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The Online What if? Planning Support System: A Land Suitability Application in Western Australia

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Abstract Recent advances in cloud computing and the ability to more easily deliver online tools and services provide exciting opportunities for the development and application of online planning support systems. This paper describes the application of an online open source land suitability tool which has been developed as one of the

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many tools available through the Australian Urban Research Infrastructure Network (AURIN) workbench. The tool is part of the larger open source online What if? planning support system (PSS) which implements the desktop What if? PSS developed by Klosterman (*Environment and Planning B: Planning and Design* 26:393–408, 1999; 2008). This paper describes the development of the online What if? suitability tool and the advantages and disadvantages of developing this novel solution. The paper focuses on a case study which used the tool for collaborative planning in the context of developing land suitability scenarios for the Metro North West sub-region in the Perth-Peel region undertaken by the Department of Planning in Western Australia. The paper concludes by discussing the lessons learned from formulating the land use suitability scenarios for Perth and outlines the next steps in the development and application of the online What if? tool.

Keywords Land suitability analysis · Strategic planning · Geographical information system · Planning support system · What if?

Introduction

Land use suitability analysis identifies the most appropriate spatial pattern for future land uses on the basis of the analyst's requirements, preferences, and predictors (Hopkins 1977). The seminal exposition of suitability analysis was provided by Ian McHarg (1969) but the method had been used by landscape architects and planners for decades before McHarg (Collins et al. 2001). Suitability analysis is one of the most useful—and widely used—applications of geographic information systems (GIS) for urban and regional planning. GIS-based suitability analysis has been used for an extensive array of applications including defining suitable habitats for animal and plant species, assessing the suitability of land for agricultural uses, environmental impact assessment, selecting the most suitable site for public and private sector facilities, and many other planning applications (Malczewski 2004, 2006). In the Australian context Pettit and Pullar (1999) used land suitability analysis in the site selection process for the Roma Street Precinct in Brisbane and Pettit (2005) used it for strategic planning in Hervey Bay, Queensland.

This paper describes the application of an innovative online open source suitability tool that has been developed as a key component to the Australian Urban Research Infrastructure Network workbench (Pettit et al. 2014). AURIN is a rich online information infrastructure platform which allows urban researchers, planners, and policy makers in Australia to access diverse data sources, sophisticated data integration capabilities, and advanced capabilities for analysing and visualizing those data through a user-driven Web-based environment (Sinnott et al. 2014). AURIN facilitates urban research which will enhance Australia's understanding of key issues of national significance relating to the sustainable development of the country's urban settlements and improve the evidence base for informed public policy making and planning.

The land use suitability analysis tool described in this paper is the first part of the open source online What if? planning support system (OWI), a component of the AURIN workbench described by Pettit et al. (2013). OWI is one of a broad range of advanced computational and visualization capabilities available via the AURIN workbench which provides seamless access to a wide range of diverse data sets and high-performance computational resources for supporting urban research and planning. AURIN utilizes a high-performance cloud-based infrastructure to provide computationally intensive applications for researchers, planners, and decision-makers who lack extensive computing resources. AURIN also provides access to over 1,000 datasets and a suite of open source analytical tools such as OWI which provide greater access to these resources, helping bridge the gap between PSS developers and users.

To the authors' knowledge OWI is the first fully operational PSS that makes GIS-based suitability analysis readily available as an online, open source interactive tool. In previous research Carver (1999) developed an online GIS-based multi-criteria evaluation (MCE) tool which allowed users to create their own land suitability maps but this tool was not open source. Pettit et al. (2002) also developed an online PSS for the Wide Bay Burnett Region in Queensland which provided some dynamic functionality and included a static land suitability analysis scenario. In contrast, the OWI tool is a dynamic land suitability model which has been coded entirely with open source software. It is expected that the source code will be published at https://github.com/AURIN on the GitHub source sharing platform in the near future.

Advantages and Challenges of Online Planning Support

GIS has proven to be a chameleon technology which is extremely useful for a wide range of applications but poorly adapted to planners' unique concerns with helping public and private decision-makers deal with an uncertain future. These limitations have led to the development of a large number of PSS which combine the spatial analysis and display capabilities of GIS with specialized forecasting and visualization tools that serve the needs of planners (see, for example, Brail 2008; Geertman et al. 2013).

PSS have been developed and applied literally around the world but continue to be not widely used in academic research and professional practice (Vonk, et al. 2005). A particularly important obstacle to widespread PSS adoption is the difficulty of implementing and accessing current PSS which have generally been available only as proprietary desktop applications. OWI directly addresses this issue by providing any time, any place online access to a state of the art PSS which allows users to create what if? scenarios exploring alternative futures.

It does this by, for the first time, allowing urban researchers and government officials in Australia to use the Web to explore the implications of different assumptions about the future and alternative public policy choices. As such, it represents an early example of a new generation of understandable and easy to use online tools that will allow planners, public officials, stakeholders and ultimately private citizens to quickly and easily address their shared concerns about the future of the cities and regions in which they live. The development of OWI provides an important step towards the current efforts such as public participation

GIS and volunteered geographic information which attempt to use the power of GIS to empower private citizens and marginalized groups (Sieber 2006).

However, one of the challenges in making online participatory planning tools available to the public is the issue of copyright identified by Carver et al. (2001). Although open source systems such as OWI can be made available to anyone, restrictions may remain on the data used in the PSS. While there is a movement for government departments to provide open data access (Delaney and Pettit 2014), restraints on their public release are often imposed to protect the commercial value and privacy of the fine-scaled data required for systems such as OWI. This important issue must be resolved before communities can fully engage in an evidenced based planning process.

The Online What if? Planning Support System

As its name suggests, OWI does not attempt to predict an unknown future. Instead, it is an explicitly policy-oriented planning tool that can be used to determine *what* would happen *if* clearly defined policy choices are made and assumptions about the future prove to be correct. Policy choices that can be considered in the tool include the staged expansion of public infrastructure, the implementation of alternative land use plans or zoning ordinances, and the establishment of open space protection programs. Assumptions about the future that can be considered in the tool include future population and employment trends, household characteristics, and development densities.

OWI is a relatively simple, rule-based model which does not attempt to duplicate the complex spatial interaction and market clearing processes that shape the urban fabric (Klosterman and Pettit 2005). Instead, it incorporates a set of explicit rules for determining the relative suitability of different locations, projecting future land use demands, and allocating the projected demands to the most suitable sites. As such, it is an example of a new generation of simple and understandable planning support systems which attempt to replace technocratic top-down planning for the public with community-based planning with the public (Klosterman 2013).

OWI can be adapted to the available data and policy concerns for any area which satisfies the model's rather modest requirements. These requirements include: (1) a GIS layer describing the area's current land uses; (2) optional layers describing the area's natural features, public infrastructure, administrative boundaries, land use controls and infrastructure expansion plans; and (3) the region's current and projected population, employment, and development densities. The case study describes the model's application to the data and policy concerns for the Perth-Peel region of Western Australia. The model has also been applied to other areas, including Hervey Bay in Queensland (Pettit et al. 2013).

OWI includes three major components: suitability, demand, and allocation. The suitability component considers the supply of land by allowing the user to prepare scenarios which determine: (1) the relative suitability of different locations for accommodating future land use demands; and (2) the implications of public policies that limit the amount of developable land. The demand component considers the demand for land by allowing the user to prepare scenarios projecting the amount of land that will be required to accommodate future population and employment growth. The allocation component jointly considers supply and demand by allowing the user to create scenarios which project future land use, population, and employment patterns. This component allocates the projected land use demands (as determined by a demand scenario) to the most suitable locations (as determined by a suitability scenario). The allocation scenarios can also incorporate public policies such as the implementation of a land use or an open space preservation plan or the staged expansion of public infrastructure. Only the OWI suitability component will be described in this paper.

Technical Architecture

The OWI PSS has been developed within the larger system architecture of the integrated AURIN workbench which facilitates data access, manipulation, analysis and visualization for a range of disciplines, including regional geography, environmental health, transport and urban planning. The system uses an advanced service-oriented architecture and state of the art web portal technology to ensure system scalability, enforce component isolation, and communicate using publicly documented interfaces (Sinnott et al. 2014; Tomko et al. 2012).

The OWI component of the AURIN e-Infrastructure was developed by re-engineering the What if? desktop tool developed by Klosterman (1999, 2008). This was achieved using state of the art, open source computer languages and exchange formats that support distributed computing and 'big data' analytics. OWI is written mainly in Java 7 using the spring framework, postGIS geospatial databases enhanced with GeoJSON formats to describe spatial data, and NoSQL to implement its configurations and cloud storage capabilities.

The advantages of the distributed computing and flexible architecture of the AURIN workbench were accompanied by challenging technical issues that were not present in the desktop version of What if?. The overhead of operating within the loosely coupled AURIN environment meant that the OWI module was dependent on the availability and resilience of many external interrelated components. Equally importantly, system interoperability required the OWI module to observe system restrictions such as a limit of the number of features that can be visualized simultaneously in a map. In summary, building the OWI component within the sophisticated AURIN system architecture made it more flexible and more powerful but also more complex and difficult to implement.

Online What if? Suitability Component

The OWI suitability component uses a traditional weighting and rating procedure adopted from multi-criteria evaluation (Voogd 1983) to compute suitability scores for all projected land uses and all locations in the study area. The program requires the user to specify assumptions concerning the land use conversions, factor weights, and suitability ratings to be used in the analysis. The procedures for doing this are described below.

Specifying Land Use Conversions

The user must first specify the existing land uses that may—and may not—be converted to other uses as the region develops, as shown in Fig. 1. For example, the user can specify that areas which currently contain medium density residential land may be converted to high density residential uses but may not be converted to low density residential uses. The tool also allows users to identify land uses such as water bodies or protected areas that cannot be converted to other uses. Some of the conversions express the user's assumptions concerning the land development process, e.g., that areas which currently have high density residential uses are too valuable to be converted to low density residential uses. Other conversions express the user's preferred policy choices, e.g., that environmentally sensitive areas should not be converted to other uses. Land use conversion assumptions must be specified for each current and future land use, i.e., the user must specify whether each current land use can be converted to each future land use.

Specifying Factor Weights

Next, the user must specify the relative importance of different suitability factors for satisfying future land use demands. The factor importance weights range from zero for factors which will not be considered to 100, the highest importance weight. Some of the factor weights reflect the user's assumptions concerning the land development process. For example, if it is assumed in the case study example that land located in a public water supply area is twice as attractive for new development as proximity to railway stations, the first factor could be given a weight of 100 and the second a weight of 50.

The factor weights can also reflect the user's policy choices. For example, an environmental protection scenario may assume that protecting environmentally sensitive areas is important and give a high weight to this factor. On the other

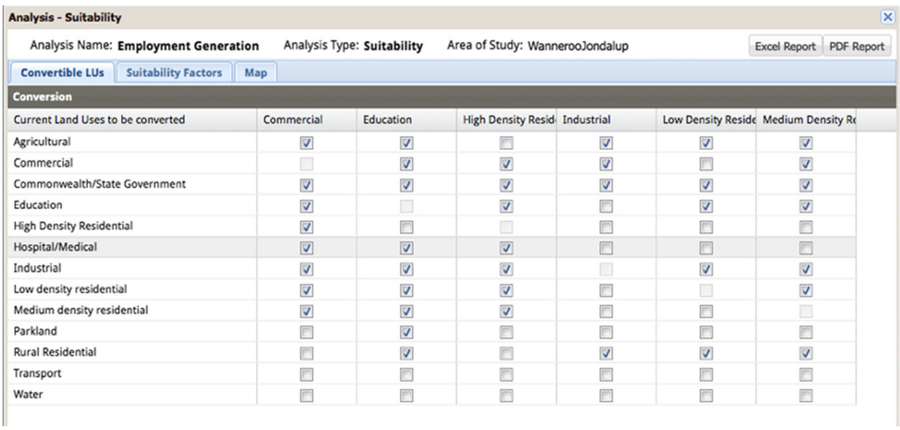


Fig. 1 Interface for specifying land use conversions

hand, an economic development scenario may assume that protecting environmentally sensitive areas is not important and assign this factor a low weight so that it has little impact in computing the overall suitability scores.

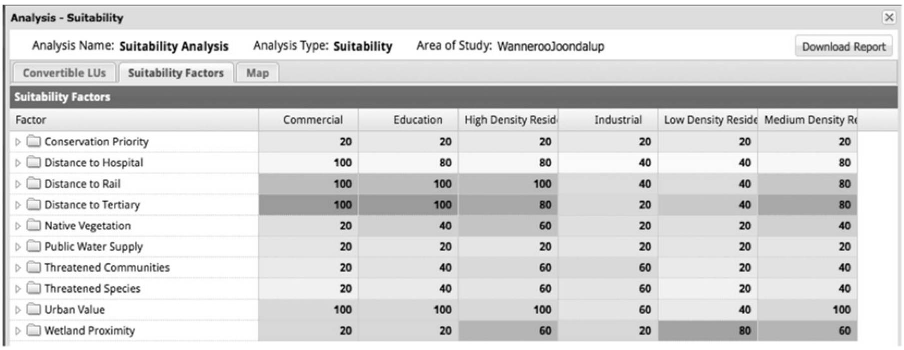
Figure 2 shows the OWI interface for specifying the factor weights. The ten suitability factors used in the case study are listed on the left side of the form. The body of the form records the user-specified weights for each factor and each future land use. For example, in this example the user has assigned a factor weight of 100 for the Distance to Hospital factor and Commercial development and a weight of 80 for the Distance to Hospital and Education factors.

Specifying Suitability Ratings

Finally, the user must specify a suitability rating for the factor types of each suitability factor. The OWI interface for specifying the suitability ratings is shown in Fig. 3. The left side of the form lists the user-defined factor weights and suitability ratings. The major headings report the factor weights which the user had defined previously, as shown in Fig. 2. The user must then assign a suitability rating for each factor type and each land use. The user-defined suitability ratings range from zero, indicating areas from which development should be excluded, to 100 for areas that are highly suitable for development. For example, in Fig. 3, the user has specified a suitability rating of 75 for Commercial development in Low Conservation Priority areas.

Computing Suitability Scores

After the user specifies the land use conversions, factor weights, and suitability ratings, OWI computes a suitability score for each future land use and all polygons in the study area. The suitability scores are computed by: (1) multiplying the user-defined importance weight for each suitability factor by the user-defined suitability rating for the associated factor type and (2) summing



Factor	Commercial	Education	High Density Resid	Industrial	Low Density Reside	Medium Density Re
Conservation Priority	20	20	20	20	20	20
Distance to Hospital	100	80	80	40	40	80
Distance to Rail	100	100	100	40	40	80
Distance to Tertiary	100	100	80	20	40	80
Native Vegetation	20	40	60	20	20	40
Public Water Supply	20	20	20	20	20	20
Threatened Communities	20	40	60	60	20	40
Threatened Species	20	40	60	60	20	40
Urban Value	100	100	100	60	40	100
Wetland Proximity	20	20	60	20	80	60

Fig. 2 Interface for specifying factor weights

the products. That is:

$$s_{ij} = \sum\nolimits_{(k=1)}^{n} \left(w_{ijk} {}^{*} r_{ijk} \right)$$

where:

s_{ij} suitability score for current land use i and future land use j
w_{ijk} importance weight for current land use i, future land use j, and suitability factor k
r_{ijk} factor rating for current land uses i, future land use j, and suitability factor k
n number of suitability factors.

Suitability Maps

The computed suitability scores are used to prepare a series of maps which show the relative suitability of each polygon for each future land use. The equal interval method was used to divide the suitability scores for each land use into five categories: Low, Medium Low, Medium, Medium High, and High. A Not Convertible category is assigned to parcels where the user assumes that the existing land use cannot be converted into the future land use being considered.

Factor	Commercial	Education	High Density Resid
Conservation Priority	**20**	**20**	**20**
High Conservation Priority	0	0	0
Low Conservation Priority	75	80	75
Low-Medium Conservation Priority	50	60	50
Medium Conservation Priority	25	40	25
Medium-High Conservation Priority	0	20	0
No Conservation Priority	100	100	100
Distance to Hospital	**100**	**80**	**80**
Outside 4000m from Hospital	40	20	60
Within 1000m of Hospital	100	100	100
Within 2000m of Hospital	100	90	100
Within 4000m of Hospital	60	60	80
Distance to Rail	**100**	**100**	**100**
Greater than 8000m from Railway Sta...	1	20	0
Within 1600m of Railway Station	80	80	75
Within 4000m of Railway Station	50	60	50
Within 8000m of Railway Station	20	40	0
Within 800m of Railway Station	100	100	100

Fig. 3 Interface for specifying suitability ratings

OWI improved on the desktop version of What if? by changing the values used in the equal interval classifications of the suitability scores displayed in the suitability maps. The original version utilized equal interval classifications that ranged from zero to the maximum suitability score. However, in practice, the minimum suitability score is generally well above zero because a zero suitability score can only occur if none of the factors are suitable. As a result, there is always a very large gap between zero and the lowest suitability score. OWI clarifies the suitability scores with equal intervals between lowest and highest non-zero suitability scores, providing a much more effective classification between the suitability scores.

Case Study

The OWI Suitability tool was used with data for the Strategic Assessment of the Perth-Peel region conducted by the Western Australian State Government. The assessment is driven by the Australian Federal Government's Environmental Protection and Biodiversity Conservation (EPBC) Act (Commonwealth of Australia 1999) and anticipated rapid growth in the state. Population forecasts published in the Western Australia Tomorrow report (Western Australia Planning Commission 2005) and the Outer Metropolitan Perth and Peel Sub-regional Strategy (Western Australia Planning Commission 2010) suggest that the state's population may grow from 1.65 million in 2010 to 2.2 million by 2031. The Western Australia Department of Planning (WA DoP) is also considering scenarios for 3.5 million residents by 2050. This growth has the potential to negatively impact the valuable environmental assets of the Perth-Peel region.

The strategic assessment has been conducted to: (1) significantly reduce the need for project-by-project reviews under the EPBC; (2) develop an effective long-term strategic response to key environmental issues in the region; (3) give industry greater certainty on areas which can be developed and their obligations in terms of impact mitigation and environmental offsets; and (4) provide greater certainty on the supply of land required to support a future population of 3.5 million residents (Western Australia Planning Commission 2013a). The OWI tool was used primarily to address the last two objectives.

The Wanneroo and Joondalup Local Government Areas (LGAs) shown in Fig. 4 make up the case study area. This area, which is known as the Metro North West sub-region in the Perth-Peel Strategic Assessment, is expected to experience the second largest population growth of the state over the next twenty years, behind Perth Metro Central region (WAPC 2010). The study area includes over 135,000 land parcels, each of which is given a suitability score by the OWI suitability model. Data have been prepared for the entire region and will be the focus of future analysis. However, this paper will consider only the Metro North West sub-region for two land suitability scenarios.

Suitability Scenarios

Two scenarios were used to consider the study area's suitability for accommodating the following land uses: (1) commercial, (2) industrial, (3) education, (4) low density residential, (5) medium density residential and (6) high density residential.

The following factors were used to assess the area's suitability for accommodating these uses: (1) native vegetation locations, (2) threatened species and vegetation community locations, (3) public water supply zones, (4) proximity to railway stations, (5) regional conservation priority, (6) proximity to hospital and university precincts, and (7) urban value. These factors were determined to be important for the Metro North West sub-region during workshops and planning sessions with planning experts within the WA DoP. Details on the computation of some of these factors are provided below.

Conservation Priority

A two-step process was used to define regional conservation priorities for the Perth-Peel region. First, the distributions of 213 threatened species and ecological

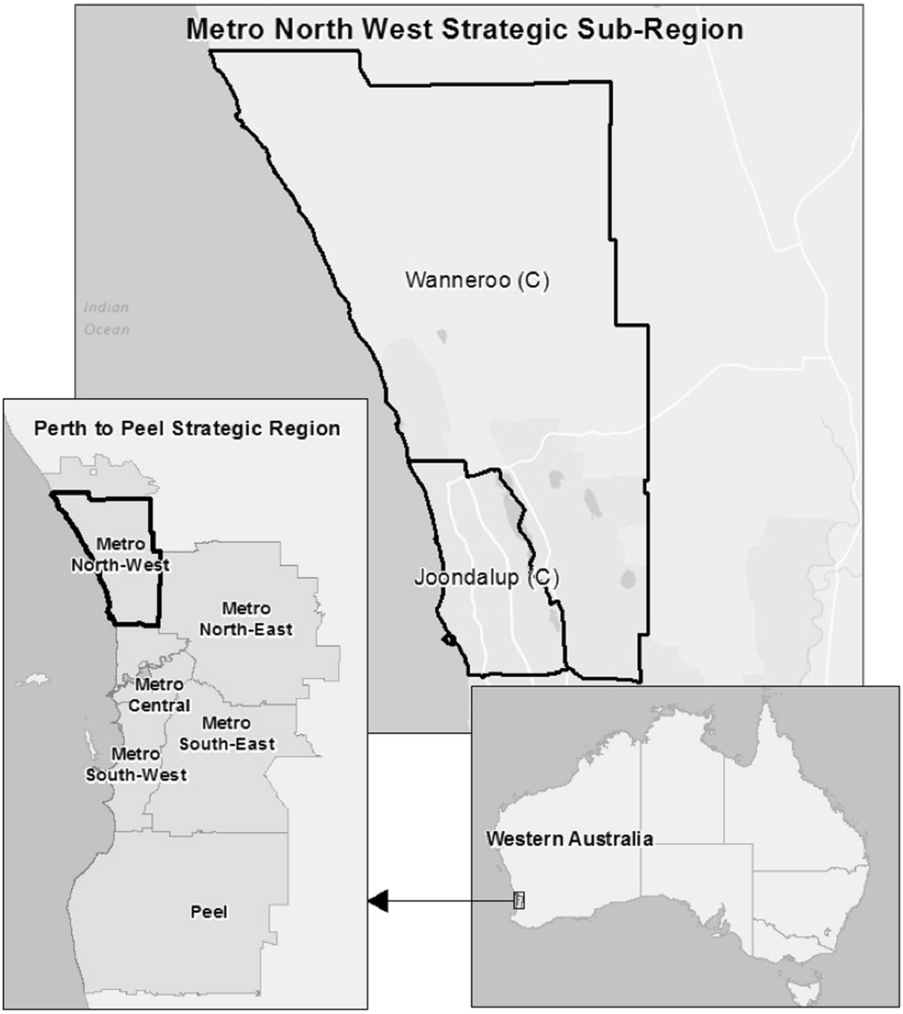


Fig. 4 Study area location map

communities were mapped across the Perth-Peel Strategic Assessment Region, using available spatial data for known occurrences and ecologically-relevant environmental parameters (See Online Resource 1 for more details). The distribution mapping was done in raster format with a cell resolution of 100 m.

The distribution maps were then combined in the Zonation spatial conservation prioritization software (Moilanen et al. 2005, 2012), which uses information about biodiversity features' relative occurrences and biological needs to rank the conservation importance of different areas in the landscape based on their conservation importance. Values in the resulting continuous rank map range from 0 to 1, with high values representing areas with a high priority for conservation. The Zonation output was reclassified into six classes representing the degree of conservation priority across the landscape: (1) No Priority, 0.0; (2) Low, 0.0–0.2; (3) Low–Medium, 0.2–0.5; (4) Medium, 0.5–0.75 (5) Medium–High, 0.75–0.9; and (6) High, 0.9–1.0. The classes were assigned to each land parcel in the study area for use in the OWI suitability analysis. The zonal maximum was used to minimize the risk of impacting areas of high conservation priority. As a result, if part of a land parcel has a high conservation priority ranking, the entire parcel was given a high conservation rating.

Urban Values

The WA DoP created an Urban Value Atlas for the entire Perth-Peel Strategic Assessment Region to assist in preparing the sub-regional structure plans. This dataset is a composite mix of data designed to identify areas which can provide good urban outcomes under the current Western Australian Government Directions 2031 planning policy. The dataset contains measures and indicators which are aligned with the Directions 2031 themes of liveability, prosperity, accessibility, sustainability and responsibility (WAPC 2013b).

Ten urban values were used to create the Urban Values dataset. GIS spatial analysis was used to evaluate all land parcels in the assessment region against each indicator. Urban Value scores of 0, 1, 2, or 3 were assigned to each parcel: 0 indicates no urban value; 1 indicates a low urban value, 2 indicates a medium urban value; and 3 indicates a high urban value. Nine of the ten indicators had sufficient data for this assessment; the tenth indicator was not present in the case study area. As a result, each land parcel was given a score between 0 and 27. The WA DoP created the following Urban Value classes from these scores: (1) Unfit for Urban (2–9 points); (2) Low Urban Value (10–15 points), (3) Medium Urban Value (16–21 points), and (4) High Urban Value (22–27 points).

Public Water Supply

The Western Australian Department of Water is responsible for protecting the water supply quality and quantity of Western Australia. To support this, the state's land use strategy identifies and protects existing and future water supply areas, particularly public drinking water sources (Western Australia Department of Water 2006). The Public Water Supply factor includes three priority categories. Areas classified as

Priority 1 or 2 have development limits in local planning schemes. Areas identified as Priority 3 are not restricted by the local planning schemes. As was true for the conservation priority factor, land parcels were assigned the most severe restriction for any part of a parcel.

Suitability Scenarios

The WA DoP is currently using the complete OWI tool to consider four scenarios for the entire Perth-Peel region. However, this paper considers only two scenarios illustrating the outputs generated by the OWI suitability component.

Employment Generator Scenario

The first scenario promotes employment generation by making the Metro North West sub-region more productive and better educated. Achieving this goal requires improving the sub-region's transportation system to reduce the number of residents who must commute a long way to the Perth CBD for high income employment. This scenario attempts to protect areas of environmental significance, but only to the extent currently required by WA planning laws. As such, areas containing threatened species or and native vegetation were give low suitability scores but were not barred from development.

Environmental Conservation Scenario

The second scenario continues to promote employment in the region but takes a much stricter approach to minimising environmental impact. This scenario implements the state's strategic assessment goals by classifying all areas containing any environmentally significant features as not suitable for development.

Scenario inputs for both scenarios were incorporated into the OWI tool as described above. The factor weights and ratings were developed during a workshop with the WA DoP. These scenarios promote employment generation in the Metro North West sub-region by: (1) increasing the density of residential areas around existing activity centres, hospitals and tertiary education facilities, (2) allowing broader commercial development for most land uses, and (3) exploring new industrial areas on the fringe of the urban areas. As discussed above, the key difference between the scenarios is the suitability scores given to the environmental factors.

Scenario Results

Figures 5 and 6 show the OWI suitability maps for residential development near the urban center of Joondalup, where future employment is likely to be located around the university and hospital precincts. Figure 5 shows the suitability results for the

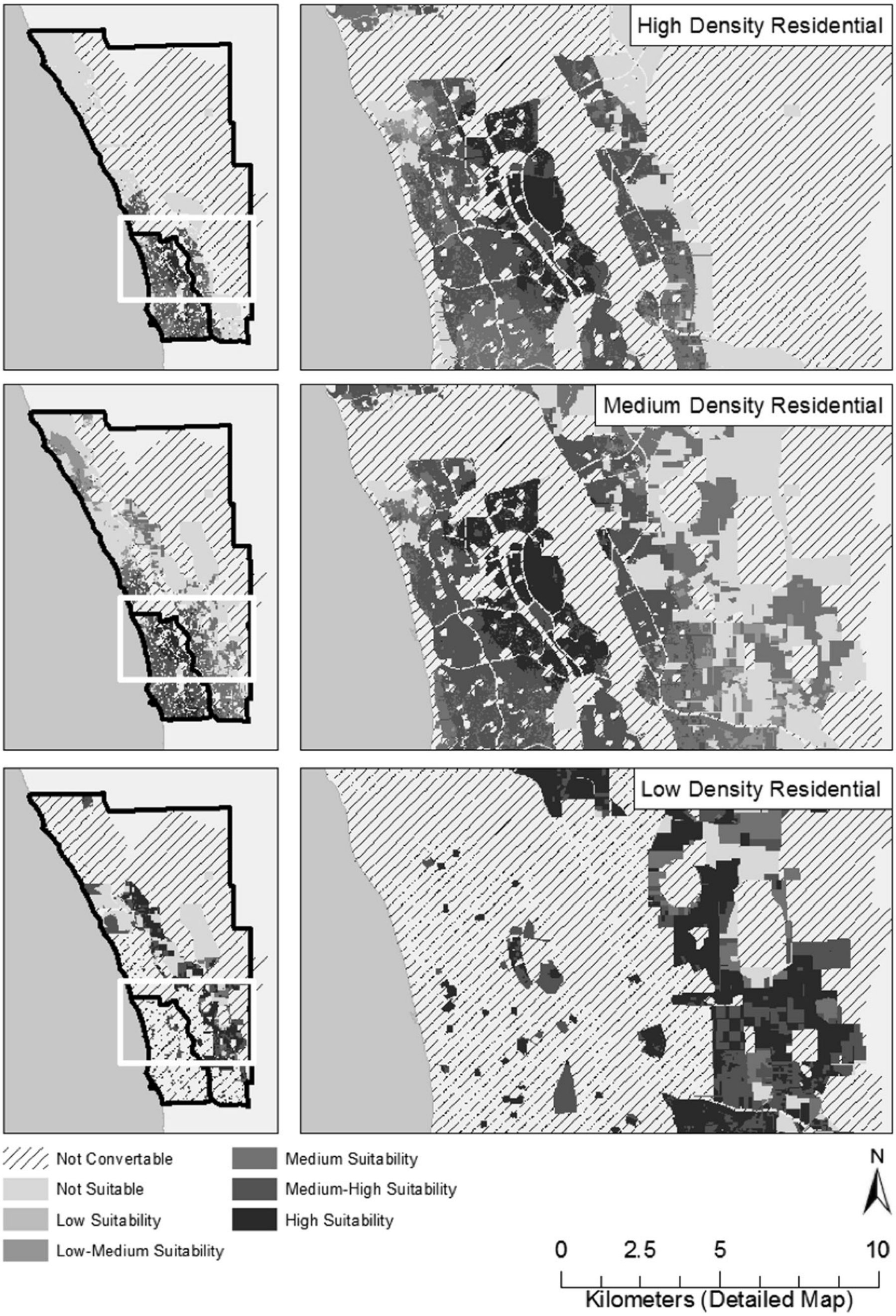


Fig. 5 Residential suitability maps for the employment generation scenario

Employment Generation scenario; Fig. 6 shows the results for the Environmental Conservation scenario. Table 1 provides a detailed breakdown of the amount of land in each suitability category.

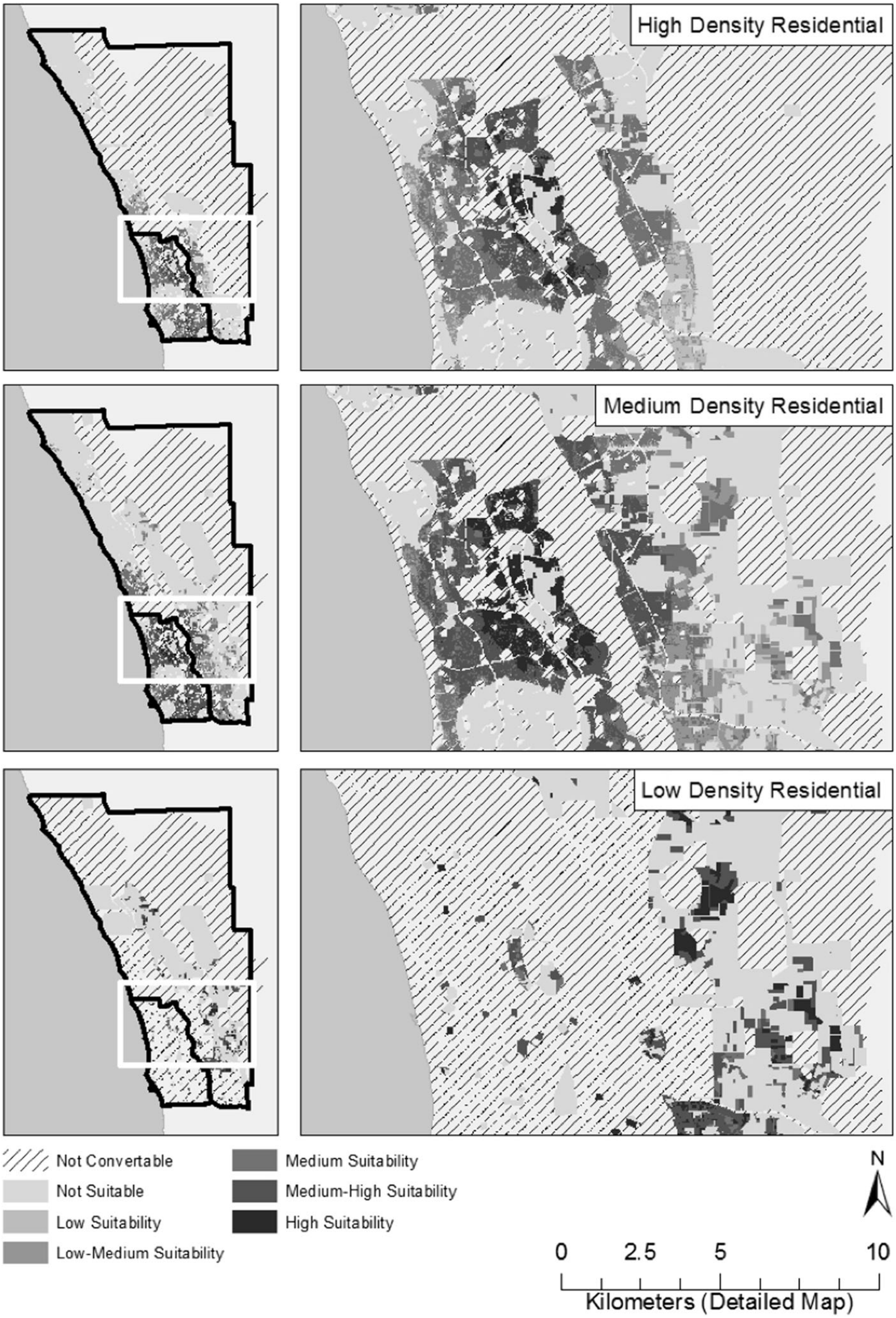


Fig. 6 Residential land use suitability maps for the environmental protection scenario

The maps and table clearly show that the Environmental Conservation scenario greatly reduces the amount of suitable land. For example, the Employment Generator scenario identified 5,500 ha as either medium-highly or highly suitable for High

Table 1 Quantity of suitable land uses (area in hectares)

Suitability category	Employment generation	Environmental conservation
High density residential		
Not convertible	54,320	54,320
Not suitable	12,100	14,260
Low	10	720
Low–medium	330	1,690
Medium	2,620	2,480
Medium–high	4,530	1,200
High	1,050	190
Medium density residential		
Not convertible	40,540	40,540
Not suitable	16,760	24,530
Low	10	420
Low–medium	3,400	1,960
Medium	6,780	3,630
Medium–high	5,840	3,030
High	1,550	760
Low density residential		
Not convertible	58,160	58,160
Not suitable	6,610	14,290
Low	0	0
Low–medium	0	0
Medium	800	270
Medium–high	3,990	1,350
High	5,320	800

Density Residential Land development. In comparison, the Environmental Conservation scenario reduces the amount of suitable land for this land use to 1,400 ha. The same is true for Medium Density land, where the Employment Generation and Environment Conservation scenarios identified 7,300 and 3,800 ha of suitable land, respectively.

Table 2 Suitable land results for environmental sensitivity tests

Environmental factor	Suitable medium density residential land (ha)	Suitable high density residential land (ha)
High conservation priority	3,900	1,400
Native vegetation	5,300	2,500
Threatened communities	5,100	2,300
Threatened species	5,500	2,300
Wetland proximity	4,100	2,300

Sensitivity Testing

With such a significant difference between the amounts of suitable land for the two scenarios, it is important to understand the key environmental drivers affecting the results. The open source QGIS desktop GIS software was used

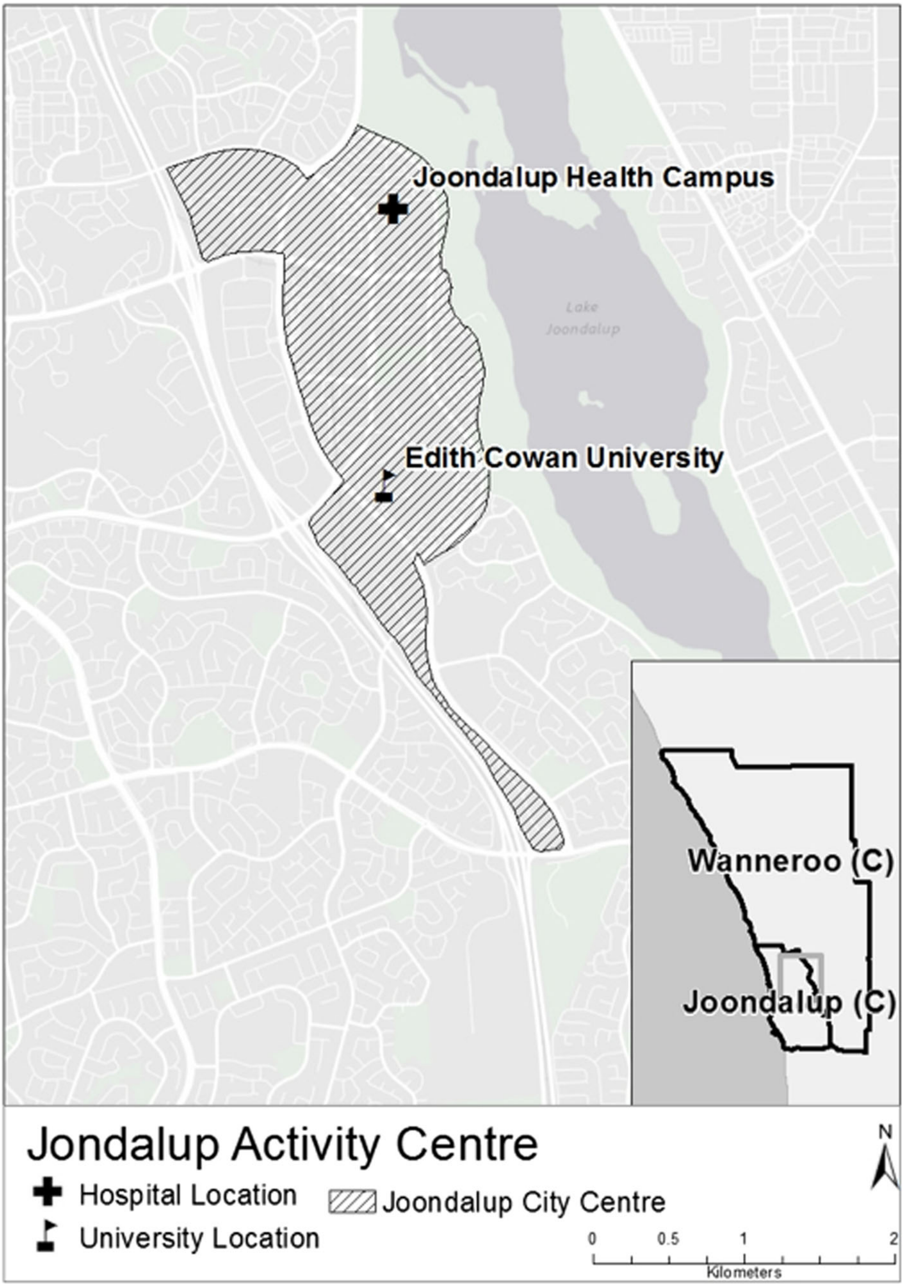


Fig 7 Joondalup activity centre with key employment locations

Table 3 Quantity of suitable residential land within 2 km of the Joondalup activity centre

Land use	Employment generation scenario (ha)	Environmental conservation scenario (ha)
High density residential	1,940	920
Medium density residential	2,037	1,471

to conduct a sensitivity analysis identifying which of the following factors had the most influence on the amount of suitable land: (1) native vegetation, (2) threatened species or communities, (3) high or medium–high conservation priority, or (4) location within 50 m of a wetland. The Environmental Conservation scenario assumptions were used to prepare a series of scenarios that assigned suitability values of 0 or 10 to each of these factors.

Table 2 reports the total area of medium-highly or highly suitable land for Medium Density and High Density Residential Land under each of these scenarios. The analysis revealed that threatened species and native vegetation had the largest impact on the quantity of suitable land. Recognizing the importance of these factors will be very helpful for the WA DoP's efforts to develop effective environmentally sensitive plans.

Proximity Analysis

Both scenarios attempt to simultaneously increase employment and densify residential areas. The Outer Metropolitan Sub-Regional Strategy (WAPC 2010) recommends that the majority of this densification occur around existing activity centres. In particular, development is encouraged in Joondalup which is the primary metropolitan centre of the North West sub-region and contains the region's major hospital and university, as seen in Fig. 7.

The suitable areas identified in the previous analyses include the entire North West sub-region, so it is important to understand the impact that the two scenarios have on the quantity of suitable land located in close proximity to the Joondalup Activity Centre. QGIS was used to determine the quantity of suitable land within 2 km of the Joondalup activity centre under each scenario, as shown in Table 3 below. The table indicates that there is a significant decrease in the quantity of suitable land for both high and medium density residential development under the Environmental Conservation scenario. However, it is important to note that this scenario still provides enough land to meet the projected needs of the entire North West sub-region as identified in the Directions 2031 strategy. According to this strategy, the sub-region will require an additional 65,000 dwellings by 2031 (WAPC 2010). Using a conservative 100 dwellings per hectare for high density residential development, and 60 dwellings per hectare for medium density residential development, the land requirements are 650 ha and 1083 ha respectively. This suggests that the Environmental Conservation scenario can satisfy both the population growth and environmental aims set out in the state's strategic plan.

Conclusions

This paper describes the development and application of the OWI land suitability tool, one of the advanced spatial planning and decision support system tools available from the AURIN online workbench. As one of the world's first open source online PSS, OWI demonstrates the potential that easy-to-use and understand online tools offer by allowing planners, public officials, stakeholders, and ideally private citizens to prepare their own scenarios exploring the implications of alternative assumptions about the future and different policy options.

The paper demonstrates the tool's value for considering two land suitability scenarios for the North West Metro Perth sub-region. The ability to compare scenarios demonstrates that the OWI tool can be used in a collaborative way to inform practical planning questions. The case study illustrates that a wealth of useful information can be derived from the different suitability scenarios. For example, the sensitivity analysis on the OWI generated land suitability analysis results revealed that threatened species and native vegetation had the largest impact on the quantity of suitable land. The case study analysis also demonstrated that even though the Environmental Conservation scenario produces a smaller quantity of suitable land, it may still be the preferred scenario because it satisfies the region's projected land needs.

The OWI tool only requires internet access and a browser to create and evaluate suitability scenarios such as the ones described in this paper. Once created these scenarios were accessible to all participants involved in the project, which included people in Canberra, Perth, Melbourne and the United States. This demonstrates a significant advantage of online tools such as OWI to allow collaborative planning involving geographically dispersed teams.

However, it is important to acknowledge that online tools have their challenges. For example, performance issues were encountered in visualizing large vector maps online that potentially contained hundreds of thousands of parcels that had to be rendered. Work is currently in progress to overcome this issue by utilizing raster maps instead of vector maps to visualize large online maps, but this entails complex on the fly transformation between vector maps and their raster counterparts. In addition, not all of the desired functionality could be performed in OWI, as was true for the desktop What if? tool. For example, the sensitivity and proximity analysis described in this paper required the use of QGIS.

Future research will focus on the development and application of the growth and allocation modules of the OWI tool and their application to the case study area.

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