Scenario Planning Software Tool Review

A Report for the WA Department of Planning

By Curtin University

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Acknowledgements

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Citation Information

This document should be referenced as follows:

Executive Summary

Background
The Western Australian Department of Planning (DoP) identified the need for additional decision support capability regarding land use and infrastructure planning using current, leading scenario modelling software tools. The DoP has identified a broad range of scenario planning needs at the state, regional and local scale associated with social, economic and environmental concerns. This review of land-use scenario planning and modelling software conducted by Curtin University will assist the DoP with identification of appropriate planning software tools. Effective use of appropriate planning software can enhance stakeholder engagement and assist with justification of planning decisions through evidence based decision making.

Objectives
The review includes both business aspects and technical issues regarding various scenario modelling software. The project objectives are as follows:

1. Identify the scope of scenario planning tools relevant to State-wide, regional and local planning for multiple land uses.
2. Include assessment of existing modelling tools in terms of their role/relevance within a statutory modelling environment.

Approach
Information regarding planning needs and data issues was gathered through interviews and meetings with DoP staff. Assessment of the scenario modeling tools was based on comprehensive first hand review of the software tools, contact with software developers and published information. Criteria included in the assessment were as follows:

<table>
<thead>
<tr>
<th>Technical considerations</th>
<th>Acquisition and use</th>
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<tbody>
<tr>
<td>Software tool design</td>
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<td>Model architecture.</td>
<td>• What type of research questions can be addressed?</td>
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<td>Modelling mathematics (e.g. dynamic or static, strategic or tactical, empirical or theoretical).</td>
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<td>Hardware and software requirements.</td>
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<td>Spatially explicit/visual?</td>
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<td>Ability to draw on different databases.</td>
<td>• Cost of associated supporting services.</td>
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Findings

Interview main points
• There are two broadly stated needs from planning software tools:
  1. A need for scenario planning at different scales to generate the range of possibilities associated with different planning options.
  2. A need to visualise planning options and infrastructure at different scales.
• There is a perceived need to enhance capacity for identifying clear and concise questions in the initial stages of planning – this is central to identifying what data is needed and what planning software tools could be used reliably and accurately.
• DoP data varies in quality, timeliness and scale, this affects the capacity for using planning software tools.
• There is pressure from short time frames for planning outputs versus the amount of time required for data acquisition and updating modelling software tools.
• There is a perceived need for more effective communication within the Department between data managers and planners.
• There is potential for DoP staff to network with planning and data professionals outside the DoP to enhance capacity and knowledge regarding current planning tools and methods.

Scenario planning software tool assessment
• Most software tools reviewed include first order effects only, rather than the more complex feedback loops required for effective strategic scenario planning.
• Most tools are specialised and focused on a ‘part’ of the big picture (water, vegetation, transport).
• Most are based in ArcGIS.
• Many software tools require some input from the tool developer for effective use.
• Expect to interact with the model developers rather than buy a stand-alone tool in most cases.

Software tools with average assessment scores of at least 2.5 or greater [0-poor, 5-excellent]

<table>
<thead>
<tr>
<th>Software Tool</th>
<th>Avg score</th>
<th>Lowest score attributes</th>
<th>Highest score attributes</th>
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</thead>
<tbody>
<tr>
<td>CUBE – urban transport networks</td>
<td>3.5</td>
<td>Cost</td>
<td>Design quality, Documentation, Data flexibility, Publications</td>
</tr>
<tr>
<td>eWater Toolkit – hydrological systems modelling</td>
<td>3.1</td>
<td>Range of application</td>
<td>Publications</td>
</tr>
<tr>
<td>Whatif? – land use change and urbanisation</td>
<td>2.9</td>
<td>Dynamic, Range of application, Cost</td>
<td>User Friendliness, Data flexibility</td>
</tr>
<tr>
<td>CommunityViz - first order impacts of urban land-use change</td>
<td>2.8</td>
<td>Dynamic, Range of application, Cost, Publications</td>
<td>Design quality, Documentation</td>
</tr>
<tr>
<td>UrbanSim – complex urban systems and planning issues</td>
<td>2.8</td>
<td>Publications</td>
<td>Cost</td>
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<tr>
<td>ALCES – complex cumulative impacts of multiple land-uses</td>
<td>2.8</td>
<td>Cost</td>
<td>Dynamic, Range of application, Data flexibility</td>
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<td>INVEST - ecosystem service valuation</td>
<td>2.6</td>
<td>Range of application</td>
<td>Cost</td>
</tr>
<tr>
<td>MARXAN - nature conservation planning</td>
<td>2.5</td>
<td>Dynamic, Range of application</td>
<td>Cost</td>
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• CUBE is globally popular and advanced in transport network modelling but weak in other system level processes. It is relatively expensive to purchase.
• eWater Toolkit is a suite of hydrological modelling tools designed to assist with water management in relation to human and ecological impacts. Has a specific application but is well published.
• Whatif? appears to be a sophisticated land use change model with an intuitive interface. The primary limitation is that the model user defines all the land use scenarios and conversion rules. As such, the model appears to simply grow out the pattern that is defined by the user. In this sense it is useful to spatially depict the range of possible scenarios for envisioning land use patterns into the future.
• CommunityViz is an ArcGIS toolbox that estimates impacts of land use change and urban design. User friendly with good functionality but limited to simple 1st order impacts.
• UrbanSim represents common elements in urban dynamics and has significant ability to represent second and third order dynamics at a highly disaggregated scale. It uniquely uses micro-scale simulation to represent processes at different scales. The model is very complex and interaction with the developer would be expected.
• ALCES tracks multiple human and natural processes with complex feedback loops. It is spatially stratified and requires an add-on tool ALCES Mapper to be spatially explicit. ALCES requires engagement with the developer for effective use. It is relatively expensive to purchase.
• INVEST and MARXAN are inexpensive, effective tools but have very specific applications regarding ecosystem service valuation and nature conservation planning.

Conclusions

Communication

• There is a need to enhance capacity for identifying clear and concise questions in the initial stages of planning. This is central to identifying what data is needed and what planning software tools could be used reliably and accurately.
• Improved lines of communication within DoP, especially between planners and data managers, could enhance planning and data management processes and assist with development of clear planning questions.
• Providing opportunities for staff engagement with planning and data management professional networks outside DoP may also enhance data management and planning capabilities.

Scenario planning tools

• Given the absence of a single, effective all-purpose planning tool, there is a current need to access a range of urban and regional planning software tools to address the various planning requirements of the DoP.
• All planning software tools have their strengths and weaknesses in terms of functionality and use.
• There is a need for access to a regional to state-wide scale complex scenario planning tool for strategic planning purposes.
• There is a need for a comprehensive urban planning software tool able process the complex and wide range of factors that interact within the urban form.
• In the absence of this, there is a need for software tools with different planning strengths that can effectively and efficiently interface with each other and existing databases.

Scenario planning capacity

• A main consideration relates to specific project needs versus in-house capacity.
• Developing scenario planning capacity within DoP may assist with more effective planning as well as better identification, acquisition and use of required data.
• It is apparent that DoP may need to use a combination of in-house and outsourced skills and capacity to access the range of planning software tools required for addressing various land use requirements in different locations and scales.
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Introduction

The Western Australian Department of Planning (DoP) identified the need for an analysis of current, leading scenario software modelling tools that may provide additional decision support capability to land use and infrastructure planning within the Department. Scenario modelling underpins the Draft State Planning Strategy and is seen as an important tool for integrating a broad range of physical, social and economic issues into land use planning. An important component of scenario modelling for land use planning includes collaborative decision making and effective communication between stakeholders. This need was identified in the Regional and Urban Scenario Planning brief aimed at ensuring WA State Government investment results in value adding to DoP land use and infrastructure planning functions (Dept of Planning, 2010).

In this context, the DoP has identified a broad range of scenario planning needs at the state, regional and local scale associated with social, economic and environmental concerns. This includes questions regarding future infrastructure requirements, regional economic diversification, various social and demographic change indicators, environmental protection, climate change, future resource extraction developments, population dynamics and employment, housing needs and so on. This applies to WA regional areas such as the Pilbara and Kimberley as well as the more densely populated Perth and Peel regions. This complexity of scenario questions at a range of scales presents a planning challenge that could be facilitated by investment in appropriate scenario planning software tools and capability (Bunny, 2012).

Consequently, the DoP engaged Curtin University to undertake a review of existing scenario modelling software tools. The review includes assessment of the technical aspects and business models various tools operate under. This report aims to help guide future expenditure on spatial and non-spatial modelling tools. This will contribute to supporting the DoP’s strategic direction and to avoid unnecessary software duplication and the excessive spending of public monies. Effective use of appropriate planning software can enhance stakeholder engagement and assist with justification of planning decisions through evidence based decision making.

Objectives

The review scope includes both business aspects and technical issues regarding the scenario modelling software tools. The project objectives are as follows:

1. Identify the range of scenario planning tools relevant to state-wide, regional and local levels of planning for a range of needs.
2. Include assessment of existing modelling tools in terms of their role/relevance within a corporate modelling environment.
Approach
The project was conducted in close collaboration with the DoP and included desktop research and interviews with key contacts. Contacts include DoP staff and developers and users of software tools. A list of modelling software tools was identified for review based on expert knowledge, a database search and information provided by DoP. Where possible, the modelling software tool was directly assessed by a project team member. Where software was not accessible for use, due to proprietary issues or lack of public availability, associated technical and operational related information was gathered from published documentation and interviews with model developers and users.

DoP staff interviews
Interviews with DoP staff were conducted regarding planning, data management and modelling software use and needs. DoP staff were recruited by the DoP and allocated to a series of 30 minute time slots over the course of one day. Interviews were conducted by a project team member preceded by a brief description of the purpose of the review project and interview. The Interviews were discussion based using a loose framework of questions to guide conversation. Issues of importance and the general focus of discussions were also determined by participating DoP staff during the interview. Notes were taken during the interview and the information used to inform the assessment of tools in the context of DoP operational needs.

Modelling software tool review
The review of the modelling software included consideration of technical elements of the model itself as well as the practical and business related issues associated with acquiring and using the modelling software. Based on the project brief provided by the DoP, the main points for consideration are outlined in Table 1.

Table 1: Summary of modelling software tool attributes included in the assessment.

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</tr>
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<td>- Spatially explicit/visual?</td>
<td>- Amount and quality of tool documentation.</td>
</tr>
<tr>
<td><strong>Data requirements</strong></td>
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Direct assessment of the modelling software tools was based on the experience and knowledge of an expert project team member in combination with reviews of published material and information obtained from other users and the software developer. Findings were summarised in a table. A more detailed one page ‘snapshot’ description of each model was also generated along with a graphical representation (radar gram) summarising the quality of each tool in terms of the various key factors.
The blue outline represents the quality of the tool in terms of the summary variables indicated at the eight points of the graph. The scale ranges from 0 (poor) in the centre to 5 (excellent) for each factor. The closer the blue line is located to the factor labels on the outer perimeter of the radar gram, the more positive the assessment in relation to that factor. The more area contained inside the blue outline, the more positive the modelling tool’s overall assessment. The positioning of the blue line in the radar gram also represents the extent of balance in quality across the factors. An overall average score provides a guide in terms of the general quality of each tool.

**Limitations**

The review was limited somewhat by the short project time frame in terms of ability to access relevant modelling software tools and key contacts. The review was restricted to English language modelling tools. Some modelling software tools could not be directly accessed due to ownership by private consulting firms unwilling to provide access.
Findings
This section summarises the response to DoP staff interviews and the results of the review of scenario planning software tools. The interview summary outlines the perspectives of DoP staff in relation to data management, planning and use of planning software tools.

Interview response summary
The summary points that follow are based on interviews, email and phone call exchanges with DoP staff and feedback obtained during meetings. The summary includes the common points raised across all interviews. The content reflects the perspective of DoP staff and has been presented in the context of themes relevant to this project.

Main points raised during interviews include:

- There were two broadly stated needs from planning software tools:
  1. Capacity for scenario planning at different scales to generate the range of possibilities associated with different planning options in different settings.
  2. A need to visualise planning options and infrastructure at different scales.
- There is a perceived need to enhance capacity for identifying clear and concise questions in the initial stages of planning – this is central to identifying what data is needed and what planning software tools could be used.
- DoP data varies in quality, timeliness and scale; this affects the capacity for using planning software tools.
- There is pressure from short time frames for planning outputs versus the amount of time required for data acquisition and updating modelling software tools.
- There is a perceived need for more effective communication within the Department between data managers and planners.
- There is potential for DoP staff to network with planning and data professionals outside the DoP to enhance capacity and knowledge regarding current planning tools and methods.

General issues regarding DoP and planning
- There is a current need for enhanced scenario planning capacity for multiple land-uses with multiple order effects at various scales in WA.
- Based on interviews with staff, DoP has a limited internal capacity for use of scenario planning software tools in terms of staff resources and time allocation within the Department.
- Currently, DoP would require increased recurrent funding for effective upkeep of scenario modelling software tools that are managed in-house.
- There appears to be a need to enhance communication and understanding between DoP data managers and planners based in terms of data requirements and identifying ‘the right questions to ask’.
- Interviewed DoP staff indicated they have limited contact with counterparts in other government departments, states and the broader professional planning community.
- There is potential for DoP staff to enhance opportunities to network with planning and data management professionals outside the DoP (for example attend conferences).
- Effective networking in this context could enhance DoP staff capacity through knowledge sharing, acquisition of new skills and improvement of existing skills.

Data quality
- DoP manages data at different scales and varying quality, some is out of date or requires updating.
- This is generally because data has been inconsistently collected on a needs basis (mainly in terms of cadastres and topographical data).
- Data at different scales is important for different planning needs but accuracy can be an issue at different resolutions and for different parameters.
Data quality tends to be poor in remote / regional areas of Western Australia. This creates difficulties when attempting to apply modelling software tools to these regions.

Data is geographically patchy, mostly focussed on the main population centres of Perth and Peel region in the southwest.

There is a need for more comprehensive and consistent state-wide data that can be effectively used for planning purposes.

There is a need for better access to timely data. Data gathering via government can be slow, acquiring data from commercial operators (e.g. Nearmap) is fast but expensive, the corporate sector is reluctant share data (i.e. resources sector).

**Modelling software tools**

- There is a need for scenario planning software tools that can function at different scales with a range of datasets of varying type and quality.
- There is considered to be no single ideal software tool that can run scenarios at different scales for different purposes using a range of data.
- Current tools tend to have specific application and/or are data hungry and require time and effort to update.
- There is a need for access to a range of planning software tools that can address different planning needs at different scales.
- Ideally these tools could interface with each other and share information.
- Alternatively, there is a need for a comprehensive scenario planning software tool that can address the full range of planning issues, especially for urban areas.
- Planners are working to very short time frames to deliver complex planning outputs that can include scenario planning from the local to regional level.
- Short planning time frames are determined by government policy time frames.
- This means that there is a preference amongst some DoP staff for ‘off the shelf’ planning software tools that can be used in-house and that are able to use existing databases with minimal requirements for data conversion or pre-processing.
- Some staff think there is a need for better understanding about scenario planning and modelling software generally in that it should be seen as a discussion facilitation tool rather than a predictive tool.

**Review of modelling software tools**

A range of modelling software tools were review by the project team based on the attributes identified in the project brief.

The main points relating to the software tools reviewed by the project team are as follows:

- All planning software tools have their strengths and weaknesses in terms of functionality and use.
- Most software tools reviewed include 1st order effects only, rather than the more complex feedback loops required for effective strategic scenario planning.
- Most are specialised and focused on a ‘part’ of the big picture (e.g. water, vegetation, transport).
- Most are based in ArcGIS.
- Many require some collaboration with the tool developer for effective use.
- A main consideration relates to specific project needs versus maintaining on-going in-house capacity.
- Expect to interact with the model developers rather than buy a stand-alone tool in most cases.
Summary of software tool review

Table 2 summarises the average scores and the attributes that received the highest and lowest score for each of the software tools reviewed. Table 3 summarises the various geographical scales each software tool can effectively operate at. Table 4 provides a brief descriptive summary of each tool reviewed including business model and costs. It is important to note that a high average assessment score does not reflect the balance of strengths and weaknesses for each tool. For example, a tool with a high average score may have scored highly on some attributes but very poorly on others. A tool with a moderate average assessment score may have an even spread of medium scores across the various attributes assessed. Certain attributes may be preferred for particular planning needs. The assessment scores for each attribute (detailed in the one page summaries for each modelling tool) should be considered in combination with the overall average score.

Reviewed software tools tended to have strengths associated with modelling particular functions but not others that may be important to planning, for example some focus specifically on water, or vegetation, or transport. There appears to be no software tool that could effectively model all aspects of urban or regional planning irrespective of the scale. CUBE received the most favourable average score, mainly in terms of design, data flexibility, documentation and publications. It also scored well in terms of user friendliness and has a broad international community of users. However, it is the most expensive tool to purchase. In addition, CUBE is excellent for transport planning and modelling traffic routing but is weak in relation to modelling socio-economic and environmental factors. The eWater Toolkit also received a relatively high score based on its extent of use and publications. However, the Toolkit focuses on hydrological modelling. This could potentially be applied to urban and non-urban areas to inform planning but is a toolkit mainly used by hydrologists. Whatif? addresses issues relating to land use change and urbanisation. It scored well for data flexibility and user friendliness. It represents nature conservation and urbanisation processes over time but appears to simply reflect back what the user has inputted in terms of land use change and urban growth patterns. CommunityViz software also scored well based on its design and usability but is not dynamic and has a limited range of reliable application. UrbanSim and ALCES are probably the most flexible and dynamic modelling tools for scenario planning use at a range of scales and applications. Both tools include multiple processes and represent second and third order dynamics. However, neither tool is user friendly and engagement with the developer would be necessary for meaningful application in a scenario planning context. ALCES may be applied to urban and non-urban areas at the sub-regional regional and state-wide scale. UrbanSim is designed for application at the urban precinct to city scale. ALCES is spatially stratified and relatively expensive to buy while UrbanSim is spatially explicit and the software is freely available.
<table>
<thead>
<tr>
<th>Software Tool</th>
<th>Main focus</th>
<th>Avg score</th>
<th>Lowest score attributes</th>
<th>Lowest score score</th>
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<tr>
<td>CUBE</td>
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<td>3.5</td>
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<td>Data flexibility</td>
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<td>Cost</td>
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<td>Autodesk Infrastructure Modeller</td>
<td>Visualising infrastructure</td>
<td>1.4</td>
<td>Dynamic Publications</td>
<td>0</td>
<td>Design quality</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Data flexibility</td>
<td></td>
</tr>
<tr>
<td>InVitro</td>
<td>Marine research</td>
<td>1.4</td>
<td>Documentation User friendliness Publications</td>
<td>0</td>
<td>Dynamic Range of application</td>
<td>3</td>
</tr>
<tr>
<td>Urban Housing Growth Monitor</td>
<td>Visualising urban growth scenarios</td>
<td>1.0</td>
<td>Documentation Publications</td>
<td>0</td>
<td>Range of application</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Data flexibility</td>
<td></td>
</tr>
<tr>
<td>Precinx</td>
<td>Urban energy efficiency and carbon intensity</td>
<td>0.9</td>
<td>Documentation Publications</td>
<td>0</td>
<td>Data Flexibility</td>
<td>2</td>
</tr>
<tr>
<td>MLUFS</td>
<td>Urban dwelling, population, employment and labour force projections</td>
<td>NOT RATED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Modelling software tools and applicability to different land-uses and geographical scales

<table>
<thead>
<tr>
<th>Software Tool</th>
<th>Scenario planning capacity</th>
<th>Land-uses</th>
<th>Scale tool can be applied to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Urban</td>
<td>Non-urban</td>
</tr>
<tr>
<td>ALCES</td>
<td>Yes</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Autodesk Infrastructure modeller</td>
<td>No</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>CommunitViz</td>
<td>Limited</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>CUBE</td>
<td>Limited</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>eWater Toolkit</td>
<td>Limited</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>inVitro</td>
<td>No</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>INVEST</td>
<td>Limited</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>MARXAN</td>
<td>No</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>MLUFS</td>
<td>No</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Metroquest</td>
<td>No</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Ningaloo Destination Model</td>
<td>Yes</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Precinx</td>
<td>Limited</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Rapid Fire</td>
<td>No</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>SUSIP</td>
<td>Yes</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>STEM</td>
<td>Limited</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>TELSA</td>
<td>Limited</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Urban Housing Growth Model</td>
<td>Limited</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>UrbanSim</td>
<td>Yes</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>What If?</td>
<td>Yes</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Model Name</td>
<td>Description</td>
<td>Application</td>
<td>Software Cost</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>ALCES</td>
<td>A spatially stratified, integrated systems dynamics ‘cumulative effects’ model. Represents multiple processes on a landscape, and tracks the combined effect of change on economic, social and environmental indicators.</td>
<td>Tracks a variety of economic, environmental and social indicators for defined scenarios. Simulates landscape dynamics with and without human impacts, and ‘grows’ the system dynamics from sets of defined relationships. Tracks multiple sectors of economy and multiple environmental metrics. For use at state-wide, regional and local scale.</td>
<td>Approx $15000.</td>
</tr>
<tr>
<td>Autodesk Infrastructure modeller</td>
<td>High-resolution 3D visualisation software used to prototype a project or visualise alternative designs of a project.</td>
<td>Not a scenario modelling tool. Cannot address research questions or represent outcomes of processes. May be used to assist in stakeholder collaboration and community engagement. Precinct to city scale.</td>
<td>AU$5,175</td>
</tr>
<tr>
<td>CommunitViz</td>
<td>A set of add-on tools for ESRI ArcGIS. Functions like a spatially explicit spreadsheet with a good visual interface and good functionality for 1st order dynamics.</td>
<td>Directed toward land use planning, estimating first-order impacts of land use change, and urban design. For use at the urban precinct to city scale.</td>
<td>Single user license with tech support US$850 Single user license no tech support US$500 Network license US$850 - $3060</td>
</tr>
<tr>
<td>CUBE</td>
<td>Models spatially explicit maps for transportation networks. Algorithms for least-path, travel time are used to route traffic through a network. Includes a broad range of land use and transportation planning functions.</td>
<td>Main model capability is in traffic routing and route finding. Add on features model land use value change, but are very basic. May be used to facilitate collaboration across discipline areas but mainly about transport networks. Application for urban areas, precinct to city scale.</td>
<td>US$18000 Includes modules CUBE base $10800 CUBE voyager $7200 Other modules available</td>
</tr>
<tr>
<td>Model Name</td>
<td>Description</td>
<td>Application</td>
<td>Software Cost</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>eWater Toolkit</td>
<td>A suite of software tools and information related to the modelling and management of water resources. Designed to integrate an organisation’s existing models, with a holistic approach to water management including human and ecological impacts.</td>
<td>Developed to provide a suite of tools model all aspects of water quantity and quality. Ability to represent hydrological function at multiple scales. Ability to consider impacts from urban, agricultural and other human use, as well as represent environmental requirements. Some tools can also be used at a site specific scale (e.g. a single property).</td>
<td>Tool pricing and proprietary licence varies within suite. Ranges from free software to $6000 and above.</td>
</tr>
<tr>
<td>inVitro</td>
<td>InVitro is a series of modules developed within CSIRO and used in a limited number of studies in house.</td>
<td>CSIRO CMAR in-house suite, deployed for a particular project, tools maintained, updated, added to over time. It has a marine focus.</td>
<td>N/A</td>
</tr>
<tr>
<td>INVEST</td>
<td>A set of ArcGIS toolbox add-ons that calculate the biophysical amount, and dollar value of ecosystems services.</td>
<td>Estimates the amount and dollar value of ecosystems services. Can address questions of changing land use, and track natural capital under alternative GIS-based scenarios. Useful for scenario modelling, in that the technician can provide an estimate of ecosystems services under two different GIS data sets, each representing a scenario and its alternative. Local to regional scale.</td>
<td>Freely available</td>
</tr>
<tr>
<td>Model Name</td>
<td>Description</td>
<td>Application</td>
<td>Software Cost</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>MARXAN</strong> University of Queensland <a href="http://www.uq.edu.au/marxan">www.uq.edu.au/marxan</a></td>
<td>A spatial decision support tool for conservation planning and management. Can interface with ArcGIS via a range of add-on tools for input to MARXAN and visualising outputs.</td>
<td>It provides decision support to a range of conservation planning problems, including designing new reserve systems, reporting on performance of existing reserve systems and developing multiple-use zoning plans for natural resource management. Intended as a collaborative tool. Regional scale.</td>
<td>Freely available</td>
</tr>
<tr>
<td><strong>MLUFS</strong> Research Branch, WA Dept of Planning</td>
<td>MLUFS is a suite of tools based on various software including ArcInfo, SQL scripts and spreadsheets used to prepare spatially explicit socio-economic forecasts for input into small area transport modelling.</td>
<td>Designed to address questions regarding urban dwelling, population, employment and labour force projections for input into urban transport modelling by DoP, Main Roads WA and Dept of Transport. Other organisations may use the projections to guide facility planning and activity centres modelling. Precinct scale.</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Metroquest Envision Sustainability Tools Inc</strong> <a href="http://www.metroquest.com">www.metroquest.com</a></td>
<td>Metroquest is a platform to facilitate stakeholder input into planning. It asks the participant to input preferences for a variety of attributes of the region or city in question, and reports back the results.</td>
<td>Designed for use in community engagement forums to envision potential urban forms and gather Precinct to regional scale.</td>
<td>Cost varies according to scale of project.</td>
</tr>
<tr>
<td><strong>Ningaloo Destination Model</strong> Curtin University, CSIRO.</td>
<td>A non-spatial system dynamics model built using VenSim. It represents impacts of different tourism development scenarios on economic, social elements as well as environmental factors including energy and water used and waste generation.</td>
<td>Can address questions regarding potential tourism development scenarios in the Ningaloo coastal region and the impacts on the character of tourism and its influence on local communities. Regional in scale.</td>
<td>Freely available</td>
</tr>
<tr>
<td>Model Name</td>
<td>Description</td>
<td>Application</td>
<td>Software Cost</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Precinx</td>
<td>Kenesis A spread sheet “first order effects” model that tracks social, economic and environmental indicators for new urban residential developments</td>
<td>Developed to address questions regarding energy, emissions, water, transport and housing indicators for new urban developments. It has limited capacity for collaboration. It is applicable to the urban precinct to city scale.</td>
<td>Not released by developer.</td>
</tr>
<tr>
<td>Rapid Fire</td>
<td>Calthorpe Associates, US. <a href="http://www.calthorpe.com/scenario_modeling_tools">www.calthorpe.com/scenario_modeling_tools</a> A spread sheet “first order effects” model that tracks regional to national indicators for transport.</td>
<td>Developed for urban planning in Southern California. It can address research questions relating to transport related processes. Limited capacity for collaboration. Applicable to the national, state-wide and regional scale.</td>
<td>Not released by developer.</td>
</tr>
<tr>
<td>SUSIP (under development)</td>
<td>Curtin University, Monash University CRCSI Contact Roman Trubka <a href="mailto:r.trubka@gmail.com">r.trubka@gmail.com</a> SUSIP simulates urban redevelopment and infill scenarios and housing typologies based on current urban form and various property indicators.</td>
<td>Design to address questions regarding sustainable urban form and where to focus future urban redevelopment. Models likely urban residential redevelopment and housing typology scenarios for improved productivity outcomes. Intended for use as a discussion facilitation tool at the LGA scale.</td>
<td>Still in development.</td>
</tr>
<tr>
<td>STEM</td>
<td>WA Dept of Planning A transport focussed model, which calculates trips and associated metrics under different land use and economic parameter scenarios. The model has its roots in travel cost modelling</td>
<td>Designed to address transport related issues associated with commuting, such as trip time and how travel patterns change when the attributes of the transport system change. Precinct to city scale</td>
<td>N/A</td>
</tr>
<tr>
<td>Model Name</td>
<td>Description</td>
<td>Application</td>
<td>Software Cost</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-------------</td>
<td>---------------</td>
</tr>
</tbody>
</table>
| **TELSA**  | ESSA Technologies LTD.  
[essa.com/tools/telsa](essa.com/tools/telsa) | An ArcGIS toolbox spatially explicit model of vegetation dynamics. The model simulates vegetation succession, natural disturbances, and management. | Designed to address questions regarding how vegetation dynamics respond to human and natural disturbances. It does not represent multiple processes apart from those directly related to vegetation dynamics so would not facilitate collaboration across disciplines. Regional in scale. | Freely available | Training offered by developer (Canada).  
$950 per person or $9000 for groups up to 17. | Acquire software tool for in-house use. Knowledge of vegetation dynamics and skills in using VDDT and ArcGIS necessary. | It is adaptable to different locations.  
appears to be the toolbox of ecologists, but not frequently used. |
| **Urban Housing Growth Model**  
[www.lesterfranks.com.au/gis.html](www.lesterfranks.com.au/gis.html) | A standalone visualisation tool built using Eonvision software. A tool for modelling and visualising future residential housing growth scenarios. | Designed to address questions regarding likely urban expansion patterns based on current urban form and various population, infrastructure and urban area growth variables. Local to regional scale. | Not released by developer | Consulting services by developer, cost negotiable and depends on scale of project. | Engagement with developer required to modify and apply tool to location other than Hobart, Tasmania. | Has been built and applied to Hobart, Tasmania. Considerable work required to apply to other locations. |
| **Urban Sim**  
Urban Analytics, Inc., US  
[www.uanalytics.com](www.uanalytics.com) | A Python based platform that represents common elements in urban dynamics with detailed feedback dynamics at multiple scales. | Can address a broad range of urban / regional planning issues, relating to how the urban system functions, including jobs, land, real estate, travel, transport, residential decision making. Applied at the precinct to city scale. | Freely available | Maintenance agreement  
$3500 pa per user  
1 day Training courses offered (US based)  
$500 per person  
Consulting service offered by tool developer. | Although the tool may be acquired for in-house use, engagement with developer is highly recommended. Advanced programming skills are required for effective use of the tool. | Could be adapted for use in different locations.  
Seems to be only mainly used in the US in collaboration with tool developer. Some use in Europe. |
| **What If?**  
Whatif Inc.  
[www.whatifinc.biz](www.whatifinc.biz) | A GIS based planning support system that tracks land use, population, housing and employment projections for flexible spatial scales. | Addresses land use patterns in time under different development scenarios, specifically focussed on land use change and urbanisation. Could be used for monitoring. Applied at the city to regional scale. | Free demo version.  
Full version $1000 per user | Annual maintenance fee $200 per user. First year’s maintenance included in price. | While it may be possible to use the modelling tool in-house, interaction with developers may be necessary. Requires GIS skills and basic programming skills depending on the What if? modelling language | Can be adapted for use in different locations.  
Mainly applied in the US but has been used in other locations globally. |
Modeling software tool snapshots

This section provides one page snapshots for each software tool reviewed in alphabetical order of name. The snapshots expand on the summaries provided in Tables 2, 3 and 4. Each snapshot includes:

1. A **brief description** of the software tool;
2. its **intended application** in terms of the questions it is designed to address, how it is meant to be used and the land use scale to which it applies;
3. Tool **design** in terms of the type of model, software code and accessibility, data outputs, whether it can interface with other modeling tools etc.;
4. **Data requirements** including the type of data required for input and any notes relating to data handling;
5. **Adaptability to different locations** in terms of where it has been applied and whether it could be readily used in a range of geographical locations;
6. **User Friendliness** based on availability of user documentation, publications, a community of practice and the type of interface presented as well as the level of training and/or engagement with the developer required for effective use; and
7. **Cost** including the cost of acquiring the software tool itself, any add-on tools and necessary license costs as well as training programs offered and additional services such as consulting by the developer.

Where possible, a radar gram provides an overall summation of the software tool based on these elements as an indication of its generally assessed quality and its strengths and weaknesses.
**ALCES (A Land-use Cumulative Effects Simulator)**
**Authors / Designers:** ALCES Group Ltd. ([www.alces.ca](http://www.alces.ca))

![Diagram showing the scores for Dynamic?, Range of Applications, Design Quality, Documentation, User friendliness, Cost (0=high), and Data flexibility. Avg score: 2.8]

**Brief description:** ALCES is a system dynamics model built using the software Stella. ALCES represents elements of an integrated model, with modules for economy, social and environmental processes. It is a ‘cumulative effects’ simulator meaning that it represents multiple processes occurring on a landscape, and tracks the combined effect on economic, social and environmental indicators. ALCES is spatially stratified, but not spatially explicit. However, a companion tool, ALCES Mapper, can take output from the model and assign outcomes to space based on a series of spatial allocation algorithms.

**Intended applications:** ALCES has notable ability to represent different landscape types and footprint types of different human and natural impacts. The model tracks human activity and natural processes, and represents the magnitude of impacts. This includes modelling the range of natural variability (pre-human impact), history of human impact and future scenarios. ALCES is ideally used as part of a multi-stakeholder collaboration. Can be applied at the local to regional scale.

**Design:**
- Systems dynamics model (stock and flow model) using Stella model code from ISEE Systems, Inc.
- Modelling mathematics - aggregated functions describing relationships between inputs.
- Stratified model (not spatially explicit).
- The model’s code can be altered with collaboration with the ALCES Group.
- Limited capacity to directly interface with other models.
- Outputs from other models can be used as inputs to ALCES.
- ALCES outputs in the form of graphs and tables; a Mapper add-on tool can be used for spatial representation.

**Data requirements:** There is a significant effort to populate the model with relevant data. This mainly entails setting up a series of 2 dimensional functions which define relationships between input and output variables. The actual process of populating the model with data is easy, using Graphical Input Devices (much easier than raw data, scripted equations or coding).

**Adaptability to different locations:** Model parameters can be altered to suit any geography.

**User friendliness:** There is insufficient documentation for a researcher to start using ALCES without prior training. Training is available and a skilled modeller would be able to use the tool to self-teach with some time investment. Although possible to use independently, interaction with the ALCES Group would significantly improve the learning curve and timeframe for practical use. ALCES is widely known in Canada, with more recent applications internationally (Australia, South America, India). It can be used on any desktop or laptop computer.

**Cost:**
- **Software:** ALCES Model $15,000. ALCES Mapper add-on $5,000. (No annual license fee)
- **Training:** Delivered in Alberta, Canada - 4 day course $2500/person
  - Delivered abroad - $4000/day for up to 20 participants
- **Services:** online/email/phone support - $200/hr, project consulting with or without purchase of software $1000-$1500/day.
**Autodesk Infrastructure Modeller**  
**Authors / Designers:** AutoDesk  (usa.autodesk.com/adsk/servlet/pc/index?id=17276659&siteID=123112)

**Brief description:** Autodesk Infrastructure Modeller is high-resolution 3D visualisation software. This software does not ‘model’ planning outcomes, but rather depicts them in a visually realistic fashion. The software is related to CAD (computer assisted design) used by engineers and industrial designers to prototype a project or visualise alternative designs of a project, such as a highway or real estate development.

**Intended applications:** Autodesk Infrastructure Modeller is not a modelling tool in the sense of scenario planning. It is simply a visualisation tool for architectural and urban design. As such it is not designed to address research questions or represent outcomes of processes. It can however be used for visualisation of different possible designs in relation to a given urban area, and as such may be used to assist in stakeholder collaboration and community engagement. Applicable at the urban precinct to city scale.

**Design:**
- Software tool architecture and code is unknown as it is a standalone commercial product.
- No modelling mathematics, it is simply a visualisation tool.
- Outputs include 3D spatially-explicit high-resolution visualisation.
- Is able to import GIS data and CAD data but not easily interface directly with models.

**Data requirements:** GIS, CAD.

**Adaptability to different locations:** Flexible application in different locations

**User friendliness:** Model documentation is sufficient to understand the model and get started. It is a standalone product for use in-house. There is evidence of a substantial level of technical and user support provided by the developer and associated organisations. There also appears to be a broad international community of users that could provide an avenue for sourcing information. Using the tool requires substantial skills in industrial design / engineering / CAD. Use of the tool in house would require a skilled technician.

**Cost:**
- **Software:** Autodesk 3ds Max AU$5,175
- **Training:** available from a wide range of organisations accredited by Autodesk
- **Services:** 1 year subscription AU$880 includes priority technical support, updates, cloud computing – collaboration capability.
CommunityViz

Authors / Designers: Placeways LLC, Boulder, Colorado (placeways.com/communityviz)

Brief description: CommunityViz is a set of add-on tools for ESRI ArcGIS. Essentially it functions like a spatially explicit spread sheet with a good visual interface and good functionality for 1st order dynamics. It is somewhat dynamic, in that changes made in the GIS data are reflected in changes to related variables, but it is not a ‘model’ per se, any more than an excel spread sheet is a model. It does however handle data nicely and includes a useful interface.

Intended applications: CommunityViz is directed toward land use planning, estimating first-order impacts of land use change, and urban design. The system is flexible in that any spatial process can be simplistically represented. There is an interface by which simple calculations can be made based on the area of land uses and multipliers attached to these, such as the number of cars per area of residential area is tracked, and as land use changes, so do the number of cars. Applicable at the urban precinct to city scale.

Design:
- CommunityViz is an ESRI ArcGIS add-on toolbox.
- Uses areas calculated in ArcMap and multipliers for impacts defined by the user.
- Code is proprietary.
- Spatially explicit with output represented as maps and graphs.
- Could visualise and summarise the outcomes using GIS data generated by other models.

Data requirements: Regular GIS data.

Adaptability to different locations: Easy to adjust geography using GIS data.

User friendliness: The tool is well documented and has a significant international community of users to refer to. The software receives regular updates as well as upgrades to new ArcGIS versions. CommunityViz could be used by anyone familiar with ArcGIS. Training programs are offered by Placeways or certified training organisations. Placeways also offers professional consulting services. It can be used on any desktop or laptop computer able to run ArcGIS.

Cost:
Software: Single-user license up to 3 installs - US$850 (incl tech support)
   “Self Service” Single-user license up to 3 installs - US$500 (limited tech support, no network license).
   Network license range from 3 users @ $850 up to 12 users @ $3060.

Training: available from software developer and certified groups.
   e.g. Placeways (US based) 3 day course - $1500 / person
   e.g. Geodata (US based) 3 day course - $900 / person
   Limited training offered in Australia on request.

Services: regular software cost includes 12 months of technical support including email and phone support bug fixes, Dot and full releases.
   ‘self-service’ option = no tech. support apart from website resources, bug fixes only.
CUBE
Authors / Designers: Citilabs (www.citilabs.com/products/cube)

**Brief description:** Cube is a popular planning tool, primarily focussed on transportation along networks. It appears to be the most advanced tool reviewed, and certainly has the most material available online, including webinars and training sessions. It handles transportation networks with an impressive detail and flexibility. The obvious drawback is that other system level processes are not adequately represented. However, for transportation, it would appear to be the industry leader. Citilabs is an established company with offices in several countries, and the CUBE software seems to be commonly used in universities and engineering firms.

**Intended applications:** CUBE includes a broad range of land use and transportation planning, however the significant majority of the model capability is in traffic routing and route finding. CUBE models spatially explicit maps for transportation networks and algorithms for least-path, travel time are used to route traffic through the network. There are add on features that model land use value change, although these are very basic in comparison to the detail invested in the traffic network modelling. The tool may be used to facilitate collaboration across discipline areas but mainly about transport networks. CUBE could be useful for monitoring traffic flow. Applicable at the urban precinct to city scale.

**Design:**
- The tool uses a ‘windows like’ interface.
- Mathematics - uses optimisation algorithms.
- Spatially explicit, visual representation of output.
- Proprietary software tool and not realistically alterable.
- Model code unknown – not open source.

**Data requirements:** Uses GIS data, and can generate transportation networks.

**Adaptability to different locations:** Easily adapted to different locations.

**User friendliness:** CUBE software is associated with a large quantity of information in multiple media. It has a very large international community of practice, including an annual conference for sharing of information. Currently used in the U.S., Spain, Italy, Germany, Ireland, Australia and the UK. CUBE software is regularly updated. It may be used as a standalone product for use in-house or in collaboration with model developers. While basic modelling and GIS skills are required, the tool is very user-friendly relative to other tools. There is no special hardware requirements, CUBE can be used on any desktop or laptop computer.

**Cost (US$ approx):**
- **Software:** Total purchase price US$18,000 (Includes Cube Base US$ 10,800, Cube Voyager $ 7,200)
- **Training:** Supplied by Citilabs and other accredited CUBE providers.
  - E.g. Citilabs 3 day course (US based) $1200
  - Services: Annual maintenance costs are 15% of the purchase price (Email pers. comm. Charlesworth, 2012).
Consultant services may also be purchased from Citilabs, developers of CUBE and other Cube accredited providers with costs to be negotiated.
**eWater Toolkit**  
**Authors / Designers:** eWater CRC ([www.toolkit.net.au/Tools/](http://www.toolkit.net.au/Tools/))

**Brief description:** eWater Toolkit is a suite of software tools and information related to the modelling and management of water resources. It is aimed at water industry professionals involved in the management and modelling of catchments and water resources. The Toolkit is designed to support issues like:  
- Urban water modelling and decision making;  
- River management, including allocations in regulated systems;  
- Management and modelling of aquatic systems;  
- Hydrological modelling of catchments; and  
- Integrated monitoring and assessment of freshwater systems.  

**Intended applications:** eWater Tool is being developed to effectively integrate an organisation’s existing models, with a holistic approach to water management including human and ecological impacts. It is being developed to address water sharing and savings for Entire River and connected groundwater systems including cities, agricultural and environmental demands.  

The tools are broadly classified into 5 themes, as above. Several are generic hydrology (and related i.e. sedimentation) models which are not particular to the eWater set of tools alone (i.e. Sednet, TIME), but are included due to their broad applicability to water issues in Australia. There is an impressive array of 13 different tools available. There are several tools useful for facilitating collaboration, and the eWater toolkit was designed in part for this. Applicable at the local to regional scale depending on specific tool.  

**Design:** Consists of a suite of tools with a large number of modelling components – e.g., urban water balance models, 3D GIS catchment simulation, crop growth, unsaturated soil moisture movement, integration platforms, multi-criteria analysis tools, etc. See [http://www.toolkit.net.au/Tools/](http://www.toolkit.net.au/Tools/).  

**Data requirements:** varies according to specific tools.  

**Adaptability to different locations:** varies according to specific tools.  

**User friendliness:** This varies as eWater toolkit is a suite of different tools; however some are aimed towards user friendliness, but most are hard science models of hydrological processes. It would take significant in-house skill to use most hydrology models. There is a large community of practice, but mostly restricted to hydrological professionals / scientists. Significant in-house skills required for most tools in this suite, however, contacts within Australia are noted on the eWater website and collaboration with an existing team of skilled model users is possible.  

**Cost** Each tool in the toolkit has its own separate pricing and proprietary licence. Several tools are free and several are relatively expensive ($6000 and upwards).
**InVitro**

**Authors / Designers:** CSIRO ([www.cmar.csiro.au/research/mse/invitro.htm](http://www.cmar.csiro.au/research/mse/invitro.htm))

**Brief description:** InVitro is a series of modules developed within CSIRO and used in a limited number of studies in house. It is not possible to determine more detail owing to limited available information. It appears that there is not a standalone product available for external use, and that investment was around a particular CSIRO set of projects and has not continued. However, the research group has continued to develop a suite of models based on InVitro and partnering with CSIRO would allow access to this significant skill set.

**Intended applications:** CSIRO CMAR in-house suite, deployed for a particular project, tools maintained, updated, added to over time. It has a marine focus.

**User friendliness:** Not able to be used by others as it what only deployed for specific CSIRO projects might require significant time to adapt to research questions for other projects.

Software tools are not available outside CSIRO. Access to the tools would require partnering with CSIRO on a project. This would enable access to a significant skill set of experts.
**InVEST**

**Authors / Designers:** Natural Capital Project (www.naturalcapitalproject.org/)

**Brief description:** InVEST is a set of ArcGIS toolbox add-ons that calculate the biophysical amount, and dollar value of ecosystems services. GIS data is inputted according to a certain format and the model measures ecosystems services based on parameters for land uses. The tool offers the ability to change parameters based on the location in question. In essence, it serves the purpose of a spatially-explicit spread sheet, in that feedbacks are not accounted for. The tool is useful for scenario modelling, in that the technician can provide an estimate of ecosystems services under two different GIS data sets, each representing a scenario and its alternative.

**Intended applications:** InVEST estimates the amount and dollar value of ecosystems services. This tool can address questions of changing land use, and track natural capital under alternative GIS-based scenarios. Different land uses are assigned a value and totals are calculated within ArcGIS. Multiple ecosystem services are represented, but not other domains such as economic sectors. While the tool itself may not facilitate collaboration across disciplines, it may partly serve this purpose through its ability to report on the change in ecosystem services. InVEST is useful for monitoring changes in values of ecosystem services. Applicable at the regional scale.

**Design:** ArcGIS toolbox add-on
- Relatively transparent, is proprietary but free.
- Code can be altered with advanced GIS scripting skills.
- Static spatially-explicit comparisons of data sets.
- Could interface with other models only via ArcGIS.
- Uses the ArcGIS interface only, does not have stand-alone interface, nor does it prepare figures and other common software functions.

**Data requirements:** GIS data according to documentation, for example, land cover files have to be in a recognised format and some data cleaning / preparation is required in ArcGIS.

**Adaptability to different locations:** InVEST can be used anywhere as long as GIS data are available.

**User friendliness:** InVEST requires basic to intermediate skills in ArcGIS. The model is well documented at: http://ncp-dev.stanford.edu/~dataportal/invest-releases/documentation/current_release/. There appears to be an active, albeit small, community of people using this tool. There are practical applications in developing countries, as well as key case studies from USA see http://www.naturalcapitalproject.org/publications.html. The tool receives regular and timely updates and upgrades to maintain functionality with ArcGIS. There are no special hardware requirements; it can be used on any desktop or laptop computer able to run ArcGIS.

**Cost:** Freely available.
MARXAN

Brief description: MARXAN is a spatial decision support tool for nature conservation planning, design of new reserve systems, reporting on performance of existing reserve systems, and developing multiple-use zoning plans for natural resource management. It is essentially used for developing a business case for conservation of defined areas.

Intended applications: MARXAN is designed for nature conservation planning. It provides decision support to a range of conservation planning problems, including:
- the design of new reserve systems;
- reporting on the performance of existing reserve systems; and
- developing multiple-use zoning plans for natural resource management.

Marxan is intended to operate as part of a collaborative planning process. Its effectiveness relies on involvement of stakeholders knowledgeable in ecology, land or marine conservation and spatial dataset development. The tool is also designed for monitoring. Applied at the local to regional scale

Design: Can interface with ArcGIS via a range of add-on tools for input to MARXAN and visualising outputs.

Data requirements: GIS

Adaptability to different locations: Can be used in any geographical location where GIS data is available.

User friendliness: A considerable amount of data processing is required to prepare inputs for MARXAN. This can be time consuming. There is a broad community of users and a significant number of publications to draw on when using this tool. MARXAN can be run on any computer able to operate commercially available GIS software.

Cost: Freely available

Training A series of 2 day courses are provided in Brisbane by University of Qld on a regular basis at $600 per person per course.
**Metroquest**

**Authors / Designers:** Envision Sustainability Tools Inc ([www.metroquest.com](http://www.metroquest.com))

**Brief description:** Metroquest is a platform to facilitate stakeholder input into planning. The tool guides participants through a series of ‘panes’ where participants are asked to set priorities, make choices about trade-offs, and evaluate the outcomes. Participants input preferences for a variety of attributes of the region or city in question. It is similar to a state preference survey or multi-criteria analysis, but not necessarily as statistically robust. Metroquest is visual and intuitive, and is a good example of an approachable tool for stakeholder engagement and envisioning scenarios, but is not a simulation model.

**Intended applications:** Metroquest is a platform to facilitate stakeholder input into planning. As such it does not address any particular research questions, but rather bounds the sets of common decisions and tradeoffs in urban / regional integrated planning and navigates participants through a decision making process. Metroquest asks the respondents to provide information on common urban / regional planning issues, including access to jobs, parking, emissions, housing affordability, taxes, water, air, access to schools, amenability, lot size, green spaces, traffic and driving time. The tool is primarily for scenario envisioning purposes and includes considerations across several disciplines. It cannot be used for monitoring. It is generally applied at the city to regional scale.

**Design:**
- Model architecture and language is unknown, access to software unavailable
- Proprietary software, cannot be altered but can be calibrated to different areas
- The tool is spatially explicit using pre-defined maps
- It is regularly updated
- It cannot interface directly with other models

**Data requirements:** Few data requirements. Includes provision of spatial maps based on GIS.

**Adaptability to different locations:** Metroquest can be adapted to any location. Mainly applied in the US and Canada. Has also been applied to Southeast Queensland.

**User friendliness:** There is a sufficient amount of documentation to use the tool. The program is visual, intuitive and simple. Application of the tool requires interaction with the developer. There is an active community using this tool based mainly in the US.

**Cost:** Metroquest is available for use through engagement with the developer. Cost varies and depends on the scale of the project.
MLUFS

Authors / Designers: WA Dept of Planning

Brief description: MLUFS is a suite of tools developed and applied in-house at DoP. It is based on various software including ArcInfo, SQL scripts and spreadsheets used to prepare spatially explicit socio-economic forecasts for input into small area transport modelling.

Intended applications: MLUFS is designed to address questions regarding potential future urban dwelling, population, employment and labour force projections for input into urban transport modelling by DoP, Main Roads WA and Dept of Transport. Other Government agencies and the private sector may use the projections to guide facility planning and activity centres modelling. Applied at the urban precinct scale.

Design: A suite of tools based on various software including ArcInfo, SQL scripts and spreadsheets. Outputs can be used as input for STEM.

Data requirements: Local area census data and related data sets.

Adaptability to different locations: Designed for and applied to Western Australian urban areas to prepare data sets for input into STEM to inform transport modelling.

User friendliness: The DoP has staff trained to apply MLUFS to the Perth metropolitan area. As such it would appear that the community of users is specific to DoP although the knowledge and skill sets involved in operating the suite of tools to obtain forecasts are common to demographers and perhaps other professionals involved in urban planning.

Cost: Developed in-house. Costs relate to DoP staff time and resources required to use the modelling suite.
Ningaloo Destination Model
Authors / Designers: Curtin University, CSIRO

Brief description: NDM is a system dynamics model built using the software VenSim. It represents elements of an integrated model that includes economic, social and environmental factors including energy and water use and waste generation. The NDM is focused on impacts relating to tourism dynamics in the region. It is not a spatially explicit tool and outputs are represented as graphs and tables. Some ‘front end’ web based and stand alone applications have been developed to represent output visually but are not directly linked to the tool.

Intended applications: The Ningaloo destination modelling tool is designed to address questions regarding the socio-economic and environmental impacts of different tourism development scenarios in the Ningaloo Coastal region. The tool includes dynamic relationships between different types of tourism activity, tourism development pathways and various socio-economic factors as well as energy and water consumption, waste production and some indicative ecological impacts. The Ningaloo Destination Model is designed to facilitate discussion between stakeholders regarding the character of tourism development and its potential influence on local communities. NDM is ideally used as part of a multi-stakeholder collaboration. It is applied at the regional scale.

Design:
- Systems dynamics model using VenSim model code from Ventana Systems Inc.
- Modelling mathematics - aggregated functions describing relationships between inputs.
- Not spatially explicit.
- The model’s code can be altered by an operator experienced with VenSim software in collaboration with the model developers.
- Can be operated on any computer on which VenSim software is installed (requires purchase of a license).
- Cannot interface with other models directly.
- NDM outputs in the form of graphs and tables.

Data requirements: There is a significant effort to populate the model with relevant data. This mainly involves setting up a series of 2 dimensional functions which define relationships between input and output variables.

Adaptability to different locations: Significant effort would be required to apply the NDM tool outside the Ningaloo region for which it was built.

User friendliness: There is documentation relating to the development of the model and a skilled modeller would be able to use the tool to self-teach with some time investment. With training it is possible to use the NDM tool independently. The tool has only been applied to the Ningaloo Coast Region as this is what it was designed for. There are no special hardware requirements; it can be used on any desktop or laptop computer with VenSim installed.

Cost: NDM software tool is free though access requires personal contact with model developers. Training by the model developer is available for a negotiable price (Jones, pers. comm., 2012).
Precinx
Authors / Designers: Kinesis Pty Ltd (www.kinesis.org)

**Brief description:** Precinx is a set of Excel spreadsheets used to measure the impact of residential development plans. From information available online, it tracks carbon intensity of new developments, environmental performance, living costs and affordability and liveability. Developers admit it is a ‘black box’ model. Although the information online discusses the tool tracking complex interrelationships and that it is an integrated model, it is advised this likely is not the case. The tool consists of 6 (maybe 7) ‘modules’. For each module, a series of calculations determine KPIs. As a spreadsheet based mode, it is likely to only capture first order dynamics. However, it is developed for an Australian context and assistance with reworking the tool to WA conditions is available.

**Intended applications:** The model is designed to address questions regarding the first order dynamics of energy, emissions, water, transport and housing for new residential developments. The model tracks greenhouse gases, water, housing affordability and vehicles hours travelled based on input data sets prepared for the location in question. In this sense it represents multiple processes based on typical housing indicators. The tool has a limited ability to facilitate collaboration across discipline areas as it requires specific data inputs on a limited range of modules. The tool has a limited capacity for monitoring. It can be applied to the urban precinct to city scale.

**Design:**
- A series of Microsoft Excel spreadsheets.
- Tool is proprietary but can be modified.
- Impacts limited to first order dynamics.
- Very limited capacity to interface with other models.
- It is not spatially explicit.

**Data requirements:** Precinx requires data inputs into 44 separate spreadsheets relating to various urban housing development indicators.

**Adaptability to different locations:** Precinx was developed for the Sydney region but could be applied to any location where data is available. Considerable effort is required in collaboration with the developer to update the model for new locations.

**User friendliness:** There is inadequate documentation to use the tool without engagement with the developer. If in-house use of the tool was possible independently of the tool developer, advanced Microsoft Excel skills are required. There is currently a limited community of users that includes Landcom in NSW and Landcorp in WA.

**Cost:** The Precinx software tool is only available for use through engagement with the model developer on a consulting basis. Cost varies and depends on the scale of the project (Trubka, pers. comm., 2012)
**Rapid Fire**

**Authors / Designers:** Calthorpe Associates, US. ([www.calthorpe.com/scenario_modeling_tools](http://www.calthorpe.com/scenario_modeling_tools))

**Brief description:** Rapid Fire is a spreadsheet model that tracks regional to national indicators for transport. The model reports on: emissions from cars and buildings, air pollution, fuel use and cost, building energy use and cost, residential water use and cost, land consumption, fiscal impacts (local capital infrastructure and O&M), costs, city revenues, and public health impacts. However, Rapid Fire is a ‘first order effects’ model, and although it tracks these indicators, they are ‘forced’ in the model and there appears to be no endogenous feedback processes.

**Intended applications:** Rapid Fire was developed for urban planning in Southern California. It can address research questions relating to transport related processes for regional (and up) scale research questions. It has limited integration capacity with first order effects represented across multiple processes (direct knock-on effects). Rapid Fire appears to have limited capacity to facilitate collaboration across discipline area based on its limited scope and function. It has no capacity to be used for monitoring over time. It can be used on any computer that can run a spreadsheet program. Applicable to the national, state-wide and regional scale.

**Design:**
- Modelling architecture and code is spreadsheet based.
- The tool is proprietary, but can be altered.
- Modelling mathematics are very aggregated.
- No capacity to interface with other models.
- Rapid Fire is not spatially explicit but there is a tool in development to map outcomes in a grid-based environment, although it is not currently available.

**Data requirements:**
- Requires regional transport data.
- The ease with which model can be applied in different locations and draw on different databases is limited to changing spreadsheet parameters.

**Adaptability to different locations:** Could be adapted to different locations. It has so far been applied to Southern California.

**User friendliness:** There is adequate documentation to understand the model and start using it. There is a limited community of practice. The model is not distributed by Calthorpe Associates and use of the model would require hiring their services in a consulting capacity. The tool receives software updates in so far as it operates using an Excel spreadsheet and benefits from updates to that software. It is a standalone product.

**Cost:** Cost is determined by negotiation for consultation services provided by Calthorpe Associates and depends on the specific project scale and requirements for modifying the model to a region other than Southern California (Distefano, pers. comm., 2012).
**STEM (Strategic Transport Evaluation Model)**

**Authors / Designers:** WA Dept of Planning

**Brief description:** STEM is a transport focussed model, which calculates trips and associated metrics under different land use and economic parameter scenarios. The model has its roots in travel cost modelling, and is mathematically robust in terms of the way it treats trip selection. Input data is defined based on a zonal map of the Perth region. From census based datasets, household trips are calculated for work, education, shopping, etc.. Commuters select between a choice of modes (car, bus, train etc..) based on a multiple regression. The regression is a multinomial logit model, which is good at estimating people’s decisions when faced with different choices of varying attributes (cost vs travel time for example). Overall the model is interesting and robust for what it does, which is to measure trips and associated metrics for transport planning. There are no other associated dynamics relevant to planning incorporated into the model, and not really any scope to do so.

**Intended applications:** STEM is designed to address transport related issues associated with commuting, such as trip time and how travel patterns change when the attributes of the transport system change. Processes represented include trip decision making from households to work and amenities. The model represents trip decision making and how these relate to attributes of the city. Multiple processes are not represented as STEM is specifically designed to model transportation and dynamically represent how patterns in travel behaviour change. It could potentially be used to monitor transport patterns. It may be applied at the urban precinct to city scale.

**Design:** The model executes a series of functions which calculate household trip demand, travel model availability, model choice, and trip distribution. Outcomes from these functions feed back to the next series of operations.

- Model Code is EMME/2
- Not open source
- Not strictly spatially explicit or visual apart from spatial segmentation

**Data requirements:** Specific data formatted from census and related databases

**Adaptability to different locations:** Designed specifically for the Perth metropolitan area.

**User friendliness:** STEM has been developed in-house at the DoP. Specific DoP staff have the skills sets required for operating STEM and as such, the community of users appears to be confined to the DoP. It has been applied to the Perth region.

**Cost:** Software developed in-house. Other costs relate to salaries and resources associated with operating STEM.
**SUSIP (Shared Urban Spatial Information Platform)**

**Authors / Designers:** CRCSI, Curtin University  

**Brief description:** Currently in development. SUSIP is a toolset built using Quantum GIS software. It has been designed as part of the sustainable urban development, Greening the Grey Fields Program with the CRC for Spatial Information (CRCSI). The SUSIP toolset is designed to apply spatial information to inform urban planning decision-making, for improved economic, social and environmental outcomes in urban areas. This includes modelling urban redevelopment scenarios and housing typologies based on current urban form variables.

**Intended applications:** The SUSIP toolset is designed to address questions about where to focus future urban redevelopment. This includes identifying properties that are ready to be redeveloped and urban areas that are best suited for redevelopment while considering a range of market segments. SUSIP is also intended to address questions relating to how efficiently residential land is being developed and how many more dwellings could be accommodated by rezoning. Finally the toolset will model housing typology options for prospective redevelopments sites. The tool is designed for use as in workshop discussion facilitation and will be applicable at the urban local government area scale.

**Design:**
- Designed using Quantum GIS software with Postgres as the back end.
- Model code/language is Python, built using open source software.
- In terms of modelling mathematics
  - The toolset is static insofar as the input datasets are static and feedback loops are not modelled or simulated.
  - Modelling techniques involved include Multi-criteria Evaluation (MCE) and Binary Logistic Regression.
- Can be used on any basic laptop or desktop computer.
- SUSIP has no capacity to interface with other existing modelling tools but will be compatible with subsequent tools to be developed as part of the CRCSI project.
- SUSIP is spatially explicit but not dynamic.
- Outputs in the form of maps, tables and graphs.

**Data requirements:** input requires Valuer-General datasets (property values, demolitions), ABS datasets (demographics and SEIFA), constructed datasets (distance measures) and GIS. Can use either ArcGIS or MapInfo data.

**Adaptability to different locations:** The toolset is ready for use by LGAs in WA or Victoria assuming required datasets are available. SUSIP can be adapted to other states, but updates to the software may be required.

**User friendliness:** Given the toolset is still in development, no documentation has been written to date. The toolset is designed for stand-alone use in workshop situations with operators requiring some minor training to obtain proficiency in its use (1-2 hours). Basic GIS skills are an advantage.

**Cost:** Has not been determined. (Trubka, R., 2012)
**TELSA**

**Authors / Designers:** ESSA Technologies LTD. ([essa.com/tools/telsa](essa.com/tools/telsa))

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**Brief description:** The Tool for Exploratory Landscape Scenario Analyses (TELSA) is a GIS-based spatially explicit model of vegetation dynamics. TELSA is a landscape-level model built to assess the consequences to vegetation of alternative management scenarios. The model simulates vegetation succession, natural disturbances, and management. TELSA can be used as a tool for landscape unit planning and adaptive management. It runs a series of sub-models, including the Vegetation Dynamics Development Tool (VDDT) which defines transition rules between vegetation succession classes and the probabilities and impacts of disturbance by insects, fire or other agents.

**Intended applications:** TELSA is designed to address questions regarding how vegetation dynamics respond to human and natural disturbances. As such, the model represents processes regarding vegetation succession in response to natural and human disturbance. TELSA does not represent multiple processes apart from those directly related to vegetation dynamics. Consequently, use of the tool itself would not facilitate collaboration across discipline areas, though the outputs could be integrated into a collaborative process. This tool cannot be used for monitoring. TELSA can be used on any desktop or laptop computer. Applied at the regional scale.

**Design:**
- TELSA is an ArcGIS toolbox.
- Model code / language is ArcGIS scripting.
- TELSA is somewhat open source, and theoretically can be altered by a skilled GIS analyst.
- Modelling mathematics is dynamic and bottom up to some degree.
- It has capacity to interface with other models via ArcGIS to a limited degree.
- It is spatially explicit / visual.

**Data requirements:** Standard GIS. TELSA works with the Vegetation Dynamics Development Tool (VDDT), which is a non-spatial state-and-transition model. Models developed in VDDT are a key input for TELSA and is strongly recommended that non-spatial models are developed with VDDT before moving to TELSA.

**Adaptability to different locations:** It is adaptable to different locations.

**User friendliness:** TELSA documentation is sufficient to understand the model and start using it. The community of practice in terms of numbers and range of users is unknown though it appears to be the toolbox of ecologists, but not frequently used. In terms of ongoing updates, TELSA appears to have been last update 2009 and upgraded to ArcGIS10. It is a standalone product for use in-house with basic ArcGIS skills required.

**Cost:**

**Software:** Freely available

**Training:** ESSA technologies offers introductory and advanced courses suited to people familiar with VDDT and ArcGIS - $950 per person or group rate (up to 17): $9000. Based in Canada.
**Urban Housing Growth Model**

**Authors / Designers:** LesterFranks Inc, Hobart (www.lesterfranks.com.au/gis.html)

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**Brief description:** The Urban Housing Growth Model appears to be in development, with an application in Tasmania viewable online. The model allocates urban spatial features within realistic 3D visualisation. The main value seems to be in the visualisation software, Eonfusion, which appears to be a 3D particle physics simulation model. Online examples of Eonfusion are mostly to do with hydrology, at very fine resolution, such as the way water flows in stream beds. Although the visual environment is impressive, there appears to be little modelling of processes. Any processes must be built from scratch by the model user. This tool is potentially similar to Urbansim, but at a much earlier stage of development.

**Intended applications:** The stand alone software tool can be used to visualise future housing development across a sequence of time periods. This can include incorporating changes to infrastructure at arbitrary times to investigate the effects on future housing location and timing (Lester & Leith, 2011). No modelling appears to occur beyond simple spatial allocation rules. The tool may be useful as a communication tool to engage across discipline areas. It cannot be used for monitoring. The tool can be applied at the precinct to regional scale.

**Design:**
- Uses Eonfusion software, other details unknown.
- Modelling mathematics are bottom up, highly disaggregated.
- The tool is spatially explicit with outputs as maps and numeric data

**Data requirements:** unknown

**Adaptability to different locations**, Potentially adaptable. It has been applied to Kingborough and Hobart, Tasmania.

**User friendliness:** The documentation is not sufficient to understand the tool and use it. Application of the tool requires engagement of developer as a consultant to adapt and operate the tool. There appears to be only one user, the developer.

**Cost:** Software not released by developer, costs relate to hiring LesterFranks Inc as a consultant to apply the software tool to locations other than the Tasmanian examples.
**Urban Sim**

**Authors / Designers:** Urban Analytics, Inc., US ([www.uanalytics.com/urbansim](http://www.uanalytics.com/urbansim))

**Brief description:** Urbansim is a Python based platform which operates in conjunction with GIS software such as ESRI. A central ‘engine’ handles input – output from various modules representing key elements of the urban system. The model is among the few reviewed that has significant attention to computational architecture. It represents common elements in urban dynamics such as mobile decision makers, land, markets, and policies regarding development. The model allows for feedback dynamics and so has significant ability to represent second and third order dynamics at a highly disaggregated scale. The micro-scale simulation aspect is particularly interesting, and appears to be the most advanced tool with respect to method flexibility and the ability to handle multiple scales of processes..

**Intended applications:** The model can address a broad range of urban / regional planning issues, relating to how the urban system functions, including jobs, land, real estate, travel, transport, residential decision making. Unlike most other software reviewed (barring ALCES), Urbansim models full feedback systems, and uniquely uses micro-scale simulation to represent processes at different scales. This makes the tool particularly flexible. Different assumptions on how each module operates could be incorporated as needed. As such it can represent multiple processes and can facilitate collaboration across discipline areas. It probably cannot be used for monitoring. It is applied at the precinct to city scale

**Design:**
- Model uses python scripting and software is open source
- The model engine is Open Platform for Urban Simulation (OPUS)
- Modelling mathematics are bottom up, disaggregated and multi scalar
- Hardware requirements unknown
- Appears to have regular updates
- May be able to interface with other models with input from development team
- It is spatially explicit

**Data requirements:** Unknown

**Adaptability to different locations:** Mainly applied to US urban areas. The tool can be adapted to different locations but engagement with developer is highly recommended.

**User friendliness:** Documentation is sufficient to explain how the model functions, but very advanced programming skills are required to operate the model in-house. As such, it is doubtful that anyone outside the development team could use the tool in a meaningful fashion, so interaction with Urban Analytics would be expected. The community of practice appears to include programmers in the US and a range of other programmers in Europe, Asia, Oceania and Africa.

**Cost:** Freely available software

**Training** Urban Analytics, Inc. offers six 1 day courses ($500 ea) ranging from intro to Urban Sim through to programming

**Services** Maintenance agreement: $3500 pa per user – priority support, bug fixes, dedicated user forum etc
Consulting services are offered by the developer with costs variable depending on the project with a price on request for quote. See [http://www.uanalytics.com/projects](http://www.uanalytics.com/projects) for examples. All US based.
**What if?**

**Authors / Designers:** Whatif Inc. ([www.whatifinc.biz](http://www.whatifinc.biz))

**Brief description:** Whatif? is a GIS-based planning support system, tracking land use, population, housing and employment projections for flexible spatial scales. It loads prepared data into an easy to use GIS interface. Different data layers can be viewed, such as land use, roads, soils, etc. The tool automatically calculates several GIS layers from base data such as elevation. Once this GIS layer is prepared, the model user defines a set of scenarios for conservation and for development (called sub urbanisation). These scenarios are specifically set by altering ‘suitability factors’ for different land uses, and conversion rules by which land use can change. The tool is flexible in this regard however the options are pre-set to a limited and commonly useful set of land uses and conversion rules. The next step requires the user to define land use demand scenarios (i.e. growth trends). Given the input parameters for these, the model allocates land use into the future. This model would appear to be a sophisticated land use change model, and offers an intuitive interface. The primary limitation would be the fact that the model user defines all the land use scenarios and conversion rules. As such there are few endogenous processes occurring, the model appears to simply grow out the pattern that is defined by the user. In this sense it is useful to spatially depict the range of possible scenarios for envisioning land use patterns into the future. However the processes that underpin this, such as land markets and other economic processes are not represented. The tool could be seen as a multi-criteria analysis combined with a GIS interface, with rules to define conversion patterns.

**Intended applications:** This model can address land use patterns in time under different development scenarios, specifically focussed on land use change and urbanisation. It represents conservation and development processes, based on a user-defined set of importance weightings, land suitability based on GIS attributes, and growth scenarios. The tool represents multiple processes within the scope of land use change and urban dynamics. The tool could possibly function in a monitoring capacity given the GIS link and temporal nature of model outputs. It could be used to facilitate collaboration across discipline areas. It may be applied at the city to regional scale.

**Design:**
- Model architecture: GIS layers with a windows based interface.
- Model language is unknown.
- Appears to have regular updates.
- Software is proprietary and may be calibrated but not altered easily.
- Modelling mathematics is aggregated based on spatial allocation rules.
- May interface with other models via the GIS layers.
- Spatially explicit.

**Data requirements:** Uses GIS data. The project data setup can be lengthy, including specific data requirements. it is somewhat complicated and requires GIS analysis functions.

**Adaptability to different locations:** Can be applied to different locations using data prepared by GIS technicians. It has mainly been applied in the US but also internationally.

**User friendliness:** Existing documentation is sufficient to understand the model and start using it. While it may be possible to use the modelling tool in-house, interaction with developers may be necessary. In-house use would require skills in GIS and basic programming skills depending on the What if? modelling.
language. There appears to be an active community of users and appears to be used extensively as evidenced by a good publication record by the primary designer and other academics who have taken on the methodology.

Cost:
Free demo version with no time limit.
Full software version - $1000 per user for public and private users.
Annual maintenance fee $200 per user. The first year’s maintenance is included in the purchase price.
Conclusions

Communication

- There is a need to enhance capacity for identifying clear and concise questions in the initial stages of planning – this is central to identifying what data is needed and what planning software tools could be used reliably and accurately.
- Improved lines of communication within DoP, especially between planners and data managers, could enhance planning and data management processes and assist with development of clear planning questions.
- Providing opportunities for staff engagement with planning and data management professional networks outside DoP may also enhance data management and planning capabilities.

Scenario planning capacity

- A main consideration relates to specific project needs versus maintaining on-going in-house capacity. Expect to interact with the model developers rather than buy a stand-alone tool in most cases.
- Developing scenario planning capacity within DoP may assist with more effective planning as well as better identification, acquisition and use of required data.
- It is apparent that DoP may need to use a combination of in-house and outsourced skills and capacity to access the range of planning software tools required for addressing various land use requirements in different locations and scales.

Scenario planning tools

- Given the absence of a single, effective all-purpose planning tool, there is a need to access a range of urban and regional planning software tools to address the various planning requirements of the DoP.
- Most software tools have their strengths and weaknesses in terms of functionality and use.
- Most software tools reviewed include 1st order effects only, rather than the more complex feedback loops required for effective strategic scenario planning functions.
- Most are specialised and focused on a ‘part’ of the big picture (e.g. water, vegetation, transport).
- Most are based in ArcGIS.
- Many require some collaboration with the tool developer for effective use.
- There is a need for access to a regional to state-wide scale complex scenario planning tool for strategic planning purposes.
- There is a need for a comprehensive urban planning software tool able process the complex and wide range of factors that interact within the urban form.
- In the absence of this, there is a need for software tools with different planning strengths that can effectively and efficiently interface with each other.

‘Highest scoring’ software tools

- CUBE is globally popular and advanced in transport network modelling but weak in other system level processes. It is relatively expensive to purchase.
- eWater Toolkit is a suite of hydrological modelling tools designed to assist with water management in relation to human and ecological impacts. Has a specific application but is well published.
- Whatif? appears to be a sophisticated land use change model with an intuitive interface. The primary limitation is that the model user defines all the land use scenarios and conversion rules. As such, the model appears to simply grow out the pattern that is defined by the user. In this sense it is useful to spatially depict the range of possible scenarios for envisioning land use patterns into the future.
- CommunityViz is an ArcGIS toolbox that estimates impacts of land use change and urban design. User friendly with good functionality but limited to simple 1st order impacts.
- UrbanSim represents common elements in urban dynamics and has significant ability to represent second and third order dynamics at a highly disaggregated scale. It uniquely uses micro-scale
simulation to represent processes at different scales. The model is very complex and interaction with the developer would be expected.

- ALCES tracks multiple human and natural processes with complex feedback loops. It is spatially stratified and requires an add-on tool ALCES Mapper to be spatially explicit. ALCES requires engagement with the developer for effective use. It is relatively expensive to purchase.
- INVEST and MARXAN are inexpensive, effective tools but have very specific applications regarding ecosystem service valuation and nature conservation planning.
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