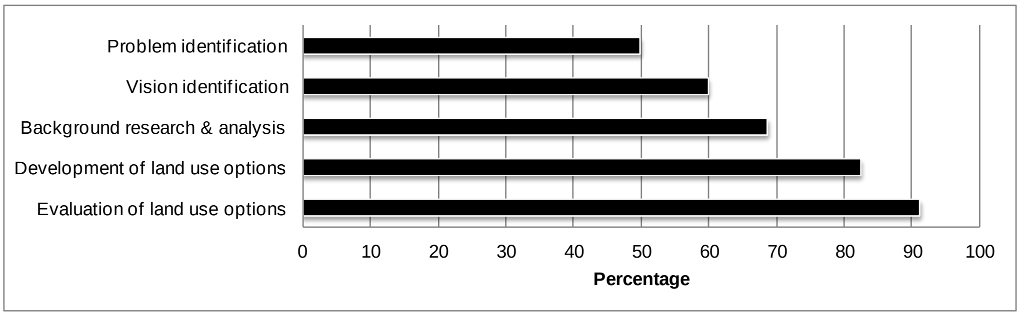
Modelling results for the urban compaction scenario were seen as most valuable and rated the highest at 75 percent (Figure 8). UrbanSim's ability to expose linkages and relationships between the area of compaction and its surroundings where found to be most useful, highlighting the spatial and temporal implications of urban compaction on infrastructure delivery.

Figure 8: The most valuable scenario results



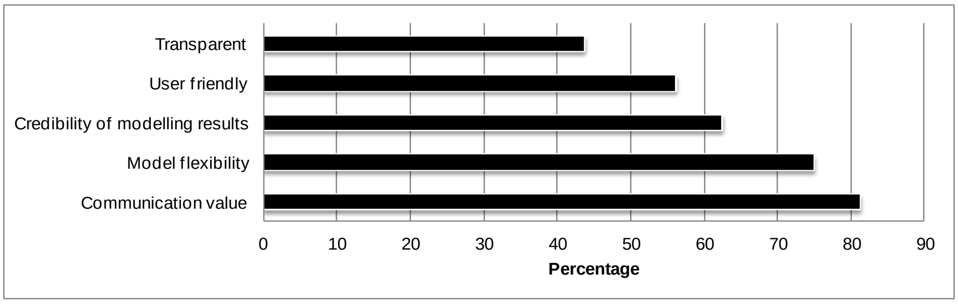
Next, respondents were asked what planning phases will benefit most from UrbanSim. More than 90 percent felt that the development and evaluation of land use options will benefit the most and phases, such as problem identification and vision formulation, will benefit the least (Figure 9). This serves as one of the reasons why modelling instruments, such as UrbanSim, tends to be implemented too late in the planning process.

Figure 9: Planning phases benefiting from UrbanSim



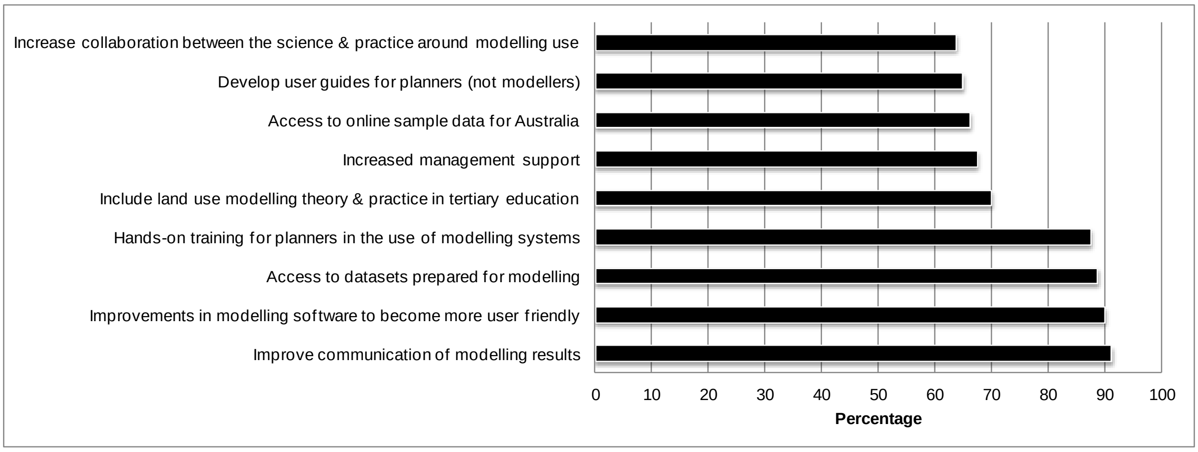
Views of respondents on a set of model performance indicators were tested. Respondents felt that UrbanSim appeared to be not transparent or user friendly scoring 43 and 56 percent respectively. In comparison, more than 70 percent of the respondents felt that UrbanSim is performing well on communication and the ability to cater for different user requirements (Figure 10). The high score on communication value was achieved by performing mapping and visualising of model results in an external GIS.

Figure 10: Performance of UrbanSim



Next the questionnaire listed actions that could help to increase the confidence of planners to use modelling instruments (Figure 11). All actions received a score of more than 60 percent implying that all are considered appropriate. Improved communication of modelling results, access to datasets for modelling; user friendly modelling software and hands-on training were viewed as the most important by more than 85 percent of respondents.

Figure 11: Increasing the confidence of planners to use UrbanSim



7. Conclusion

This research builds upon the body of literature which deals with the unsatisfactory application of modelling instruments in planning practice. It seeks to deepen the understanding of a modelling instrument; provide user-orientated insights into the attitudes towards modelling instruments; and explore avenues for improvement.

The work describes UrbanSim as a modelling instrument and the results of two distinctive land use policy scenarios for Meadowbrook at a parcel-based spatial resolution. Key stages of UrbanSim use are data preparation, model estimation, validation, scenario development and forecasting: these required approximately 60, 20, 5 and 15% of the total time to adapt UrbanSim. It took one person, two years to adapt and apply UrbanSim to the Meadowbrook area, yet various data and model enhancements are still desired before applying the model system to an entire city-region. The greatest challenge for UrbanSim users lie in data preparation. A variety of challenges also lie in the model estimation process. For example, limiting the size of the modelling area can result in a lack of statistical and practical significance or odd behavioural implications. In this regard, modellers need to be vary of which covariates make it into the final model selections and their underlying estimations.

UrbanSim's results seem unusually stable in this study across the two scenarios with the exception of a substantial increase in population for the study area under scenario two. Such stability is better than having changing results, which emerge quickly in unconstrained gravity model applications (e.g. Zhou et al., 2009). This feature no doubt emerges from UrbanSim's tight connections between land, buildings, jobs and households, but it may be an indication that the model (calibrated for Meadowbrook) is inadequately sensitive to policy changes due to the small size of the modelled area. Expanding the modelling area may generate a slightly different set of results.

The paper reiterates the consensus on the need to improve user friendliness of modelling instruments for planning practice. Model developers should not only focus on scientific rigor, detail and comprehensiveness. The respondents low level of concern for the technical challenges faced by most modelling instruments contradicts continuing efforts by the modelling community towards improving these technical aspects (i.e. improving the credibility of modelling results). UrbanSim seem better suited for phases found later in the planning process, such as assessing the effects of existing and proposed land use policies and providing background information for discussions.

In an attempt to improve model use and integration, conceptual frameworks, incorporating both supply- and demand-side aspects have been proposed to help learn where implementation bottlenecks are and to pose ways of solving them (Geertman, 2006; Vonk and Geertman ,2008). However, much needed work remains to be done in grounding these frameworks, thereby increasing the prospect of application. For example, additional processes and procedures need to be designed, as part of a comprehensive modelling support solution to suit phases earlier in the planning process. In this regard, combining known planning support techniques, such as causal loop diagramming and cost-benefit analysis with land use modelling is viewed favourably by planning practitioners.

In conclusion, there is a need to develop strategies that will improve information, support and use of modelling instruments by planners. In this regard, model instruments should function as laboratories where planners can collectively experiment and take part in learning around urban behaviour. Building on this experience, they can improve integration of land use and infrastructure planning that is more responsive to changes in the urban environment.

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