GeoDesign and Simulation of an Australian City 2016-2050: What Does the Future Hold … Are They Sustainable or not?

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Abstract

This paper demonstrates the ability of visualization and simulation techniques to aid, and simulate current and future directions in coastal planning. The coastal city of Hobsons Bay on Port Phillip Bay in Victoria, Australia, is interrogated through a progression of projections and simulated forecasts from 2014 to 2050 to comprehend its growth risks as it relates to its coastal edge and land use planning mechanisms to deal with these changes. The analysis uses Geographic Information Systems (GIS) associated with planning application software, and the paper offers recommendations in progressing this inquiry.

1 Introduction

Coastal cities around the world over the past few decades have grown at an incredible rate. Integral with this growth have come major challenges relating to land use planning, social relationships, economic development, bio-diversity and the degradation of the ecological footprint. Three forces are working to influence the growth rate of coastal cities. These forces include: population growth (i.e. the type and quantity of human demand for land); the existing and future properties of the land (i.e. current land status or changes due to nature and human activities); and, finally technical changes of a land system (i.e. zoning or the influence of other external factors).

As this development growth continues one question arises is 'is this continued growth or development sustainable?' CIEGIS et al. (2009) have described the problems of trying to identify the essential features of sustainable development that would provide models of management of 'sustainable development'. In their comparison and the clarification of processes, they concluded that none of the hundreds of 'sustainable development' definitions found in the literature included all the aspects of the concept and provide perfect understanding of the concept. CIEGIS et al. (2009) concluded that the most appropriate definition that best expresses the idea of sustainable development is from the World Commission on Environment and Development (WCED 1987) authored *Our common future* report, termed the Brundtland Commission. In this report, the concept of sustainability develop-

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ment is based on three pillars: economic, social and environmental sustainability. This concept of sustainable development is now commonplace in the planning process.

The Brundtland (WCED 1987, 43) definition, now extensively adopted by the planning profession, stated sustainable development is: ... *development that meets the needs of the present without compromising the ability of future generations to meet their own needs.* Using the Brundtland definition as guide could a research problem be developed that posed the question is current and future coastal city development in Australia sustainable. To test this question the current and future development patterns of the City of Hobsons Bay (HB) in Victoria were simulated and analysed. Three scenarios were developed for HB, based on the Victorian government population and housing forecast to 2050.

The three scenarios included a low scenario equating to ninety percent of the of the Victorian government predicted population and housing growth forecast to 2050, a base scenario which is the actual Victorian government forecast and a high scenario which is one hundred and ten percent of the of the Victorian government population and housing forecast to 2050 (VICTORIA 2014). The key element in the three scenarios is the growth in the number of houses per five-year period.

This paper addresses: To efficiently plan for future urban growth you must undertake a two-step process. Step one is to disaggregate demographic and social economic information. Step two is to combine this with environmental, infrastructure and forecast data within land use models, and, as a consequence, can visualization techniques portray information so that it is legible, easy to understand and thus more likely to be used by practitioners.

2 Hobsons Bay City

To test and validate the study research statement a case study approach was used to analyze and visualize for the future growth of HB, a municipality within the larger metropolis of Melbourne on the of Port Phillip Bay, in Australia. The City of HB represents a coastal city with a population 90,000. The City of HB municipality is situated on the north-western flank of Port Phillip Bay around 10 km west of central Melbourne. With a population of 89,111 people, HB has a current population density of 1388.22 km^2. The City has an area of 64 km^2 in size comprising 41,686 parcels or lots of which 35,386 are occupied by private dwellings. The dominant employment sectors are manufacturing which represent 11.3 % of the workforce, healthcare at 9.4 % and retail which represents 9.1 % of the workforce.

3 Research Methodology, Software and Data

The study methodology used for the research is based on the concept of scenario planning, that focuses on the use of scenarios; Landscape visualization; Sustainable development evaluations; Multi-criteria analysis; Categorization of tools for sustainability analysis; and, spatial models through the use of Geographical Information Systems (GIS).

WALKER (2011) observes that "for the purpose of this discussion the term scenario is defined as an alternative plan that is being considered". Using WALKER's definition three

scenarios were developed to test the research question, is the current and future coastal city development in Australia sustainable. Three scenarios were developed including:

- A low scenario equating to 90 % of the Victorian government predicted population and housing growth forecast to 2050,
- A base scenario that is the actual Victorian government forecast, and
- a high scenario which is 110 % of the of the Victorian government population and housing forecast to 2050

The key element is the growth in the number of houses per five-year period. The growth is what generates all of the sustainable indicators. The use of indicators is crucial because they represent a measure of comparable success of each scenario that is developed. The primary goal of scenario planning is to correctly rank scenarios by each indicator score. A build-out analysis was performed on the HB. The build-out analysis depicts the residential, industrial and commercial potential from 2016 through 2050.

As part of this investigation, Community Viz (WALKER 2011) was used. Community Viz is a planning and simulation software package. To develop economic, demographic and planning scenarios the software performs four functions including: the estimation, amount and location of new development allowed in an area according to current or proposed zoning regulations; the suitability of the new development to an area; the allocation of where growth is most likely to occur over a specific time span and finally the development of a series of environmental indicators showing the impact of the new development on the landscape. The suitability analysis was performed on the respective build out results for each city with criteria used in the suitability analysis including: Proximity to the city centre; Sewer access; Proximity to hazardous areas; and Shoreline access

The next analysis stage was the allocate procedure which takes the results from the build out and suitability analysis and allocated the demand for buildings across the available supply of potential building locations.

Through the impact function in Community Viz over 50 indicators were developed showing the impact of development over time on the urban landscape. The indicators included: Distance functions from new developments, i.e. to amenities, parks, schools, etc.; Environmental impacts from new development, i.e. CO_2 emissions, floodplain percentage, hydrocarbon emissions, residential water and energy usage, waste water generation, etc.; Land use characteristics including agricultural, commercial, industrial, open space percent, type of residential density, etc.; Transportation characteristics including; jobs, new transport, street density, bicycle coverage, etc.; and Recreation characteristics including park and recreation percentage, housing near schools, etc.

The Build-out, Suitability and Allocate analyses were performed on the HB data. The suitability analysis performed on the HB build-out analysis result used 12 criteria including coast flooding projections from 2040 through 2100; proximity to oil refineries, chemical plants and oil tank farms; and trees and native vegetation. For the period 2016 through to 2050 the number of new dwellings constructed could range from 12,686 to 28,746 dwelling units (Table 1). Figure 1 shows residential development in 2016 and Figure 10 shows development in 2050. Residential development is represented by yellow dots and commercial development by red dots. Three scenarios (Table 1) were developed from the Victorian population and housing forecast to 2050.

Table 1: Three Growth Scenarios for Hobsons Bay 2016-2050, Source: VICTORIA 2014

Low / Base / High Scenarios

- Population Dwelling and New Dwelling Units were forecast to be:

	2016	2021	2026	2031	2036	2041	2046	2050
Scenario 1 Low Population	81996	84848	87602	90119	93,002	95,977	99,047	102,215
Total Dwelling	33370	34902	36359	37739	39,319	40,965	42,680	44,467
New Dwelling Units	1376	1432	1489	1549	1,611	1,675	1,742	1,812
Scenario 2 Average Population	91,107	94,275	97,336	100,132	103,335	106,641	110,052	113,572
Total Dwelling	37,078	38,780	40,399	41,932	43,688	45,517	47,422	49,408
New Dwelling Units	2111	2577	2224	2,342	2,184	2,419	2,407	2,528
Scenario 3 High Population	100,218	103,703	107,070	110,145	113,669	117,305	121,057	124,930
Total Dwelling	40,786	42,658	44,439	46,125	48,056	50,068	52,164	54,348
New Dwelling Units	2,753	2,974	3,211	3,468	3,746	4,046	4,369	4,179

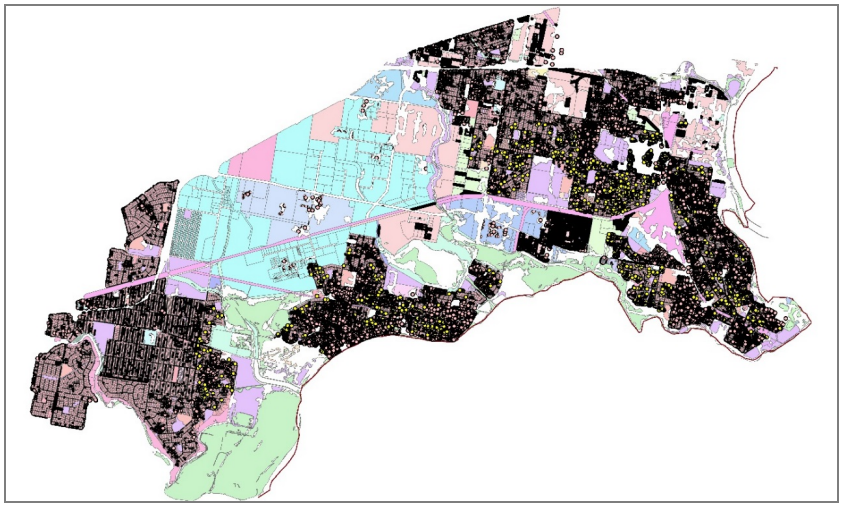

Fig. 1: City of Hobsons Bay Development, 2016; Source: HERRON 2015

Figure 2 2016 CO^2 Auto Emissions

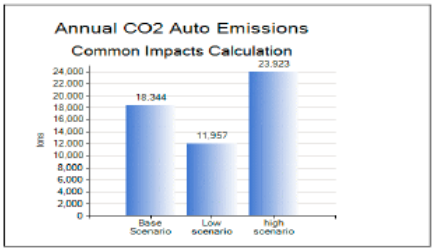

Figure 3 2050 CO^2 Auto Emissions

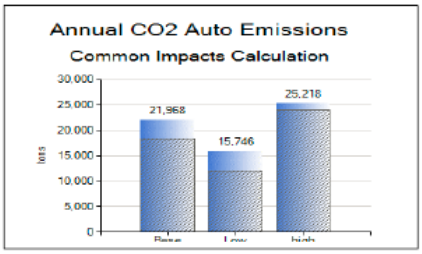

Figure 4 2016 Population

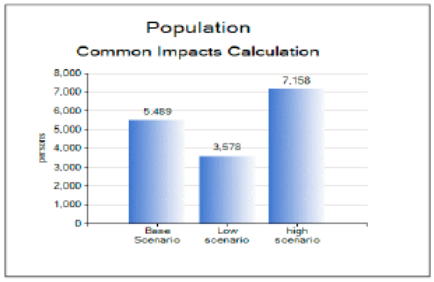

Figure 5 2050 Population

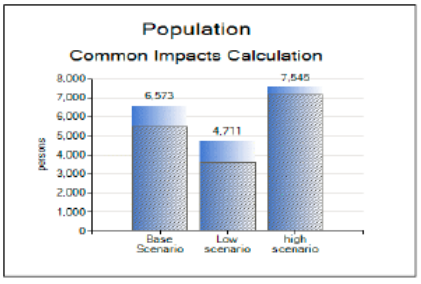

Figure 6 2016 Residential Energy Use

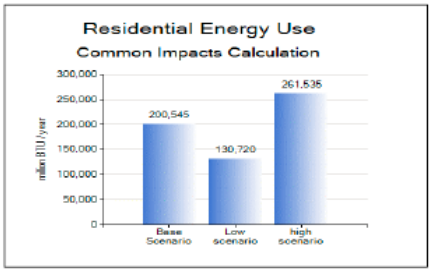

Figure 7 2050 Residential Energy Use

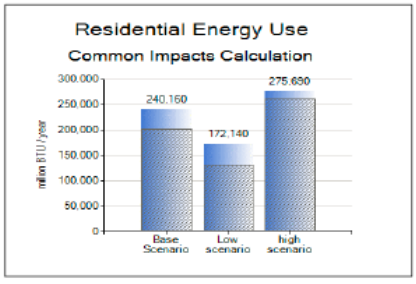

Figure 8 2016 Residential Water Use

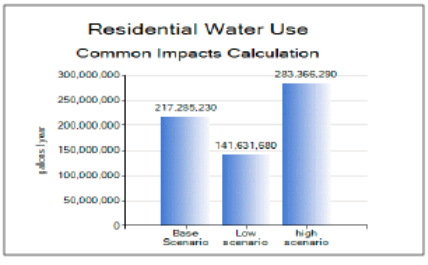

Figure 9 2050 Residential Water Use

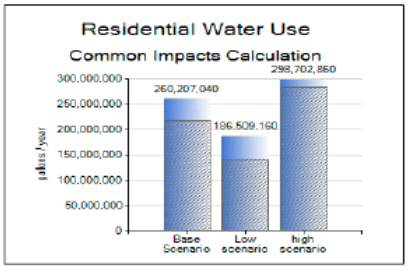

Fig. 2-9: Source: HERRON 2015

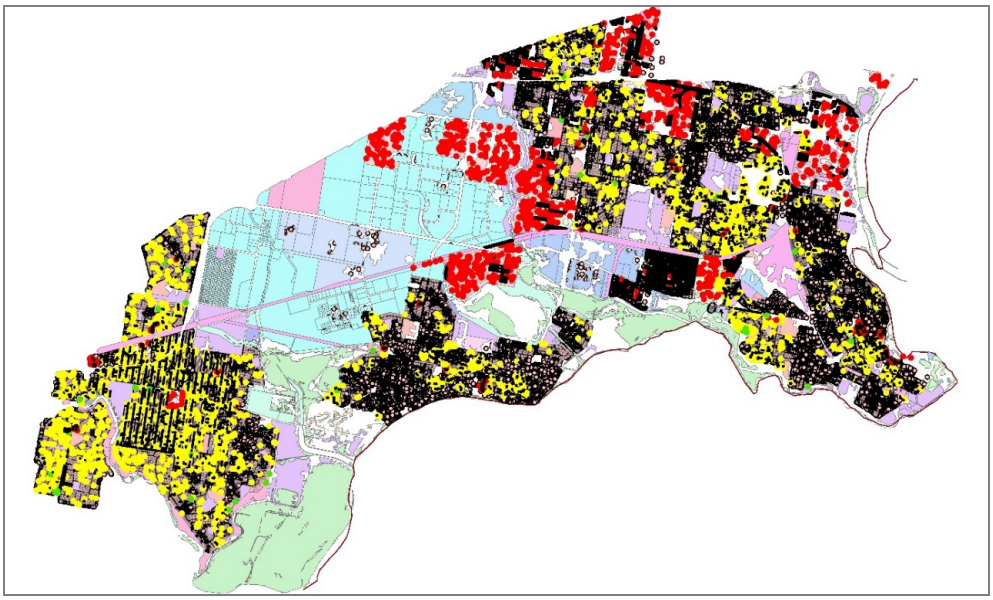

Fig. 10: City of Hobsons Bay Development, 2050; Source: HERRON 2015

4 Results

Every indicator showed substantial increase the result of increased population or development pressures. Figures 6 through are sample simulated results for 2016 and 2050.

The research undertaken for this paper relating to the HB has generated eight discussion points which are listed below that can be summarized as: Population increases generating more emissions and greater impacts of climate change; Increased consumption of energy and water resources; Open space allowances decrease for new developments and General overall open space decreases per head of population; Urban density increases; For metropolitan areas (i.e. HB the scale of development) will increase; New residential and or commercial development will add greater stress on existing physical and or natural infrastructure; The exodus of more jobs (i.e. commercial and industrial jobs to peripheral areas and being replaced service industry jobs); and, More mixed commercial / residential developments in the metropolitan and regional centres. The detail of these 8 conclusions are detailed in Table 2.

As indicated above, HB faces the impacts of climate change and sea level rise, as well as various other impacts due to population growth and human activities. It is now accepted and reflected in various literature, as well as in government policies internationally, and in Australia that concern is warranted to address the potential impacts of climate change in regional coastal areas.

Table 2: Three Growth Scenarios for Hobsons Bay 2016-2050

1	Population increases generating more emissions and greater Climate Change impacts. As the project population increases the environmental indicators used to highlight environmental degradation increased (i.e. CO, CO^2, Auto Emissions, residential water and energy consumption, etc.) The level of increase is predicated on the number of cars and individuals per household. The more individuals or cars per household the greater level of emission or consumption of water and energy per household. In the Hobson Bay there is the possibility to reduce car numbers per household. This reduction is the results of mass public transport which is located in the metropolitan region.
2	Water and energy consumption will increase as the result of population growth. The level of increase can be reduced through water sensitive design and energy efficient equipment and appliances. The other point on increased energy consumption is the substitution of coal based generated electricity with electricity generated by renewable sources will reduce the impacts of climate change on the landscape.
3	Open space ratio will decrease as a result new developments. The analysis show for communities that had prescribed city or township boundaries new development or increased development will reduce the allotted opens space per head of population. For HB the advent of high rise developments has reduced and will further reduce the open space ratio for residents as well developments come on line.
4	Urban density increases. The current population for HB is 90,000 with an urban density of 1,385 persons per ha by 2050 the population will be 125,000 with an estimated 1,922 per ha.
5	The scale of development in HB will increase. HB has only a limited area to incorporate the additional 25,000 to 30,000 residents by 2050 density and the scale of development will need to expand. HB has just passed new building regulations and zoning regulations in 2014 that allow for the construction of taller residential buildings (i.e. up 30 stories). Future regulations will increase the story limit to 50 stories.
6	New residential and or commercial development will add greater stress on existing physical and or natural infrastructure. HB will experience residential growth rate of. The residential growth levels for the period 2016 through 2050 range from 35 to 50 %. This growth will put stress on the natural infrastructure such as beaches, marshes and coast lines. The future residential development will require additional reticulated water and sewer systems. In the regional and rural study sites are serviced by a combination of septic sewer systems and reticulated.
7	The exodus of commercial and industrial jobs to peripheral Greenfield sites away from the city Centre. In HB industrial jobs are now being located in peripheral areas surrounding the respective locations as industrial land which is close to the city centers is being rezoned for residential purposes. The demand for residential land is such that current land uses are transformed into current and future residential areas.
8	More mixed commercial / residential developments in the metropolitan and regional centers. The addition of the mixed use zone into the Victorian planning system allows for greater flexibility for mixed developments that contain both residential and commercial components. The four research locations each have had their planning legislation augmented to incorporate the new planning zone. Developers can obtain greater return through the use of mixed residential and commercial development

5 Conclusion and Outlook

It is comprised of significant numbers of data sets, interdependencies, analyses, scenarios and outcomes the topic of land use planning is both complex and multifaceted. The research question specifically asked could visualization techniques portray the information so that it is easily understood and thus more likely to be used. Over 150 datasets, 100 assumptions, 100 attributes and 100 indicators were used in the spatial analysis of the HB site. Through the process of visualization what type of development would occur, where it would occur, when it would occur and the impact that development would have on the landscape and the environment, were evaluated

The end product was a series of maps and charts that simply explained the proposed residential and commercial development of HB and its associated impacts till 2050.

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