Social and Economic Impact Assessment for A Development Project

PREPARED FOR:

Deep River Group Pty Ltd t/a Precise Planning

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University of Technology Sydney

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LIST OF ABBREVIATIONS

SIA	Social Impact Assessment
EIA	Economic Impact Assessment
CIA	Community Impact Analysis
DIA	Distributional Impact Analysis
SV	Social Value
EV	Economic Value
DBL	Double Bottom Line
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
DCF	Discounted Cash Flow
NPV	Net Present Value
IRR	Internal Rate of Return
NSB	Net Social Benefit
DRG	The Deep River Group t/a Precise Planning

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EXECUTIVE SUMMARY

We were commissioned by the Deep River Group t/a Precise Planning to undertake an economic and social impact study for a proposed residential subdivision, which involves creating a 182-lot development on approximately 20.4 hectares of land (Lot 172 DP 755923 & Lot 823 DP 247285). The project is located in Manyana, in the City of Shoalhaven Local Government Area.

The study was to address the following questions:

- To what extent will the development generate economic activity and tourism and enhance existing residential dwelling values in the local area?
- To what extent will the development create social impacts (positive or negative)? What is the extent of the impact, and who is affected? How are the social impacts qualified/quantified?

A quantitative model was developed to measure the development project's net economic and social benefits and distributional impacts. The model applied a benefit-cost analysis (BCA) and used Distributional Impact Analysis (DIA) to assess the implications of the economic and social impacts of the development. The time frame of the analysis was 28 years (2022 – 2050).

The BCA assessed development impacts against a base case which assumed that no development occurred. The construct and operational stages were taken to determine the economic and social implications of the development. The environmental impact was not included in this study. However, the effects on the economic and social implications resulting from the ecological elements were discussed.

Results from our BCA (2017) indicate that the benefit and cost ratios for the base case, construction and operation stages were 0.62, 1.37 and 2.9, respectively, given the assumptions. The results suggest that the development would create positive economic and social benefits to the Manyana locality and the Shoalhaven area.

Findings from our DIA suggest that the development would benefit the developer, government, investors and residents. The internal rate of return (IRR) has exceeded the required rate of return of 20% for the developer. The government would gain the highest return. The investors and residents would receive the benefit-cost ratios of 2.9 and 1.29, respectively, in the operation stage post-development.

The analysis indicated a high demand and shortage of residential land supply for the area. Analysis of social impact using word cloud suggested that the residents were mainly concerned about bushfire impacts and the removal of natural bushland for the development. However, these claims did not raise the cost of intergenerational equity. Our findings suggest that the younger and future generations would find it difficult to own houses if supply was reduced. A 'no development' scenario for this development site would cost future generations the opportunity for affordable home ownership by reducing the housing supply in this locality.

The study also suggested that environmental impacts must be considered alongside economic and social impacts to appropriately integrate ecologically sustainable development (ESD) principles into land development projects. Based on the conclusions of ecological investigations (by others), the elevation of environmental protection of this property, at the expense of economic and social benefits to the local community, is not a legitimate integration of ESD principles. Based on the benefit and cost analysis, it is suggested that the development proceeds in stages as approved to relieve the housing supply pressure in the area.

1 INTRODUCTION

1.1 About the research project

The Deep River Group t/a Precise Planning (DRG) is coordinating this project on behalf of a property developer, Manyana Coast Pty Ltd. The authors of this report were approached by DRG on 23rd August 2021, and requested to study the potential social and economic impacts of the Manyana Beach Estate (The Project), an approved 182-lot residential subdivision on approximately 20.4 hectares of residentially zoned land at Manyana, New South Wales, Australia (Lot 172 DP 755923 & Lot 823 DP 247285) in the City of Shoalhaven Local Government Area. In 2008, The Project received development consent as a Major Project (05-0059). It was estimated that The Project would take 7-8 years and six (6) stages to fully complete. A Subdivision Works Certificates (SWC) was issued by Shoalhaven Council (Council) for Stage 1 in December 2019. On 24th June 2020, The Project was referred (ref: 2020/8704) to the Commonwealth Minister for the Environment (The Minister) under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act). The Minister determined that the proposed action was considered a 'controlled action' for Grey-headed Flying Fox and may be a 'controlled action' for Swift Parrot and Greater Glider under the EPBC Act and Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The Minister requested further information in the form of Preliminary Documentation. Thereafter, a socio-economic report, amongst other reports, was submitted and placed on public exhibition, inviting comment. In response to the public exhibition of the Preliminary Documentation, 1,132 unique submissions were received. This document forms part of a suite of documents that have been revised and amended after considering the public submissions received.

This report is an economic and social impact analysis for The Project only, and does not include any assessment of submissions received relating to ecological impacts. Accordingly, this research project will address the following questions:

- To what extent will the development generate economic activity and tourism and enhance existing residential dwelling values in the local area?
- To what extent will the development create social impacts (positive or negative)? What is the extent of the impact, and who is affected? How are the social impacts qualified/quantified?

1.2 Overall approach

A benefit-cost analysis (BCA) is proposed under the "Double Bottom Line" (DBL) framework. To achieve the research objectives, we identify the main variables considered in the social and economic impact analysis and how those variables were measured, based on standard approaches outlined in the literature. We then collect data from various sources, including publicly available information and database provided by UTS. Since the development is approved over six stages and will take approximately eight years to complete, we study the impacts during and after the development by estimating the variables to 2050.

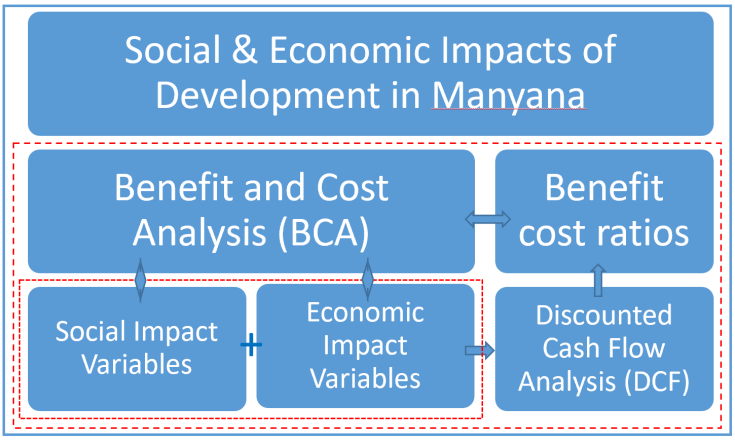

Figure 1. Overall research approach

We identify the benefits and costs for stakeholders such as developers, residents, investors and government. The economic and social impact, with or without the development project, will be examined through BCA ratios. A BCA ratio greater than 1 indicates that the benefit is greater than the cost. The higher the BCA ratio, the better the benefits. A sensitivity study will also be applied to test the impacts, without or with the development project, on the change parameters, e.g., market growth rate, discount rate and inflation. Figure 1 summarises the overall approach of this research.

1.3 Structure of this report

The report begins with descriptions of the development, the development location environment, the 2019/20 bushfire impact on the development project, and previous reports on 'the Project'. This information provides a background of the research motivation. The benefit and cost analysis for with and without The Project, including assumptions and methods of the project, will be analysed in section 3. Sections 4 and 5 will report the study of the economic and social impacts of The Project on different stakeholders. The research constraints and limitations will be discussed in section 6.

2 PROJECT BACKGROUND

2.1 Manyana

Manyana is a village in the City of Shoalhaven Local Government Area. It borders the neighbouring villages of Bendalong and Cunjurong Point, circa 219 km and 217 km or three hours driving time south of Sydney and east of Canberra, respectively. The village is surrounded by forest reserves, with beaches on the south-eastern side, i.e., Inyadda and Manyana Beach. The beautiful beachfront location attracts tourists and rental accommodations, including Airbnb business. The location is accessed by residents, tourists and visitors alike by one road - Bendalong Road – running about 12 kilometres from its intersection with the Pacific Highway (see Figure 2.1).

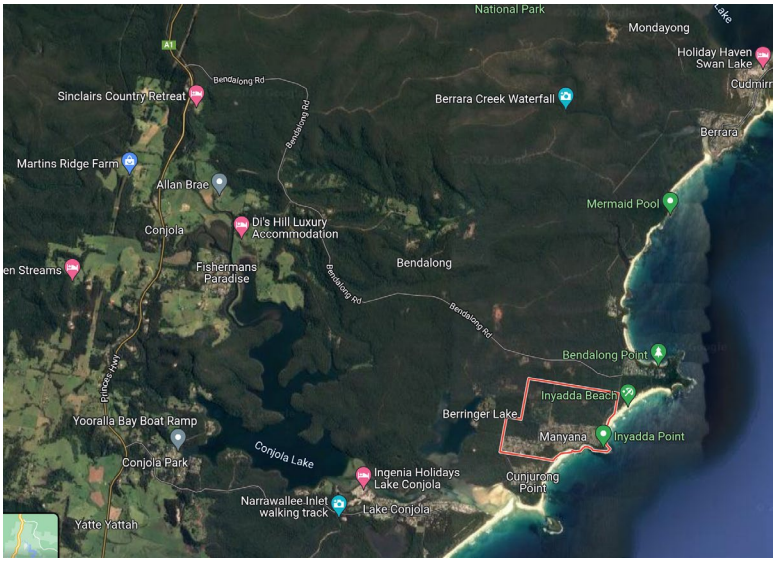

Figure 2.1. Manyana location (source: Google, May 2022)

According to the 2016 census (ABS, 2016)[1], the total population in Manyana was 521 people and 147 families, an increase of 36.4% and 37.4% from 2011, respectively (Table 2.1). The median age of the suburb was 54 years old, and 52% of the population were married. 26.4% of the population were couple families, of which 61.8% did not have children. Meanwhile, 11.8% of one-parent families had children. The nearest public schools are located at Milton or Sussex Inlet, around a half-hour drive from Manyana.

Table 2.1 Profile of Population and Families in Manyana and Shoalhaven

	2006		2011		2016		Changes 2011 - 2016	
	Manyana	Shoalhaven	Manyana	Shoalhaven	Manyana	Shoalhaven	Manyana	Shoalhaven
Population	363	88405	381	92812	521	99650	36.7%	7.4%
Families	93	24679	107	25536	147	26871	37.4%	5.2%

Compared to Shoalhaven, the 'occupied dwelling,' 'family,' and 'family without children' data groups in Manyana have increased at a faster rate (Figure 2.2). This implies that the demand for housing in Manyana increased at a proportionally higher rate than the Shoalhaven area as a whole between 2011 and 2016.

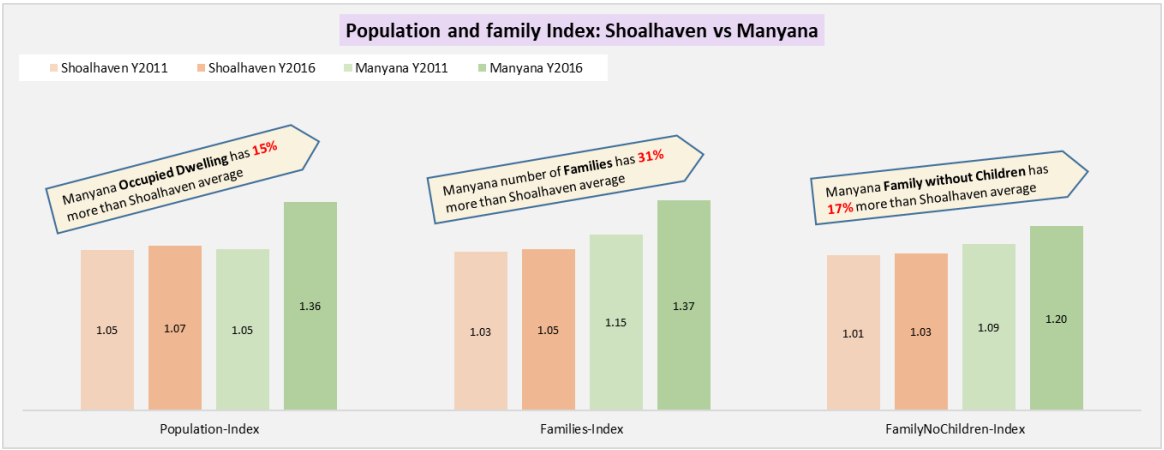

Figure 2.2. The changes in population and family

[1] The 2021 census data is not available, as it will be released on June 2022.

Manyana is mainly a residential area with 658 private dwellings, of which 36.5% were occupied, and 63.5% were unoccupied, according to the 2016 census. This could be due to many houses in Manyana being short-term stay investment properties listed on websites such as Airbnb[2], holiday houses owned by affluent Sydney and Canberra residents, or empty nesters with a second property. The occupied dwellings comprised entirely of detached houses, with no medium density properties. 56% of properties were owned outright, 26% owned with a mortgage and 14% rented. The bedroom mix was one bed (3%), two beds (18%), three beds (50%) and four beds (29%)[3].

In 2016, the median mortgage weekly payment was $312, around one-third of the median household weekly income, i.e., $947. The median house price and rent were $440,000 and $265 per week, respectively, in 2016. The evidence suggests a high demand for housing in Manyana. It is more affordable to purchase and rent houses in Manyana than in Shoalhaven. Figure 2.3 shows the housing affordability measures for Manyana and Shoalhaven. During the last couple of years, the NSW government has adopted restrictive measures to prevent the spread of the Covid-19 virus. The resultant lower consumption and relatively higher inflation have attracted many households to move away from the large urban areas and enter the housing market. The median house price increased dramatically to $910,000 in 2021. Figure 2.4 shows the median price, including the highest and lowest price and growth rate in Manyana from 1993 to 2022. Figure 2.5 displays the demand and supply of dwellings in Manyana and Shoalhaven between 2011 and 2016. Manyana house values appreciated at a greater rate than Shoalhaven house values.

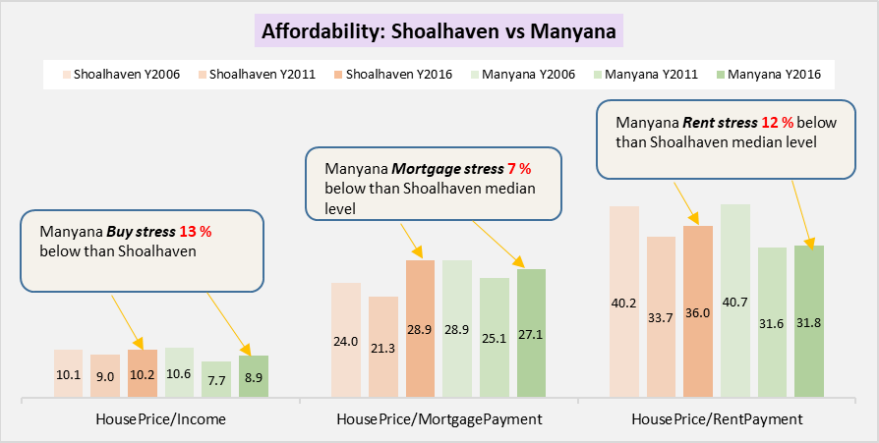

Figure 2.3. Housing affordability measure in Manyana and Shoalhaven

[2] https://www.airbnb.com.au/manyana-australia/stays
[3] Australian Bureau of Statistics. 2016. '*Manyana – 2016 Census*. ABS. https://www.abs.gov.au/census/find-census-data/quickstats/2016/SSC12482

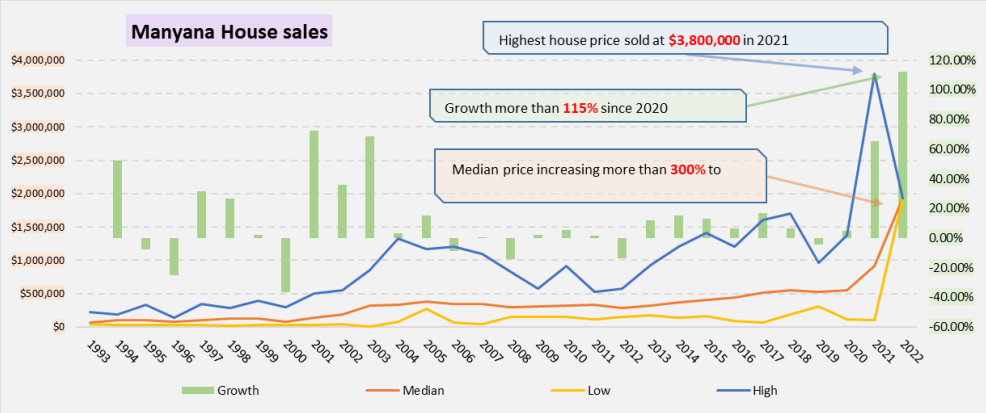

Figure 2.4 Manyana house prices

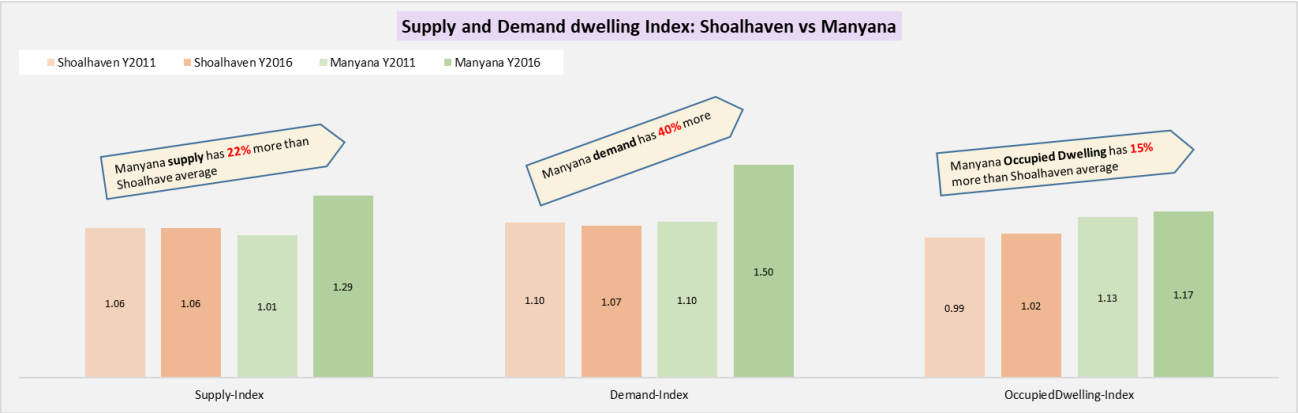

Figure 2.5 Supply and demand of dwelling in Manyana

2.2 The Manyana Beach Estate

The development site consists of Lot 172 Cunjurong Point Road and Lot 823 (DP 247285) at 148 Sunset Strip Manyana, totalling around 20.33 hectares. Manyana Coast Pty Ltd is the registered proprietor, having purchased the site for $3.85 million in March 2017. The Manyana Beach Estate, when completed, will comprise 182 homes to be built across six stages on appropriately zoned land. Whilst the Project has been approved since 2008, the proposed commencement of works has attracted significant community concern, predominantly for the impact of clearing the heavily vegetated site on flora and fauna. Following the 2019/20 summer bushfires, it has been reported that this site is now the only significant piece of unburnt bushland for kilometres after being saved by volunteer firefighters. In response to the request by the Minister for Preliminary Documentation, PPM Consulting undertook a socio-economic impact analysis, anticipating that stage 1 will be delivered in year 1, stage 2 the following year, and the subsequent stages over 5-6 years. The site has been earmarked for residential development since 1964 by being appropriately zoned by the Council. Development consent for the proposed development was issued in 2008. The council has invested in necessary services infrastructure in the area. However, certain works relating to the provision of services need to be undertaken by the proponent for the development to proceed. The Council entered into a voluntary planning agreement with the developer in 2018 for the staged payment of contributions relating to the provision of the nominated community and other services. In 2019, stage 1 of the Project was introduced to the market for sale, “off the plan.” All lots in Stage 1 were sold out, purchased predominantly by first home buyers, investors and retirees. However,

due to the Minister's Controlled Action declaration, works on site have not progressed at this time.

2.3 Planning objectives

Growth in the Shoalhaven Local Government Area (SLGA) over the next 30 years will predominately be sourced from Nowra and Milton-Ulladulla and their surrounding areas due to strong local service and social infrastructure, amenities, and employment opportunities.

Manyana has limited vacant and serviced land available, providing for nil significant infill opportunities. It should be noted that Shoalhaven Council has identified Manyana as suitable for future residential subdivisions. In the Council's Local Strategic Planning Statement, 'Shoalhaven 2040 – Our Strategic Land-use Planning Statement' under Planning Priority 1, current work 1.3 states '*administering planning and development controls to deliver residential subdivisions of existing zoned land in Manyana … (and other towns in SLGA) to provide a choice of residential locations'*[4]. Figure 2.6 overleaf illustrates the current land zoning in Manyana.

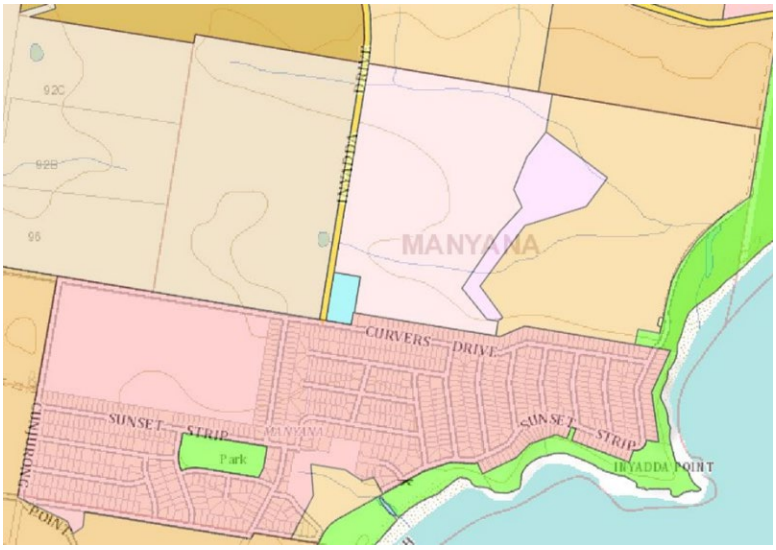

Figure 2.6. Land zoning in Manyana

2.4 The bushfire and subdivision development constraints

Manyana is surrounded by dense bushland and has a single access point from Bendalong Road, which runs through Conjola National Park. This results in significant risks associated with bushfires, which became a concern for the community, government, and developers during the summer bushfires of 2019/20. Figure 2.7 shows bushfire-prone land (category 1) is designated immediately surrounding Manyana, with a vegetation buffer applying to a large portion of land in the suburb.

According to Cassen (2020), the Currowan mega-fire was ignited by a lightning strike on 26th November 2019. The fire burned out of control for 74 days, hitting the Red Head Villages on 1st and 4th January. More than eighty per cent of Shoalhaven's National Parks were burnt, and some 3,000 residents and holidaymakers were evacuated from the villages.

The bushfires reached Manyana from the south on New Year's Eve after destroying homes and bush at Lake Conjola. The only road in and out of town was cut off. Locals lost electricity

[4] https://www.shoalhaven.nsw.gov.au/Projects-Engagement/Major-Projects-Works/Local-Strategic-Planning-Shoalhaven-2040

supply on New Year's Eve for four days and had inadequate sewerage, fuel and food shortages, and no telecommunications for several days.

Figure 2.7. Bushfire-prone land

The terrible bushfire caused millions of native animals to perish in the fire, destroyed some houses, and also threatened the safety and well-being of locals, creating mental trauma for them. These locals may take time to heal from experiencing the fire disaster. An additional road and infrastructure are likely to be needed in the area to prevent a repeat of this disaster.

Other environmental planning constraints include a requirement for a 500 m^2 minimum lot size in R2 Low Density Residential zoned land and acid sulfate soils class 5 throughout the village.

Protection of local flora and fauna has become a major issue when undertaking residential land subdivisions, particularly following recent major bushfires. Comprehensive studies were conducted in 2008 as part of the assessment of the original development application. Further extensive work has been undertaken, the reporting of which forms part of the Preliminary Documentation package and the response to public exhibition.

2.5 The surveys

A survey of five villages - Bendalong, North Bendalong, Manyana, Berringer Lake and Cunjurong Point - was conducted by the Manyana Matters Environmental Association (MMEA) after the 2019/2020 bushfire. The survey was funded by a $5,000 grant from the Australian Mutuals Foundation and Business Council of Cooperatives and Mutuals. According to the MMEA (2021), a total of 111 people, consisting of 73 (66%) females and 38 (34%) males, responded to the survey. Seventy (63%) of the 111 respondents were aged between 45 and 74, and 13 (11.7%) were younger than 17. The MMEA summarised the emotional impact of the 2019/2020 Currowan Mega-fire (Figure 2.8).

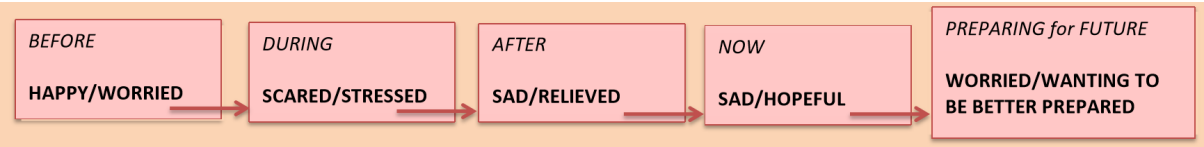

Figure 2.8. Emotional impact of the 2019/2020 Currowan Mega-fire (Source: MMEA, 2021)

We have also been provided with 1,132 submissions to the public exhibition of Preliminary Documentation, 703 (62.1%) of which were received between 21st June 2021 and 16th July 2021. Some individuals submitted multiple times, and the content in various letters is the same and duplicated. Thus, only a portion (i.e., of the total submissions) is used for the analysis. The submissions were from 623 unique authors who were predominantly Manyana residents,

tourists to Manyana, people who have properties in Manyana, and family members of Manyana residents who live in other places and became aware of the public exhibition of the Preliminary Documentation and made a submission.

To understand the main concerns of the submitters, a word cloud has been generated from the submissions by automatically extracting words from the pdf files (Figure 2.9). The word cloud shows that most of the submissions focused on the protection of the wildlife environment and called for a period of recovery after the bushfire. Besides the environmental concerns, words like 'community,' the 'future generation,' and 'government' are also frequently mentioned in the submissions.

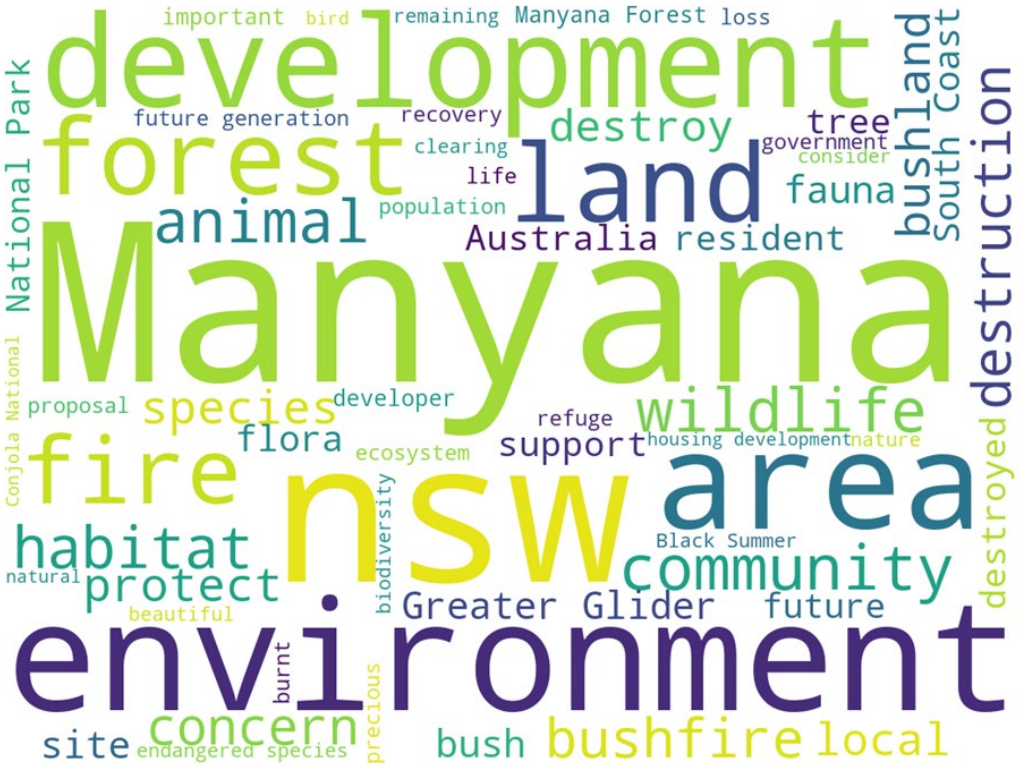

Figure 2.9. Word cloud generated from the Manyana submissions

We have also generated statistics on the survey according to the above indicators. Figure 2.10 presents the frequency of the designed indicators. The submissions were not only from the local community, but also from many tourists from all over the world (several authors claimed to be from nations such as Italy, the United Kingdom, and the United States of America) and from various educational backgrounds. Over 90% of the submissions were relatively brief and focused only on environmental impact, which is consistent with the word cloud content. One significant submission was from the Bendalong General Store & Café, consisting of a four-page report primarily focused on the socio-economic impacts of the proposed project and covering most of the indicators mentioned above, with data support.

To investigate the project's impact in the socio-economic domain, we first identified the major indicators. Referring to Dudzińska et al. (2018) and the statistical data in the Australian Bureau of Statistics, we initially selected eight indicators for the social aspect; "Population," "Dwelling," "Community," "Transportation," "Health," "Education & Future Generation," "Infrastructure," and "Recreation." We also selected five indicators for the economic aspect; "Commodity Price," "Employment," "Economic Capitals," "Protection Fund & Compensation," and "Scale of

Entrepreneurship." The indicator, "Commodity Price," includes the price of housing, rent, and daily expense.

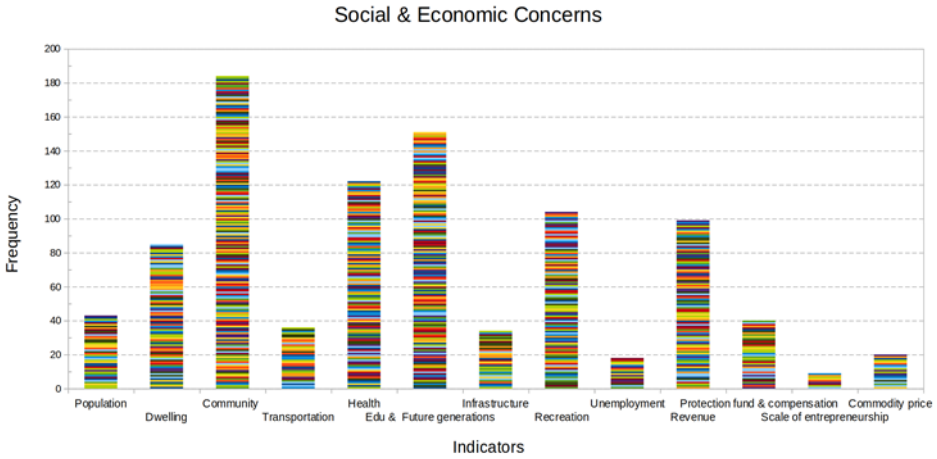

Figure 2.10. Statistical result of concerns. The variety of the colour indicates the various concerns.

The most frequent indicator is the "Community," which includes the expectation that the community's voice should be heard, the value and faith of the community, and the community's efforts after the bushfire. "Health" and "Education & Future Generation" are also mentioned many times. According to the collected data, all the "Health" concerns have to do with mental effects, and only a small amount of them mentioned the shortage of medical resources. More than 100 submissions indicated the unburnt forest is crucial for the local community's recreation and well-being. Most people's concerns relating to "Health" suggested that the unburnt forest could bring mental health to the local community, and they need time to recover from the psychological ramifications of the fire. Concerning "Education & Future Generation," a small number of submissions mentioned the need to improve the education resource. However, most repeat the theme of the preciousness and long-term value of the unburnt forest to future generations. About 40 submissions mentioned "Population," including the negative effect of population growth, as well as the 'type' of house owner (i.e., long-term residents, holidaymakers or investors). Some submissions also mentioned that the new residents might bear community resentment if they buy newly developed property within the estate. More than 80 submissions discussed aspects of the proposed dwellings, such as the ownership of the dwelling, the vacancy rate, the type of dwelling (affordable house or second holiday home), the location, sustainability, and scale of the proposed dwelling. About 40 submissions expressed concern that the capacity of the current transportation infrastructure does not support the likely increased demand from new development.

In terms of the economic influence, the frequencies of the economic indicators are significantly less than the social indicators. For "Employment," several submissions indicated that the jobs provided by the project development will not be enough, considering the population increment, and the local community wants more jobs in environment protection. For "Economic Capital," several submissions included concerns about the current income level and that the proposed project will impact the local tourism industry. Many submissions from tourists spoke in support of those in the local community who do not support the Project, some claiming that the development will push them away from Manyana. However, in contrast, some submissions discussing "Community" hold the idea that Manyana is a residential community rather than a tourist town. Most submissions raising the "Protection Fund & Compensation" indicator called

on the government to buy back or exchange the land, pointing out that many local people are funded to support their life. Some submissions expressed concern that the price of daily commodities will increase after the project. A few submissions mentioned that the new development would cause local house and rent prices to decrease. The least mentioned indicator was “the scale of the entrepreneurship.” Most related submissions pointed out that the increased stores (responding to demands from an increased population) will not significantly improve the local community’s quality of life. Submissions relating to industries such as holiday rentals also suggested that the current status can meet the needs of locals.

A word cloud of the social aspects was also generated from the submissions. According to Figure 2.11, the value of the unburned forest to the community, residents’ mental health, the shortage of infrastructure and transportation to support the new construction, and doubts about dwellings’ location were the main concerns. The frequency of these concerns is generally consistent with the statistical histogram results, as shown in Figure 2.10. A considerable proportion of words related to psychology indicates that the local community has suffered from the bushfire and expects the bushland to be recovered.

Figure 2.11. Word cloud generated from social aspects

In addition to the submissions referred to above, other submissions, such as the importance of the unburned bushland to the future generation, the influence on the community’s faith, morale and recreation, target customers and the vacancy rate of the proposed dwelling, were raised.

This word cloud is generated iteratively by manually filtering out meaningless stop words from the social-related aspects. We checked the output word cloud at the end of each iteration and added the meaningless words to the stop words set to prevent them from showing up in the next iteration.

2.6 Previous work undertaken

This report drew on academic literature and technical reports. The literature review in the context of the respective research methodology and empirical findings will be provided further

below. This research will also take the following consultancy reports as the starting point. Refer to Appendix 3 for a comparison of this study and the previous reports.

- Manyana Matters Environment Association (MMEA) (2021): This is an MMEA document reporting the 2020 survey results using the bushfire recovery grant from the Australian Mutuals Foundation and Business Council of Co-operatives and Mutuals.
- PPM Consulting (17th March 2021): This report analysed the social-economic impacts of the Manyana Beach Estate and concluded several positive social and economic impacts from the development project.
- Murry (12th July 2021): This letter provides comments by PPM Consulting on 17th March 2021 on potential economic impacts on the residential subdivision of Lot 172 DP755923 and Lot 823 DP247285 Berringer Road, Cunjurong Point Road and Sunset Strip, Manyana. The report suggests that the two assumptions underpinning the economic impacts estimated by PPM are unsound. The two assumptions include: a) spending on development and construction is a net addition to economic activity and b) the 2.8x 'multiplied' in the first year.
- Ziller (14th July 2021): This report reviewed the social impact analysis component of a socio-economic impact analysis for the Manyana Beach Estate prepared by PPM Consulting on 17th March 2021. The report addressed points such as the social impact of bushfires, the social value of the natural environment, housing costs and maintenance and jobs. '*Bushfire risk'* has been identified as a major social impact issue of the new development.
- MMEA (16th July 2021): Manyana Matters Environmental Association Inc (MMEA) sent a letter to Manyana Coast Pty Ltd and EcoPlanning Pty Ltd, with a copy to The Hon Sussan Ley MP, Department of Agriculture, Water and Environment. MMEA expressed concerns about the Manyana Beach Estate project, that it a) will have significant impacts on the listed threatened species and endangered communities, b) will result in inappropriate social and economic impacts, and c) is inconsistent with the principles of ecologically sustainable development.

This section investigated the Manyana profile, the Manyana Beach Estate, planning objectives, and bushfire development constraints. The Manyana development submissions have been analysed, and the consultant reports have been listed. The conclusions have been drawn below:

1) Manyana is located on a beachfront, is surrounded by bushlands, and attracts many tourists. The population and number of households in Manyana have increased at a greater rate than the Shoalhaven area average. There was a proportionally higher demand for purchases and rental houses in Manyana, relative to the Shoalhaven area, likely due to more affordable pricing.
2) The 2019/2020 bushfires greatly impacted local community members, some of who prefer to protect the unburned bushland from the Manyana Beach development. The MMEA survey and the Preliminary Documentation public submissions results identify some local community concerns concerning health, future generations, and environmental protection. However, less concern has been raised in submissions about the local economic development.
3) The MMEA consultant reports and formal (academic) submissions predominantly focused attention on bushland protection for local people's social benefits.

According to Camenzuli and McKinley (2020), the decision-making processes of ecologically sustainable development (ESD) should "effectively integrate both long-term and short-term economic, environmental, social and equitable considerations." The concept of ESD was

introduced by the Commonwealth government in June 1990, finalised in a National Strategy for Ecologically Sustainable Development (NSESD), and endorsed by each state and territory government in December 1992 (ACT Government, 2020). The Planning Bill 2013 in NSW [1.3(2)] states that 'Sustainable development is achieved by the integration of economic, environmental and social considerations, having regard to present and future needs, in decision-making about planning and development."

Relevant social and economic implications should be considered when undertaking environmental protection (Cordonier-Segger and Khalfan, 2004). This report presents the economic and social impacts of the Manyana Estate development applying the benefit-cost analysis. Short-term and long-term impacts have also been studied.

3 BENEFIT-COST ANALYSIS

3.1 Introduction

Benefit-cost analysis (BCA) or cost-benefit analysis (CBA) has been widely used in assessing economic and social activities (Jeddi-Yeganeh et al., 2019; Shen et al., 2019; ACT government, 2014). According to Pearce (1983), BCA was first put into practice in the 1930s in the USA. After the 1950s, international organisations such as the World Bank increasingly recognised this approach, and the recognition has continued (White and Vanlandingham, 2015). The Australian government also considers it a tool for making rationally, financially and socially responsible decisions (Commonwealth of Australia, 2006).

A BCA expresses a project's benefits and cost impacts in monetary value, and assesses it based on the net present value, benefit-cost ratio, and internal rate of return (Clark et al., 2004). Then, with an interpretation of the results, the assessor can determine the project's net impacts (Joseph et al., 2020). Nevertheless, BCA is not a strict rule that decision-makers must follow. Instead, it is only a tool to provide information (Campen, 1986).

The stakeholders affected by the development project will be established. The analysis will then predict benefits and costs over the project's life and convert any non-monetary impacts. After discounting the monetised impacts, the BCA will provide the return, and the assessors can perform a sensitivity analysis and interpret the results (Boardman et al., 2018). The discount rate selection is based on the NSW Treasury guideline for cost-benefit analysis (2017).

BCA is useful for assessing a project's financial feasibility (Joseph, 2020). In addition, it helps identify trade-offs and assesses project benefits and contributions to the public (Boardman et al., 1996; Majerova, 2021), particularly for local projects with marginal and spatial temporally limited impacts on ecosystems and their services (Wegner, 2011). SGS Economics and Planning (2017) applied BCA to assess the economic impacts of the proposed development concept at Manchester Road, Auburn, in the Clyburn industrial precinct adjacent to the Duck River, NSW.

However, there are limitations. The development of the Project in stages will complicate the identification and valuation of impacts, especially as BCA involves assumptions and discounting (Cavanagh, 2007; Greig et al., 2015; Joseph, 2020), and there is little literature identifying the impacts (Greig et al., 2015). In addition, BCA may neglect some equity considerations (Gasparatos et al., 2008) and impacts that do not fall within the traditional view (Vining & Weimer, 2010). Nonetheless, despite some commentators' criticisms of BCA, Hwang (2015) considered that they had offered no alternatives to evaluate a project's viability as well as BCA.

The BCA for Manyana Beach Development focuses on the benefits and costs of economic and social activities required to offset the impacts on the natural environment and existing residents in Manyana. The focus of this research is on the economic and social aspects.

3.2 Key variables

Economic variables

Residential property development is one of the important economic activities, and *the residential building construction industry has the second-largest economic multiplier of all the 114 industries that make up the economy* (Australian Government, 2020). The development solves the shelter issues of human beings; improves the built environment, quality of living and social equity; provides affordable housing supply and investment opportunity for the investors; and contributes directly or indirectly to economic growth by creating jobs, influencing the upstream and downstream of property business activities for the local area. This gives households access to quality education, churches, community organisations, and convenient shopping, an additional benefit.

The development can increase construction-related jobs and, thus, average wages. Many professionals, such as planners, engineers, architects, designers, and lawyers, as well as related industries such as landscaping, trucking, transportation, road and sidewalk work, sewer and water system infrastructure, financing, marketing, real estate, insurance, valuation, cable, telecommunications, cleaning services, hardware, gutter companies, locksmith, appliance and furniture stores, will benefit from the property development activities.

Using economic input-output models (EB5 Affiliate Network, 2022), between ten and 15 construction jobs are created for every $1 million in construction spend. Kimmy (2022) claimed that 17% of jobs in the economy are indirectly or directly induced if an average of $1 million is spent each year in the United States.

Based on an average metropolitan statistical area, and homes with an average construction value of $145,372, the Nation Association of Home Builders (1997) provided the impacts of developing 100 new single-family units that supported 76 jobs, increased $1,983,000 wage and salaries, $416,000 business owner's income, and contributed $393,000 to local taxes (Table 3.1).

Table 3.1 Annual economic impacts of 100 new housing units (Source: NAHB, 1997)

Type of Units	Jobs Supported	Wage and Salaries	Business Owner's Income	Local Taxes
Single Family	76	$1,983,000	$416,000	$393,000
Multifamily	36	$945,000	$238,000	$243,000

The Australian Government (2020) reported that each $1 million of residential building construction industry output supports nine jobs across the economy. Chan, et al. (2006) determined the labour flow and demand for a project at each stage using a manpower planning model for Hong Kong. The aim was for the government to determine how many jobs were created from public investment. They proposed a formula to calculate the average number of jobs created as follows:

$$Number\ of\ jobs\ created = \frac{Total\ lobour\ requirements\ (in\ man-months)}{Project\ duration\ (in\ months)}$$

The long-term impact of housing developments can be identified, as housing development can generate local economic activity, increase jobs and the income generated by construction workers and new residents, and generate additional taxes and other revenue for local

governments (SEWRPC, 2022). The increased property taxes results from increased surrounding land value due to the new housing activities. When more households move into newly developed estates, it generates an economic ripple effect that permanently increases the level of local economic activity of goods and services, such as groceries, home improvement, pet food, car repairs, beauty, salons, clothing, fitness centres, school supplies, etc.

Choi & Sirakaya (2006) developed various indicators to measure community tourism development (CTD) within a sustainable framework based on the consensus of 38 academic researchers in tourism over three round discussions. The top three indicators include a) availability of local credit to local businesses; b) employment growth in tourism; and c) the percentage of income leakage out of the community. The role of macro-economic indicators, such as GDP, unemployment, inflation, interest rate, vacancy, operating expenses, and gross rent space, were applied to explain direct real estate returns in South Africa (Akinsomi et al., 2018). The main economic variables considered in this study include employment and job creation and the impact on tourists. The literature review on the economic impact analysis can be found in Appendix 1.

On the other hand, property development creates carbon emissions and pollution, noise, traffic congestion and other problems that diminish the local community's quality of life during construction. Balancing the conflict between environmental protection and added value and economic growth (Henderson, 2002; Friedman, 1970) is a challenge.

Social variables

The discussion of social value and impact, in particular environment, social and governance (ESG) of property development, has been increasing in the real estate industry and academic literature. The Australian Centre of Social Impact (CSI) (2022) defines social impact as '*the net effect of an activity on a community and the well-being of individuals and families*. There are 17 types of social impact set by the United Nations (Table 3.2)**.**

Table 3.2 Types of social impact (Source: United Nations, 2022)

Goal 1: No Poverty	Goal 9: Industry, Innovation and Infrastructure
Goal 2: Zero Hunger	Goal 10: Reduced Inequality
Goal 3: Good Health and Well-being	Goal 11: Sustainable Cities and Communities
Goal 4: Quality Education	Goal 12: Responsible Consumption and Production
Goal 5: Gender Equality	Goal 13: Climate Action
Goal 6: Clean Water and Sanitation	Goal 14: Life Below Water
Goal 7: Affordable and Clean Energy	Goal 15: Life on Land
Goal 8: Decent Work and Economic Growth	Goal 16: Peace and Justice Strong Institutions
	Goal 17: Partnerships to achieve the Goal

The NSW Australia has also developed a Social Impact Assessment guideline (2021). This guideline includes social elements of value to people for State significant projects. Eight categories are identified in the social impact assessment (SIA) (Table 3.3).

Lind (1995) studied the intergenerational equity, discounting, and the role of cost-benefit analysis. He suggested that "*the issues of intergenerational equity are not that global climate change will significantly lower the GNP of future generations but relate to the possibility of science fiction-like changes in the planet that will produce catastrophic effects in the future.*" More literature review on the main factors of social impact analysis can be found in Appendix 2. The indicators listed in the NSW social impact assessment (2021) will be applied in this study.

Table 3.3 NSW 2021 Social Impact Category (Source: NSW DPE)

NSW 2021 Social Impact Category	
Way of life	how people live, how they get around, how they work, how they play, and how they interact each day
Community	composition, cohesion, character, how the community functions, resilience, and people's sense of place
Accessibility	how people access and use infrastructure, services and facilities, whether provided by a public, private, or not-for-profit organisation
Culture	Aboriginal and non-Aboriginal, shared beliefs, customs, practices, obligations, values and stories, and connections to Country, land, waterways, places and buildings
Health and wellbeing	Physical and mental health especially for people vulnerable to social exclusion or substantial change, psychological stress resulting from financial or other pressures, access to open space and effects on public health
Surroundings	Ecosystem services, e.g., shade, pollution control, erosion control, public safety and security, access to and use of the natural and built environment, and aesthetic value and amenity
Livelihoods	people's capacity to sustain themselves throught employment or business
Decision-making systems	the extent to which people can have a say in decisions that affect their livs, and have access to complaint, remedy and grievance mechanisms.

Other variables

The main monetary costs of the development consist of the expenses for land acquisition, cleaning up the bushland, land development (including the costs of civil work and infrastructure of the site), and construction of houses. Additional cost provisions may be made to meet the bushfire standard and house regulation and to create a defendable fire safety space. The cost measurements are mainly provided by the client. The other part of the costs relates to the effects of environmental and social perspectives during and after the construction of the houses, such as the impact on natural bushland and fauna, fears and trauma from bushfire, nuisance and disturbance to neighbours, and increased traffic in the area.

The benefits of the development project include the direct effects from the development and ripple effects, or value added to the local economy. The developed houses can directly increase the housing supply in the area and create development-related jobs. The gradual increase of new residents to the area increases the occupied dwellings, thus improving the locality's age profile and cultural diversity, as well as initiating community development. The increasing population in the area will encourage government investment toward improving the area's infrastructure and services, such as new roads, more bus routes, and so on. The tourism industry and the local economy can also be stimulated. The increased demand for housing can also push up land and rent values and attract further investment activities.

3.3 Key assumptions

Since construction is the primary industry in Shoalhaven (Shoalhaven Council, 2021), it is assumed that the project's construction contracts are awarded to businesses originating from the local area. However, it is expected that the contractors will use materials and inputs from outside of Shoalhaven.

The costs of the development, including land purchase cost, stamp duty, civil/stormwater cost, service, development contribution, consultancy, and construction landscaping & finishing costs, are borne by the client. The costs are escalated by CPI (assume average of 3% each year). The benefit of the development will be the estimated value after the development is sold, adjusted by the market growth rate (assume average of 6% each year).

It is assumed that the government will receive the cost of the land paid by the developer. The received amount will be invested into infrastructure and the good of the public. The government will also receive stamp duty on land and house purchase, development contribution, and rates.

The costs for investors are assumed to be investment equity, stamp duty, rates and finance cost, based on a 70% leverage and maintenance cost (0.4%) of rent. The benefits are the rent and sales of the investment. The discount rate is assumed 7% according to NSW Treasury guidelines.

Social benefits and costs are assumed for residents. The benefits include population growth that enhances community development, job creation from the development project, land and rent appreciation, and increased tourism. The increased insurance, building cost and rent for the tenants are assumed to be the costs for residents. The increase/decrease rate is used to measure the benefit and cost of the residents. Table 3.4 shows the assumptions of the benefit and cost models.

Table 3.4 Variables and data used in the BCA

Data Information	Value	Unit
Land purchase	$3,850,000	20.23
Government purchase of land for conservation	$185,000	
Civil/stormwater costs (per lot)	$ 93,956	per lot
Civil/stormwater costs (per stage)	$ 2,850,000	per stage
Service (water, sewer, electricity etc) costs (per lot)	$ 52,747	per lot
Service (water, sewer, electricity etc) costs (per stage)	$ 1,600,000	per stage
DA approval fee	$ 7,500	per lot
Sub divided Lots	182	lot
Development stage	6	
Consultancy costs (per lot)	$ 10,164	Per lot
Development contributions (per lot)	$ 34,615	per lot
Development contributions (per stage)	$ 1,050,000	per stage
Miscellaneous costs (per lot)	$ 46,703	per lot
Land price escaluation	4.80%	per year
Project Development Period	8	Years
Construction costs (including management, landscaping, parkings)	$2,200	per sqm
Marketing and sales	2%	per house value
Stamp duty (land)	$1,353	per lot
Stamp duty (house)	4%	per house
Legal on sales	0.5%	of sales
Cost of capital	4.68%	
Discount rate	7.00%	
Finance cost	4.14%	of house valule
CPI	3.00%	
House growth rate	6.00%	per year
Investment rate & land tax	1.0%	of value
Maintenance	0.4%	of value
Investor leverage	70.00%	
Investment period	20	Years

As per timing, it is assumed that the construction will start in 2022, and that the first 30 houses will be completed and sold in 2023. The impact study is extended to 2050. The development is a long-term project, and it is thus also assumed that the base case is before 2022. The construction stage is between 2022 and 2029, and the operation stage is between 2030 and 2050. Since the land was purchased in 2017, a BCA model for 2017 is also created for reference. Due to the limited availability of future data, most of the data are forecasted from the historical available data pattern using mathematical forecasting tools.

3.4 Methodology

In implementing BCA in this study, the research started by identifying the benefits and costs that will be generated with and without the development for both the construction and operational phases. The identified variables were also considered in terms of 'direct' (e.g., cost of construction) and 'indirect' impacts (e.g., tourism and social impact) from the development. A literature review was conducted to support the identified benefit-cost variables and methods adopted for conducting the research. To ensure that the variables were identified correctly, we conducted a correlation analysis on the 703 Manyana submissions on the project to understand the residents' concerns of the development. The results can be found in Appendix 3.

The economic and social impacts of the development, i.e., subdivision and construction of 182 houses, were assessed against the base case, i.e., without the development, in terms of benefit-cost ratios and impacts on stakeholders. The development analysis was further divided into two cases, including the construction and operational phases. The main factors in this research are listed in Table 3.5.

Table 3.5 Identified factors on the economic and social impacts of the study

	Base Case		BCA Construction		BCA Operation	
	Costs	Benefits	Costs	Benefits	Costs	Benefits
Economics Impact	Rely on car (only bus 100)		Land acquisition	Government revenue	Property management and maintenance	House supply increased
	Weekly to shop (time & petrol)	One day trip	Land development (infrastructure costs on the site, e.g., roads, drainage, utilities)	Construction-related activitity		Long-term economic ripple effects (value added to the economy)
	Car to school (time & petrol)		House construction	Additional jobs created		Attract tourists
	higher cost of house insurance due to bushfire	bushland reserved	Cost of open space provision	Stimulate local economics		Improve local economics
	higher cost of finance due to bushfire		Cost of clean up the bushland			Increase employment
	Higher cost of building houses to meet the fire resistance requirements		Additional costs for construction	Provide safety for the households		Rent value appreciation
			Bushfire standard houses			Property value appreciation
			Defendable space built			Increase household income
Social Impact	Fears about future bushfires	Quiet environment	Lost of nature fauna	Implementation of biodiversity plan	Increase local density incluidng traffic congestion	Population increased
	Trauma from the bushfire	Small community	Fears about future bushfires	Encourage building construction standard		Possible increase buses and frequency
	One way road access		Trauma from the bushfire	Encourage defendable space built	Fears about future bushfires	Encourage government planning on emergency shelters
	Inconvenience accessing to other areas		Nuisance and disturbance for neighbours		Trauma from the bushfire	Encourage government planning a new road
						Improve cultural diversity
						Change of family structure
						Improve education
						Change age profile
						Improve service and facility
						Improve health and safety

The base case

The base case indicates the scenario without the housing development. In this case, population, occupied private dwellings, and employment will be projected according to publicly available data in the area. The suburb is assumed to remain a small and stable community, with the population and households estimated to increase by seven people (0.12%) and two households yearly (0.14%) in Manyana. The detailed projection can be found in Appendix 1.

The level of bushfire risk to residents will remain as it is, and the one-way road access is still a major issue in terms of bushfire unless significant government investment is made to provide an alternate means of access/evacuation. Thus, the residents' trauma from and fear of future bushfires is assumed to be one of the social impacts. Only one bus route (100) is available for residents to travel by public transport to work, shops, and schools. The travel time by car to access those facilities is around 45 minutes. The cost of transportation is, therefore, considered to be relatively higher, as the average motor vehicle per dwelling is 1.8 in the area, higher than 1.7 in the Greater Sydney area.

The development phases

As shown in Table 3.5, the analysis is further divided into the construction and operation stages. This is because the project is proposed to be fully developed in seven to eight years, in six stages. The impact on residents can be minimised, and the economic and social impacts from the two stages (construction and operation) can be deferred.

Once the development commences, the main costs will be from the land subdivision and subsequent dwelling construction. There may be an environmental cost of losing the natural bushland. The nuisance and disturbance to residents is also a direct cost during the construction. However, the development will bring jobs to the construction-related industry and contribute to local economic growth. The local council will benefit from receiving development contributions, as identified in the relevant developer contributions plan, that may be used for public good.

Once the project is fully developed, the built environment of the developed area will be different. The increased housing supply will attract more households to move into the area. The local demographic profile and the aging population may change as a result. In the 2016 census, the median age of residents in Manyana was 54 years, compared to 52 in the 2011 census. Nearly one-third of the population (28.4%) was aged 65 years and over in 2016, compared to 18.2% in 2011, a 56% increase over five years. The increased number of households in the suburb is also expected to enhance community cohesiveness and bring greater cultural diversity.

We first analysed the supply and demand of housing for Manyana based on the average 5-year change pattern of Shoalhaven City Council, assuming that Manyana follows the same regional growth pattern. The analysis was necessary to inform our understanding of the housing supply in the area. The details of the assessment can be found in Appendix 1.

The second step focuses on forecasting variables on the base case and the development scenario. The analysis will use the marginal cost and benefit to compare with the base case.

Some social impact variables cannot be measured in monetary value. Therefore, these 'non-monetary-value' variables will be assessed qualitatively using the NSW social impact assessment tool. We also applied the 'extent,' 'during,' 'severity,' and 'sensitivity' impact rating guide to study the impact level.

3.5 Results

The section provides a summary of the Manyana housing supply and demand analysis, alongside results from the BCA for both options, i.e., with and without the development.

3.5.1 Supply and demand analysis.

There has been little change in Manyana since 2012. Some vacant blocks have been built upon in established streets, which has exhausted most of the supply for zoned and vacant land. Commencing with site clearing and subsequent vacant land sales in 2017, a residential subdivision named Manyana 'Coast Development' Land Release took place. This resulted in the extension of Bounty and Barbette streets and Manyana Drive, and the creation of Dune Crescent. All these provided an additional 39 allotments. Construction of detached housing was undertaken by purchasers, with the first house completed in 2019. As of March 2022, 20 properties were completed, and five were under construction.

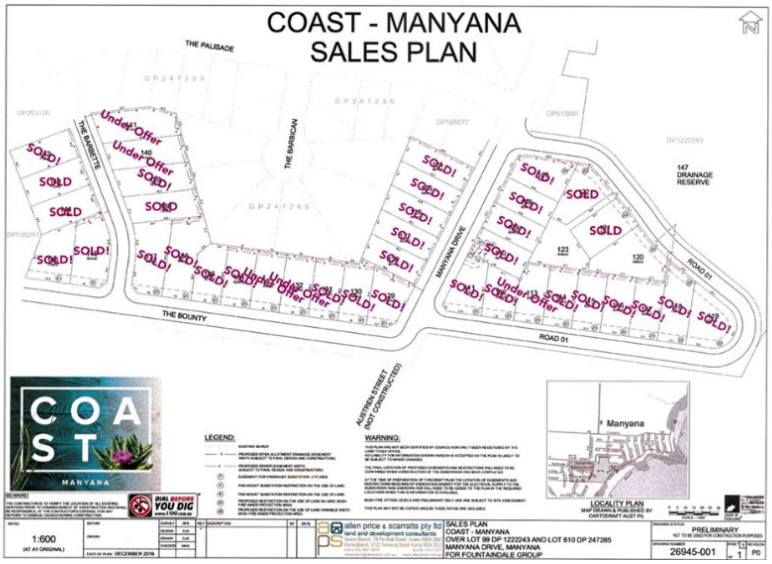

Figure 3.1 Sales Plan for Manyana Coast Development Land Release[5]

Most vacant land sales that have occurred in the past six years comprise an infill opportunity for one detached house in low-density zoned land. Some of the sales are outlined below (note that some of these properties have a DA Approval or completed dwelling as at the date of writing):

- 23 Manyana Drive.
- 162 & 245 Sunset Strip.
- 8 The Bartizan.
- 32 The Companionway
- 2 The Palisade.
- 7 The Wheelhouse.

Some minor subdivisions of two to four parcels have occurred in this period, including:

- 41-43 Manyana Drive.
- 82-84 & 159-161 Sunset Strip.

There are no current residential development sites available[6]. Excluding the Coast Development Land Release, the author estimates there are around 20 vacant land lots remaining in Manyana. Some of these lots will not be redeveloped in the short term, as landowners may passively landbank, have difficulty obtaining development approval or construction finance, experience adverse personal, family or financial situations, and have concerns about macroeconomic conditions etc. It is expected that some older dwellings or those in disrepair may be redeveloped into new houses. However, this will have nil impact on additional net supply. Consequently, this has not been discussed, as it is not within the scope of this report. These findings suggest that Manyana has an extremely limited supply of around 20 allotments available for new development in the short term.

There are five large parcels of land remaining that may be able to facilitate residential land subdivision and development. A summary of each potential source of supply is provided hereunder, and the respective locations according to the numbers below are illustrated in

[5] https://bellacoastalproperty.com.au/listings/land_sale-1021566-manyana/?doing_wp_cron=1651748976.5674068927764892578125
[6] https://www.realcommercial.com.au/for-sale/manyana-nsw-2539/land-development/

Figure 3.2. Note that Manyana Beach Estate is the only development likely to proceed in the short term.

1. Lot 172 Cunjurong Point Road 'Manyana Beach Estate' (Lot 172 in DP755923)
    a. **Land Zone**: R2 Low-Density Residential.
    b. **Land Area**: 20.23 Hectares
    c. **Ownership Details**: Owned by Manyana Coast Pty Ltd, purchased for $3.85M in March 2017.
    d. **Status**: When completed, The Manyana Beach Estate will comprise 182 homes to be built across six stages on appropriately zoned land. Whilst the Project has been approved since 2008, the proposed commencement of works has attracted significant community concern, predominantly for the impact on flora and fauna by clearing the heavily vegetated site. Following the 2019/20 summer bushfires, it has been reported that this site is now the only significant piece of unburnt bushland for kilometres after it was saved by volunteer firefighters. In response to the request by the Minister for Preliminary Documentation, PPM conducted a socio-economic impact analysis, anticipating that stage 1 will be delivered in year 1, stage 2 the following year, and the subsequent stages over five to six years. Being appropriately zoned by the Council, the site has been earmarked for residential development since 1964. Development consent for the proposed development was issued in 2008. The Council has invested in the necessary services infrastructure in the area. However, certain works relating to the provision of services must be undertaken by the proponent for the development to proceed. The Council entered into a voluntary planning agreement with the developer in 2018 for the staged payment of contributions relating to the provision of nominated community and other services. In 2019, stage 1 of the Project was introduced to the market for sale "off the plan." All lots were sold out in Stage 1, purchased predominantly by first home buyers, investors and retirees. However, due to the Minister's Controlled Action declaration, works on site have not progressed at this time.
2. Cnr Berringer Rd & Inyadda Drive (Lots 6 & 108 in DP755923)
    a. **Land Zone**: RU2 Rural Landscape.
    b. **Land Area**: 38.14 Hectares
    c. **Ownership Details**: Owned by 'Sbacko Pty Ltd', purchased for $1.1M in December 2011.
    d. **Status**: Limited information on this land could be obtained through desktop research. It is noted that the land zoning permits dwelling houses.
3. 'Inyadda Drive' (Lot 2 in DP1121854, Lot 2 in DP1161638 & Lot 106 in DP755923)
    a. **Land Zone**: R5 Large Lot Residential (west side), R1 General Residential (south and centre) and C3/E3 Environmental Management (east side).
    b. **Land Area**: 76.56 Hectares
    c. **Ownership Details**: Owned by 'Manyana Project Pty Ltd', purchased for an undisclosed amount in March 2021. Previously sold for $4.655M in October 2017.
    d. **Status**: The site sought a Planning Proposal to subdivide and rezone the site (DA SF10921) to facilitate a 100-lot residential subdivision with a minimum lot

size of 2,000 m^2 and associated works. A previous application for 274 lots was terminated by the DPE in December 2020 after 400 responses highlighting environmental issues were obtained from a community survey. The new proposal sought to limit the development footprint. However, a significant proportion of the proposed development area are affected vegetation communities listed under the Environment Protection and Biodiversity Conservation Act. The application was recently withdrawn in February 2022[7], as environmental issues could not be resolved.

4. Cnr Curvers Drive & Inyadda Drive 'The Spot Manyana' (Lot 1 in DP1161638)
    a. **Land Zone**: B2 Local Centre.
    b. **Land Area**: 1.14 Hectares
    c. **Ownership Details**: Owned by 'Manyana Capital Pty Ltd', purchased for $990,000 in September 2018.
    d. **Status**: A proposal for a $3M commercial project obtained development approval (DA09/2627). The proposal was for the construction of a commercial development over two stages. Stage 1: single-storey 677 m^2 supermarket (with office), ten retail shops. Stage 2: part1/part 2 storey building with four professional suites and four retail shops. GFA 3,979 m^2, NLA 2,725 m^2. Carparking for 106 vehicles and associated landscaping. The project was abandoned in 2018 following the lapse of the development approval.
5. Lot 147 Manyana Drive (Lot 147 in DP1248050)
    a. **Land Zone**: C3/E3 Environmental Management.
    b. **Land Area**: 4.61 Hectares
    c. **Ownership Details**: Unknown, likely owned by the council or a state government organisation.
    d. **Status**: This site would require rezoning and the acquisition by a private entity to develop the site. The likelihood of this is unknown. Adjacent vegetated land was recently cleared to facilitate the subdivision of Dune Crescent.

Figure 3.2 Future subdivision locations

[7] https://getinvolved.shoalhaven.nsw.gov.au/inyadda-drive-planning-proposal-manyana

A trend that was observed nationally during the Covid pandemic from 2020-21 was also seen in Manyana, with a rapid increase in dwelling prices and people moving from cities to regional areas. The price increase may be due to increased demand from purchasers who are becoming aware of the opportunity to buy relatively affordable and good-quality properties in a highly desirable location. The price differential compared to dwellings in Canberra and particularly Sydney led to some owner-occupiers moving to the regions, with investors entering the market shortly afterwards.

Manyana is highly sought after by purchasers seeking to live the south coast lifestyle or to utilise it as a holiday home (it can also be rented to holidaymakers when not occupied by the owner). The desirability is anticipated to be due to the small scale of the town, considerable natural amenity, and constrained land supply. Manyana has been described by local real estate agent Raine & Horne as '*one of the most prized south coast locations'*[8].

The purchasers of future land release lots are predominantly builders who construct a dwelling to sell or affluent families/empty nesters seeking to build an idealistic new home or holiday house to occupy for parts of the year and lease out when not being used. The vacant land is typically developed into a detached house after purchase. New houses typically have several buyer types, including:

- First home buyers and young families.
- Empty nesters and families moving to live in Manyana.
- Empty nesters and families seeking to reside in the property for part of the year and use it as a 'holiday house', and in the interim, lease the property (typically for short periods).
- Investors desiring to rent the property for short- or long-term leases (dependent on market cycle).

There is plentiful availability for short stay accommodation in Manyana. Airbnb lists 24 residences available for a two-day stay over a weekend, whilst only two of these residences are available for a single-night stay midweek. Additional properties are available for short stay through family connections, independent listings, and other short-stay platforms.

An analysis of forecast demand for additional dwellings is detailed in Figure 3.3. This information uses the 2016 Census as a baseline and adopts assumptions for the Shoalhaven LGA as forecast assumptions. The forecasts imply demand for 213 dwellings over the next 30 years, equating to demand of circa seven additional dwellings each year. In the 2016 period, this was likely due to a large proportion of dwellings being used as holiday houses and short-stay rental properties.

The demand forecast on a purely numerical basis is not a good indicator of long-term demand for property in Manyana. Particularly following the pandemic, a broader pool of buyers is seeking to acquire houses in desirable regional locations to live in or use as holiday houses. Demand for residential dwellings in Manyana is underpinned by the desirability of the location, natural amenity, and limited land available for future development. Given these considerations and dependent upon the quantum of supply available in future subdivisions, demand will likely be in the order of ten to 30 properties per annum over the next several years.

[8] https://www.domain.com.au/47-sunset-strip-manyana-nsw-2539-2017552682

Forecast population, households and dwellings								
Shoalhaven City Council		Forecast year						
Summary	2016	2021	2026	2031	2036	2041	2046	2051
Population	101,970	106,704	112,559	117,499	123,466	128,733	133,131	137,673
Change in pop. (5yrs)		4,734	5,855	4,940	5,967	5,267	4,398	4,542
Average 5-year change (population)	Growth rate from Shoalhaven	4.64%	5.49%	4.39%	5.08%	4.27%	3.42%	3.41%
Average annual change (population)		0.91%	1.07%	0.86%	1.00%	0.84%	0.67%	0.67%
Households	42,656	45,454	48,306	50,862	53,479	55,887	57,877	59,859
Average 5-year change (households)	Growth rate from Shoalhaven	6.56%	6.27%	5.29%	5.15%	4.50%	3.56%	3.42%
Average household size	2.32	2.28	2.26	2.24	2.23	2.23	2.23	2.23
Average household size change	2.32	-1.67%	-1.20%	-0.75%	-0.29%	-0.09%	-0.03%	0.09%
Implied Dwelling Demand	54,651	57,856	60,181	62,627	65,249	67,504	69,779	72,054
Dwelling occupancy rate	78.05	78.56	80.27	81.21	81.96	82.79	82.94	83.08
Source: Population and household forecasts, 2016 to 2051, prepared by .id (informed decisions), March 2021.								

Manyana	2016	2021	2026	2031	2036	2041	2046	2051
Population	521	545	575	600	631	658	680	703
Permanent Households	229	244	260	274	288	301	311	322
Average household size	2.28	2.24	2.21	2.19	2.19	2.19	2.18	2.19
Occupied dwellings	230	244	260	274	288	301	311	322
Unoccupied dwellings	400	426	453	477	501	524	543	561
Unaccounted for dwellings	28	30	32	33	35	37	38	39
	658	700	745	784	825	862	892	922
Private Dwellings	5-year change	42	45	39	41	37	30	30
	Annual change	8	9	8	8	7	6	6

Figure 3.3 Demand analysis for Manyana

3.5.2 BCA analysis

The BCA analysis compares the base case and the development phases (i.e., construction and operation stages) of the project. The analysis focuses on reporting the economic factors (employment and tourists) and social factors. We collected data from various publicly available sources to establish the data in 2022. Some of the data not available in Manyana were estimated from Shoalhaven City Council documents. Forecasting to 2050 was performed by applying different techniques. Details of forecasting can be found in Appendix 1.

3.5.2.1 Economic impacts

Employment creation

In Manyana, the proportion of technicians and trades (20.7%) and community and personal service workers is relatively high, compared to the NSW average. Other common occupations are professionals (17.9%) and clerical and administrative workers (17.9%). Figure 3.4 shows the top occupations in Manyana, according to the 2016 ABS census data.

Occupation *Employed people aged 15 years and over*	Manyana	%	New South Wales	%	Australia	%
Technicians and Trades Workers	38	20.7	429,239	12.7	1,447,414	13.5
Professionals	33	17.9	798,126	23.6	2,370,966	22.2
Clerical and Administrative Workers	33	17.9	467,977	13.8	1,449,681	13.6
Community and Personal Service Workers	23	12.5	350,261	10.4	1,157,003	10.8
Labourers	19	10.3	297,887	8.8	1,011,520	9.5
Sales Workers	16	8.7	311,414	9.2	1,000,955	9.4
Managers	12	6.5	456,084	13.5	1,390,047	13.0
Machinery Operators and Drivers	10	5.4	206,839	6.1	670,106	6.3

The most common occupations in Manyana included Technicians and Trades Workers 20.7%, Professionals 17.9%, Clerical and Administrative Workers 17.9%, Community and Personal Service Workers 12.5%, Labourers 10.3%, Sales Workers 8.7%, Managers 6.5% and Machinery Operators and Drivers 5.4%.

Figure 3.4 Top occupation in Manyana (ABS census, 2016)

Based on the NSW Government (2020), i.e., every $1 million can create nine jobs for residential projects. It is estimated that 15 jobs can be created directly from the project. Two hundred and eight people were living in Manyana in 2022. Without the development, employment is expected to increase by 38.7% in 2050, or 81 new jobs to be created. If the development proceeds, 46 (22%) and 130 (62.4%) new jobs will be created in the construction and operation stages, respectively. A similar trend is expected for the labour force. Table 3.6 displays the estimated direct and indirect jobs created with or without the development.

Table 3.6 Comparison of employment with and without development

	Base case	Construction		Operation	
Employment (Base case)	208	227	8.9%	289	38.7%
Employment (development)	208	254	22.0%	338	62.4%
Development benefit	**0**	**27**	**13.1%**	**49**	**23.7%**
Labor force	226	247	8.9%	314	38.7%
Labor force (development)	226	276	22.0%	368	62.4%
Development benefit	**0**	**30**	**13.1%**	**54**	**23.7%**

Effects on Tourism

Manyana beach is a favourite location for tourists in Shoalhaven, which boasts a number of rich natural landscapes, such as Jervis Bay and Hyams Beach, attracting international, domestic and day trip travellers. Domestic visits to Shoalhaven are projected to rise 12.1% and 19.5% after the construction and operation stages of the development, respectively, from 2022. Tourism will increase by 10.8% and 38.5% after the construction and operation stages, respectively (Table 3.7). A proportional growth rate is assumed for Manyana's tourism, as there is no statistical evidence to show the exact number of visitors to Manyana. The median rent per week in Manyana was $265 (ABS Census, 2016), relatively cheaper than in other areas. Thus, Airbnb in the area is attractive. It is also expected that the completion of the development will provide more accommodations for visitors.

Table 3.7 Comparison of the impacts of tourism

Visitor Type	Base case	Construction		Operation	
International Visitor	223749	224984	0.6%	228846	2.3%
Domestic Visitor	4431266	4776045	7.8%	5296174	19.5%
Tourism	6331226	7012767	10.8%	8771121	38.5%

Direct Economic Benefit-cost

The developer, government, investors and residents are the four main stakeholders considered in the BCA. The benefits of the development project include the project sales of houses if the development proceeds, stamp duty and charges received by the government, and possible rental returns received by the investors. The estimated costs for the developers consist of land, construction and government charges. The main costs for the government could be the investment of infrastructure and public good, and administrative expenses. For the residents, the benefits include the yearly percentage increase in employment, labour force, median income, occupied households, land value, rent growth and tourism. The costs for residents are the percentage increase in house insurance, building cost and rent paid by the visitors.

Based on the assumptions made in section 3.3, the impacts of the development project can be estimated. Table 3.8 compares the benefit-cost ratios for the base case, and the construction and operation stages. In the base case 2017 model, the benefit-cost ratio of 0.62 indicates the net loss for both the developers and the government due to both parties having undertaken an initial investment in the project. Without the development, the developer will suffer a great loss from the purchase of the land, cost of capital, and other fee payments. Another direct cost in the base case is that the local households have to pay expensive house insurance (50% more than other areas) and building costs ($100,000 more than other areas). The cost may pass on to tenants who have to pay a higher rent. The detailed analysis can be found in section 4.4.

If construction proceeds, the benefit-cost ratio is estimated to be greater than one, meaning that the development project is beneficial. The developer sells the constructed houses in stages while developing. Investors can purchase houses and generate rental returns. In the operating stage, the developer can sell all houses, pay off the remaining debt obligation and move on. The government continually collects land tax from the investment, while the investors benefit the most from the sale proceeds from the investment. The benefit-cost ratio of 2.9 reflects the great economic benefits. This analysis suggests that the property development should go ahead, as the benefits are greater than the costs as a whole.

Table 3.8 Direct effects of development project

Development Project Benefit Cost Analysis		Base case		Construction		Operation	
	2017	Cost	Benefit	Cost	Benefit	Cost	Benefit
	Development costs	-4096246	0	-138071228	291060783	0	0
	Government	-2217705	4096246	-2310000	18792046	0	1340376
	Investors	0	0	-107719280	15113885	-349938325	1014670942
	Residents	0	0	-5	8	-10	13
	Total	-6313951	4096246	-248100512	324966721	-349938336	1016011331
	NPV	-5765297	3577820	-218987197	300770562	-285653920	829444482
	Benefit-Cost ratio	0.00	0.62	0.00	1.37	0.00	2.90

Project Development Benefit and Cost Analysis		Base case		Construction		Operation	
	2022	Cost	Benefit	Cost	Benefit	Cost	Benefit
	Development costs	0.00	0.00	-138071228	291060783	0	0
	Government	0.00	0.00	-2310000	18792046	0	1340376
	Investors	0.00	0.00	-107719280	15113885	-349938325	1014670942
	Residents	0.00	0.00	-4.99	7.67	-10.30	13.33
	Total	0.00	0.00	-248100512	324966721	-349938336	1016011331
	NPV	0.00	0.00	-218987197	300770562	-285653920	829444482
	Benefit-Cost ratio	0.00	0.00	0.00	1.37	0.00	2.90

Indirect benefits and costs

Base Case

Under the base case scenario, there is no development activity on the site. The benefit of 'do nothing' is that the bushland and fauna can be conserved. The households living around the bushland can enjoy the quiet environment. Manyana Matters Environmental Association (2021) provides that they are happy about *one day trip a week* to another town. The fire risk is still high for residents surrounded by the bushland, with no guarantees as to the disaster level in another bushfire event. Residents' trauma may still exist due to concerns about another bushfire in the future. Without the housing development in the area, the 'one-way' road issue may take a longer time to resolve. This is because the government may need to raise funds from many property development projects foreshadowed in the local area to trigger investment in public goods. There is increasing demand for houses in the regional areas. The shortage of supply will increase the land value in Manyana. This may benefit existing households but will be detrimental to many aspiring purchasers into the local area.

Construction Stage

The development site is approximately 20.23 hectares and will produce 182 houses on lots ranging from 500 to 900 square meters. There are also a playground area and a large environment clearance certificate (ECC) buffer zone. The total cost of the development is estimated at $43,595,916, excluding the land cost.

Manyana is about 27.4 km to Milton, 32.8 km to Ulladulla, and 54.3km to Nowra by road. There were 129 drivers and 11 passengers in Manyana, according to the 2016 census. There is only one road in and out of the area and minimum public transportation available. Car is the main form of transport used by local households. Some people work in Sydney, drive cars to the public transport station, and then transit to train or buses. As the one road is also shared by

the surrounding suburbs, some minor traffic congestion issues may occur during the construction stage. The time spent travelling to access local businesses, schools, and other services will increase the vehicle kilometres travelled. The costs may include but are not limited to increased noise, traffic delays due to construction activity, and impacts on access to services industry productivity. The following formula (from NSW Transport) is used to estimate the residents' costs related to travelling during the construction:

$$Cost\ of\ Travel\ Time\ Penalty = \frac{TTV\ x\ ADV\ x\ VPH\ X\ H}{60}$$

where:
TTV is the weighted average travel time value, per vehicle hour;
ADV is the average delay per vehicle, in minutes;
VPH is vehicles per hour
H is the duration of traffic, in hours

Table 3.9 Calculation of traffic delay cost for residents

Traffic Parameters		Source
TTV	$23.39	NSW Transport
VPH	16	Assume 129/8 hours
ADV	2	Assumed
H	1.2	Assumption
Cost penalty for travel time	$14.97	

The benefit of this stage is that government can collect development contributions to help fund local community services and infrastructure upgrades. The fire-resistant standard of modern house construction, with defendable space for fire protection, can be enforced by the government to ensure increased safety measures for households. As a result, the residents' concerns in relation to fire safety can be reduced. The development can create jobs for construction-related activities (see the section employment and job creation).

Operational stage

Apart from the new supply of 182 houses and the ripple effects on the local economy, e.g., job creation, the completion of the development project may have an indirect benefit on the increase in local population (62%) and occupied private dwellings (72%) in the area (Figure 3.5 and Table 3.10). The results show that additional people will move into the area after the development project, in comparison to the development not proceeding. The gradual build-up of the community will improve the demographic profile by reducing the median age of population, improving cultural diversity, and enhancing community cohesiveness. The increased population will also allow the government to plan additional infrastructure and public facilities, including education and childcare, to improve the convenience and quality of life for locals. The trauma from the bushfire may be gradually eased when the built-up facilities become available.

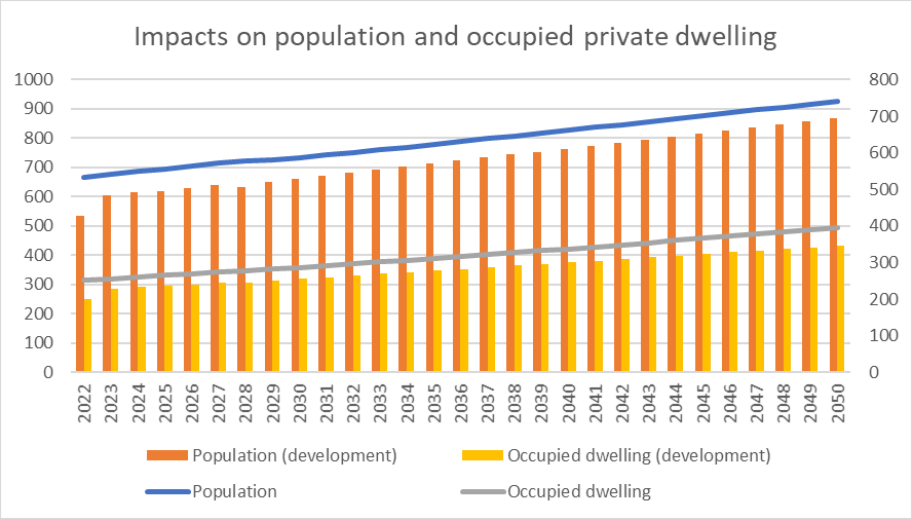

Figure 3.5 Impact on population and occupied private dwelling with and without development

Table 3.10 The impacts on population and occupied private dwellings

	Base case	Construction		Operation	
Population	534	582	8.9%	741	38.7%
Population (development)	534	651	22.0%	867	62.4%
Development benefit	**0**	**69.84**	**13%**	**126.50**	**24%**
Occupied private dwelling	252	283	12.3%	396	58%
Occupied private dwelling (Development)	252	314	24.6%	433	72%
Development benefit	**0**	**31**	**12.3%**	**36**	**14.4%**

Intergenerational equity

Environmental protection is one of the concepts of intergenerational equity. The Supreme Court has recognised the intergenerational equity principle, i.e., future generations must inherit at least as much as the present, in the context of conservation of scarce resources like minerals (Sehgal, 2020). Thus, protecting the natural environment is one of ESD's assessment criteria. Due to the fire risk, if the development does not proceed and the bushland is kept as it is, this will carry the cost of fire-related damage to younger generations. Thus, the present generation should take the necessary steps to save the future residents in the area. Intergenerational equity can be achieved if losses to the environment that future generations would face are offset by gains in economic progress.

Intergenerational equity also refers to the standard of living at a particular point in time, and this varies between people of different ages and generations. This implies that equitable living standards should be provided across ages and generations. Stebbing and Spies-Butcher (2016) investigated the emerging generational differences in home ownership in Australia and have identified a growing difficulty for younger homebuyers to gain and retain ownership. The asset-based welfare policies in Australia have created high home ownership rates in the retirement cohort. In Manyana, the median age is 54, whereas it is 38 in NSW. An average of 15% of people were less than 20 years old in Manyana, compared to 31.5% in NSW. However, the proportion of people older than 60 was 39%, compared to only 5% in NSW (Table 3.11). Given the high standard of living and low property prices and rent, the introduction of new housing in Manyana will gradually close the uneven generation gap and bring young people to the area.

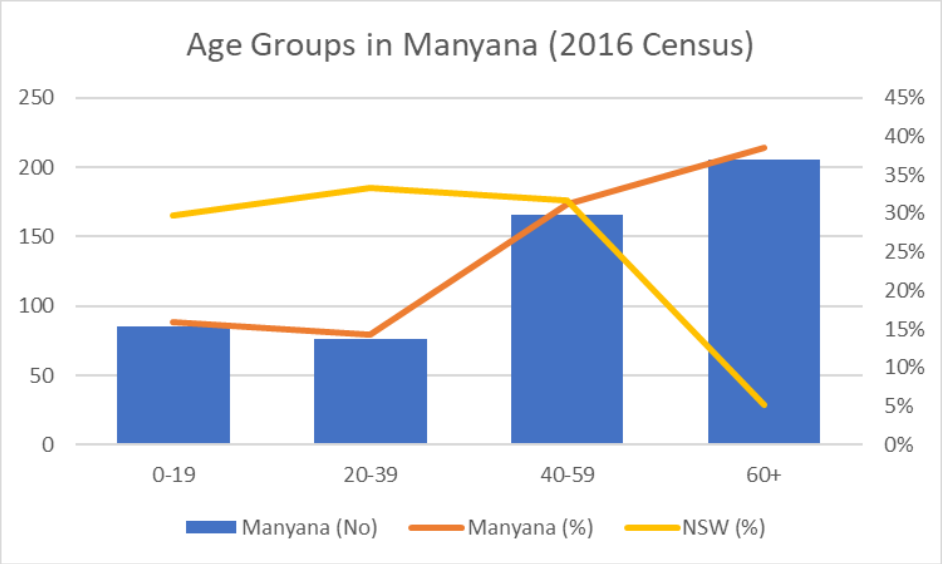

Figure 3.6 Age groups in Manyana in 2016

Table 3.11 Age groups in Manyana and NSW (2016 ABS Census)

Age groups Manyana	Manyana		NSW	
	No	%	No	%
0-19	85	16%	1834753	30%
20-39	76	14%	2056919	33%
40-59	166	31%	1950881	32%
60+	205	39%	323312	5%

3.6 Sensitivity analysis

The benefit-cost models are built from various assumptions, i.e., the change of market growth rate, CPI and discount rate are tested to study the impact of benefit-cost of different development stages. Due to changing economic conditions and market sentiments, the impacts of the development project on economic and social aspects can vary. For example, when the market growth rate changes, there will be no impact on the base case. However, the benefits will significantly increase in the construction and operation stages. In addition, a fast growth rate appears in the operational stage. This is due to the land value appreciation and the benefit to residents from the market growth rate in the long term (Figure 3.7).

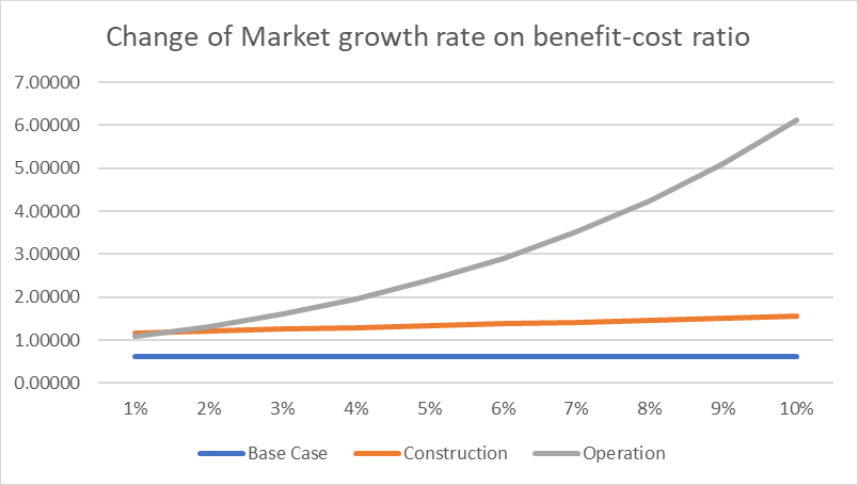

Figure 3.7 The benefit-cost of changing market growth rate

The change in discount rate will increase the cost of capital for borrowing. Figure 3.8 shows the impact of the changing discount rate on the base case and development scenarios. The developers, investors and residents can be affected in the long term.

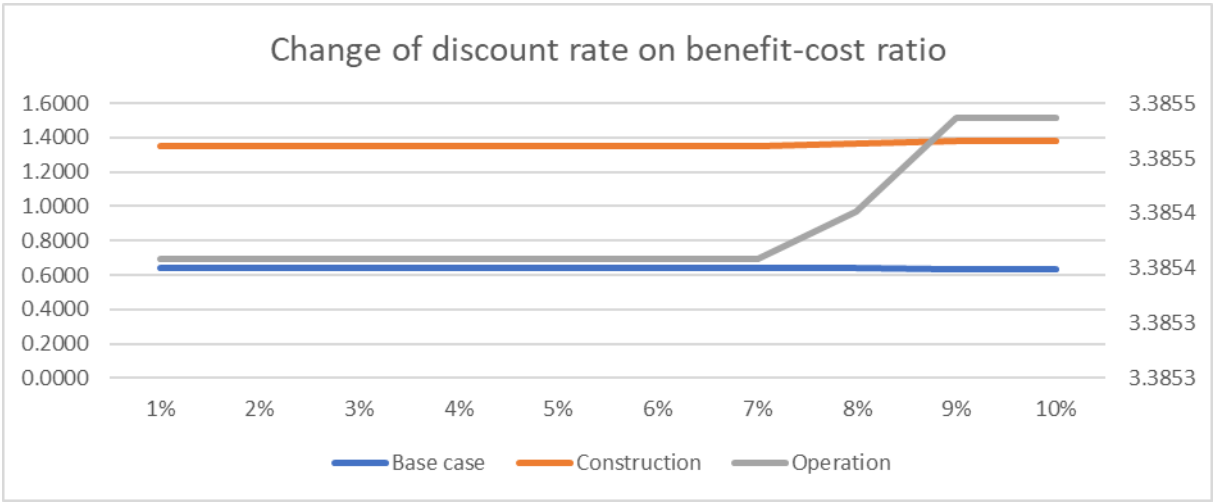

Figure 3.8 The benefit-cost of changing discount rate

4 ECONOMIC DISTRIBUTIONAL IMPACT ANALYSIS

4.1 Introduction

To protect the natural environment, governments need to source capital for biodiversity conservation and investment in infrastructure and public goods. If the costs are borne by the consumers, it will push the housing price up and reduce housing affordability. To minimise the negative impact on consumers, i.e., transfer the costs to the end users, developers incur additional marginal costs. This analysis addresses the question of how the development affects the stakeholders' decisions, which in turn affects the demand and supply of housing in the marketplace. Developers, existing residents, investors, and the government are the main stakeholders for this analysis.

4.2 Key assumptions

The estimated timeframe for the analysis is from 2022 to 2050. The rate assumptions and the cash flows of development are the same as in section 3.2. The cash outflows of the government consist of investing infrastructure and public good plus the administrative expenses at the time the land was purchased by the developer. The land price was $285,000 per lot in 2017. For investors, it is assumed that they will purchase the developed houses from the project and invest for 20 years by collecting rents. They can finance a portion of capital for the investment. The discount rate is 7%. For the residents in Manyana, the incremental cash inflows are the price and rent appreciation, increase in employment, population, occupied households, household incomes and tourism. The cash outflows are the 25%-50% additional insurance costs[9], increased rent and about $100,000 more for building costs. Table 4.1 shows an example of relatively higher insurance costs in comparison to homes away from bushland. It is assumed that insurance costs will be gradually reduced to 10% from 50% due to the new development completed to meet the new fire safety standard.

Table 4.1 AAMI bushfire insurance charge example[10]

Bushfire Attack Level (BAL)	Bushfire Loading*
BAL FZ (Flame zone)	$65,000 - $277,000 +
BAL 40	$19,000 - $73,000 +
BAL 12.5 to 40	$16,000 - $56,000 +
BAL LOW	NIL

4.3 Methodology

Discounted cash flow modelling (DCF) is the underpinning method used in the analysis. DCF is a well-established method for long-term valuation and investment evaluation. It estimates the attractiveness of an investment opportunity based on expected future cash flows and its associated discount rate. Key output variables in DCF modelling include Net Present Value (NPV) and Internal Rate of Return (IRR). The DCF model calculates NPV based on annual cash flow, discount rate (or required rate of return or cost of capital), the investment amount, and the project's expected life. When the NPV is less than zero, and the IRR does not achieve the required rate of return, the project is declined. For the purpose of this analysis, it was assumed that developers' required rate of return is 20%, and the discount rate of 7% follows Treasury guidelines. Finance costs are included in the DCF model as the cost of capital (4.68%). The discount rate and the cost of capital jointly reflect the risk and finance cost of the development project. A residential property growth rate of 6% was used.

Using MS Excel, three DCF models were developed: one for the developer, one for the government and one for the investor. For developers, cash inflows and outflows were mainly based on the purchase of the site, land development, construction of the houses and the sale of the eventual dwellings. For the government, cash inflows were collected from the development contributions, and cash outflows were the investments in infrastructure and

[9] https://www.ahuri.edu.au/research/brief/bushfires-likely-increase-cost-living-regional-australia

[10] https://www.aami.com.au/home-insurance/bushfire-prevention.html

public goods. It was assumed that development contribution costs for developers are the income to the government. Many investors are attracted to investing in property for holiday homes or Airbnb. Thus, the impact on investors' decisions is also estimated. For the existing residents, the increase in property values, rent appreciation and household income increases are assumed to be the sources of income, and additional insurance is assumed to be the outflow cash flows.

4.4 Results

The incremental cash flows of the four stakeholders were analysed for the entire period from 2022 to 2050. Given the assumptions, the positive benefit-cost ratios for the stakeholders are listed in Table 4.2. In particular, the government has gained a great income for investment in infrastructure and public goods that will benefit for the residents in the long run.

Table 4.2 Economic distributional impact of the development on stakeholders

Stakeholders Summary							
	Developers		NPV 2022	$	81,757,464	IRR 2022	61%
	Governments		NPV 2022	$	12,676,399	IRR 2022	144%
	Investors		NPV 2022	$	61,967,421	IRR 2022	10%
	Residents		NPV 2022	$	(0.22)	IRR 2022	5%

Table 4.3 depicts the cash flow performances of stakeholders in different scenarios. In the base case, the developer will lose all the initial investments plus finance and other costs if the development does not proceed. The government has received a portion of land acquisition fees and the costs of establishing the development and administrative expenses. Without the development, there will be no additional housing stock for investment on the development site. The existing residents maintain the current lifestyle, but the costs of living have increased because of the 50% rise in the cost of insurance for the bushfire areas. For residents who want to rebuild their houses, the building costs would have increased by about $100,000 relative to the low-risk bushfire areas. Households who run Airbnb may pass the increased costs to the tenant by charging higher rents.

The benefit-cost ratio of 2.11 during the construction stage indicates that the developer can gradually sell the developed houses and recover the initial investment and costs. The developers will pay out all the development expenses and move on to a new development. Thus, the ratio in the operational phase is zero. The government will incur positive cash flows during the construction and operation stages. Using the received development contributions from the developer, the government has been assumed to purchase different lands for the construction of community services and other infrastructure projects. The investors can enjoy a stable rental income from the investment in the operational stage. Due to the developed houses meeting the bushfire protection standard, insurance costs will be gradually reduced from the construction to the operational stage. In addition, the newly developed built environment will attract more tourists, stimulate local economic activities, and increase job opportunities and household incomes. Thus, the benefit-cost ratio shows a positive result for residents in the operational stage. The investors and residents will receive long-term benefits, whereas the developer benefits from the development only.

Table 4.3 Economic distributional impacts on stakeholders

	Stakeholders 2017 model	Measures	Base case	Construction	Operation
Distributional Benefit and Cost Analysis	Developers	Benefits	0	291060783	0
		Costs	-4096246	-138071228	0
		Net Cash flow	-4096246	152989555	0
		Ratio	**0.00**	**2.11**	**0.00**
	Government	Benefits	4096246	18792046	1340376
		Costs	-2217705	-2310000	0
		Net Cash flow	1878541	16482046	1340376
		Ratio	**1.85**	**8.14**	
	Investors	Benefits	0	15113885	1014670942
		Costs	0	-107719280	-349938325
		Net Cash flow	0	-92605395	664732617
		Ratio	0	0.14	2.90
	Residents	Benefits	0	7.67	13.33
		Costs	0	-4.99	-10.30
		Net Cash flow	0	2.68	3.03
		Ratio	0	1.54	1.29

	Stakeholders 2022 model	Measures	Base case	Construction	Operation
Distributional Benefit and Cost analysis	Developers	Benefits	0	291060783	0
		Costs	0	-138071228	0
		Net Cash flow	0	152989555	0
		Ratio	**0.00**	**2.11**	**0.00**
	Government	Benefits	0	18792046	1340376
		Costs	0	-2310000	0
		Net Cash flow	0	16482046	1340376
		Ratio	**0.00**	**8.14**	
	Investors	Benefits	0	15113885	1014670942
		Costs	0	-107719280	-349938325
		Net Cash flow	0	-92605395	664732617
		Ratio	0	0.14	2.90
	Residents	Benefits	0	7.67	13.33
		Costs	0	-4.99	-10.30
		Net Cash flow	0	2.68	3.03
		Ratio	0	1.54	1.29

4.5 Sensitivity analysis

The sensitivity analysis in Figure 4.1 shows the impact of change market growth rate on the stakeholders. The higher the market growth rate, the higher the benefits for the stakeholders. Residents will also benefit from the land value appreciation and the increase of rent.

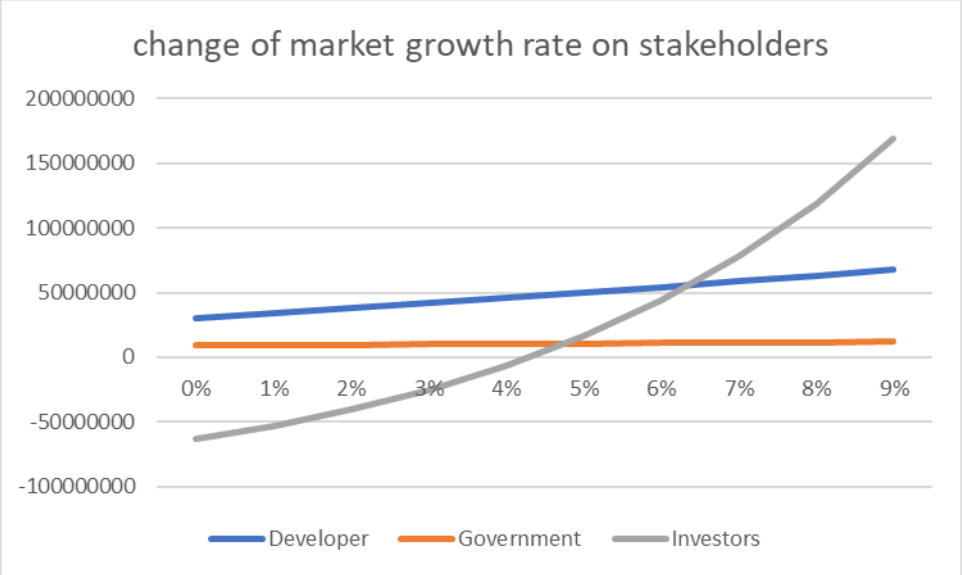

Figure 4.1 Impacts of changing market growth rate on stakeholders

The sensitivity analysis of a changing discount rate is depicted in Figure 4.2. The higher the discount rate, the higher the cost for stakeholders. Thus, downward trends are shown. Investors and residents will be impacted greatly in the long term due to the higher cost of capital.

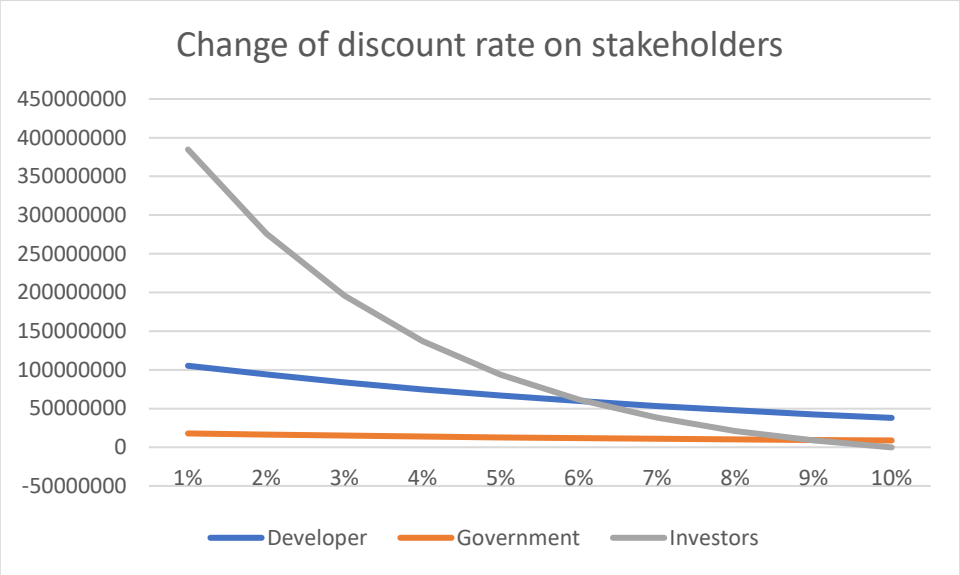

Figure 4.2 Impact of changing discount rate on stakeholders

5 ANALYSIS OF SOCIAL IMPACT ON RESIDENTS

5.1 Introduction

The main social impact of the development is the trauma from the bushfire (Ziller, 2021). Residents are concerned about the risk of a bushfire that may cause damage to their safety, health and property. The residents are also attached to the natural environment. The development project must assess the social impacts that affect residents and the natural environment. This assessment adopts the NSW social impact assessment tool for significant projects to study the impact of the development.

5.2 Key variables

The social impact variables are considered mainly in terms of what the development means for people and the environment (Table 5.1). Those identified variables of social impact analysis are supported in the literature (Appendix 2).

Table 5.1 The main variables considered in the assessment

Focus	Variables
What does the development mean for people?	Amenity, access, built environment, heritage, community, economic
What does the development mean for the natural environment?	Air, biodiversity, land, water

5.3 Key assumptions

It is assumed that the variables listed in the NSW guideline for SIA have covered the required assessment. Some data, such as household disposable income in Manyana, is not available. Therefore, the income from Shoalhaven NSW or Australia may be used as a proxy for the analysis.

5.3 Methodology

Both quantitative and qualitative assessment methods will be applied to the SIA study. The first step of SIA is to conduct an assessment, which commences with an analysis of the claims from the local community. From the Manyana Submission letters, we found that the main concern are natural environmental factors (e.g., bushfire, ecological, species, climate, long-term habitat), economics, housing and intergeneration equity. The word cloud analysis of social aspects referred to previously (Figure 2.11) has supported the identified variables. Figure 5.1 shows the statistical analysis results, and Figure 5.2 presents the correlations of the claims among the variables. The results suggest that residents are less concerned about the economic impacts. Having been traumatised from the fire and afraid of future bushfire disaster threats, residents' concerns are aimed at the subject site from the housing development.

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Expert	1132	1	0	1	37	.03	.005	.178	.032	5.263	.073	25.747	.145
Positive	1132	1	0	1	1	.00	.001	.030	.001	33.645	.073	1132.000	.145
Late	1132	1	0	1	36	.03	.005	.176	.031	5.343	.073	26.600	.145
Design	1132	1	0	1	21	.02	.004	.135	.018	7.146	.073	49.146	.145
Envi_assess	1132	1	0	1	67	.06	.007	.236	.056	3.741	.073	12.017	.145
Site	1132	1	0	1	44	.04	.006	.193	.037	4.778	.073	20.865	.145
Bushfire	1132	1	0	1	756	.67	.014	.471	.222	-.714	.073	-1.493	.145
Infrastru	1132	1	0	1	71	.06	.007	.243	.059	3.612	.073	11.065	.145
General	1132	1	0	1	309	.27	.013	.446	.199	1.021	.073	-.960	.145
Housing	1132	1	0	1	44	.04	.006	.193	.037	4.778	.073	20.865	.145
Economics	1132	1	0	1	41	.04	.006	.187	.035	4.971	.073	22.753	.145
Climate	1132	1	0	1	96	.08	.008	.279	.078	2.985	.073	6.920	.145
Species	1132	1	0	1	421	.37	.014	.484	.234	.531	.073	-1.721	.145
Ecological	1132	1	0	1	219	.19	.012	.395	.156	1.554	.073	.416	.145
Long_habitat	1132	1	0	1	422	.37	.014	.484	.234	.527	.073	-1.725	.145
Intergeneration	1132	1	0	1	182	.16	.011	.367	.135	1.849	.073	1.423	.145
Mixed	1132	1	0	1	11	.01	.003	.098	.010	10.009	.073	98.358	.145
Public_interest	1132	1	0	1	120	.11	.009	.308	.095	2.563	.073	4.577	.145
Valid N (listwise)	1132												

Figure 5.1 Statistical analysis of the data sample

		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
	Dependent variable	Intergeneration	Housing	Economics	Bushfire	Ecological	Species	Long-Habitat	Climate
Independent variables									
General Submissions	Expert					.193 (3.033)	.270 (3.537)		
	Positive								
	Late								
	Project Design								.201(3.314)
	Environmental Assessment			.072 (3.325)			.243 (4.210)	.166 (2.837)	
	Site Situation								
	Bushfire					.138 (4.915)			
	Strategic Needs (Infrastructure, Roads, etc.)		.322 (15.075)	.150 (6.276)					
	General Comments Other	-0.100 (-4.104)			-.501 (-17.651)	-.126 (-4.198)	-.353 (-11.168)	-.345 (-10.696)	-.083 (-4.424)
Economy	(Contribution to) Housing			.242 (8.056)					
	(Contribution to) Local Economy (Incl. Tourism & Jobs)		.231 (8.308)						
Ecology	Precautionary Principle (incl. Climate Change)					-.123 (-3.023)			
	Impact on Vulnerable, Threatened, Endangered, Critically Endangered Species							-.092 (-3.063)	
	Ecological Refuge				.156 (5.090)				-.065 (-3.045)
	Long Term Sustainability (Incl. Gradual Habitat Reduction)				.071 (2.793)		-.095 (-3.255)		
Social	Intergenerational Equity								
	Miscellaneous Considerations	.287 (2.606)							
	Public Interest								
	Constant	.185 (14.532)	.010 (2.017)	.013 (2.433)	.748 (37.708)	.140 (5.156)	.481 (22.961)	.491 (23.182)	.116 (10.592)
	R-square	0.21	0.271	0.163	0.294	0.083	0.124	0.098	0.031
	F test	0.009	209.788	72.979	156.922	25.417	40.042	40.657	11.844
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000
	DW	1.881	2.001	1.968	1.867	1.967	1.922	1.848	2.007

Figure 5.2 Statistical models showing the main concerns of people

As a result, the second step involves an environmental assessment using the NSW EIA excel tool provided. The EIA assessment (Table 5.2) advises that the bushland used for the development will likely affect residents. Engagement with the residents was suggested.

Table 5.2 Environmental impact assessment for the development project

Environmental Impact Statement (EIS) scoping worksheet for:																	
														Date:			
What matters might be impacted?			What activities might cause an impact?		What are the characteristics of the impact?						How will the impact be managed?	What are the community and other stakeholder views?	What level of assessment and engagement is required in the EIS preparation phase?				
Social and environmental matters i.e. natural or human assets or values aggregated at the level most appropriate for informing management and assessment requirements *Click on the matter for a description, or the link above for full glossary*			Without any mitigation, is the proposal likely to impact on the matter? *(Select from list)*	If there is a 'likely' impact: 1. list the activities expected to cause the impact; and 2. if applicable, list the receptor being impacted and its status. *E.g. construction noise will be heard at nearby school* If 'unlikely', briefly explain why. Has the impact been actively avoided through project design or site location? *(Manual entry)*	Is the impact, without mitigation, expected to cause a material effect with regard to its... *(Answer 'Y', 'N' or '?')* *Click on characteristic for description, or the link above for further detail*				Does the impact need assessment in the EIS? *(Auto fills)*	Is the impact, without mitigation, expected to have a material cumulative effect with other impacts (including from other projects)? *(Select from list)*	What safeguards and management measures are expected to be required to address the impact? *(Select from list)*	Are there community or other stakeholder concerns regarding the impact or activity? *(Based on engagement with community and other stakeholders)* *(Select from list)*	Expected level of assessment and/or engagement required *(Auto fills)*	Relevant section in Scoping Report *(Manual entry)*
					extent?	duration?	severity?	sensitivity?									
What does the proposal mean for people?	AMENITY	acoustic	Likely	It is the nature of construction, some noises may be created during the construction but manageable.	N	Y	N	N	No	No			Standard	Yes	Other Issue + Focussed Engagement	
		visual	n/a												No assessment necessary - Worksheet only	
		odour	n/a													
		microclimate	n/a												No assessment necessary - Worksheet only	
		other - please specify														
	ACCESS	access to property	Unlikely		N	N	N	N	No	No	Standard	No	Other Issue			
		utilities	Unlikely	It will be developed on the new site	N	N	N	N	No	No	Standard	No	Other Issue			
		road and rail network	Likely	Only one road in and out of the area.	Y	N	N	Y		Yes	Standard	Yes	Other Issue + CIA + Focussed Engagement			
		offsite parking	Unlikely									No				
		other - please specify														
	BUILT ENVIRONMENT	public domain	n/a												No assessment necessary - Worksheet only	
		public infrastructure	n/a												No assessment necessary - Worksheet only	
		other built assets	n/a												No assessment necessary - Worksheet only	
		other - please specify														
	HERITAGE	natural	n/a												No assessment necessary - Worksheet only	
		cultural	n/a												No assessment necessary - Worksheet only	
		Aboriginal cultural	n/a												No assessment necessary - Worksheet only	
		built	n/a												No assessment necessary - Worksheet only	
		other - please specify														
	COMMUNITY	health	Unlikely									Yes	Scoping Report + Explain avoidance			
		safety	Unlikely									Yes	Scoping Report + Explain avoidance			
		services and facilities	Unlikely									No	Scoping Report			
		cohesion, capital and resilience	Unlikely									No	Scoping Report			
		housing	Unlikely										Scoping Report			
		other - please specify														
	ECONOMIC	natural resource use	Likely	Bushland	Y	Y	Y	Y	Yes	Yes	Project Specific	Yes	Key Issue + CIA + Focussed Engagement			
		livelihood	Likely	Bushland remove	N	N	N	Y	No			Yes	Scoping Report + Focussed Engagement			
		opportunity cost	Unlikely	Without the development, lack of housing supply								Yes	Scoping Report + Explain avoidance			
		other - please specify														
What does the proposal mean for the natural environment?	AIR	particulate matter	n/a												No assessment necessary - Worksheet only	
		gases	n/a												No assessment necessary - Worksheet only	
		atmospheric emissions	Likely	construction carbon	N	N	N	N	No			No	Scoping Report			
		other - please specify														
	BIODIVERSITY	native vegetation	Likely	Bushland remove	Y	Y	Y	Y	Yes	Yes	Standard		Other Issue + CIA			
		native fauna	Likely	Bushland remove	Y	Y	Y	Y	Yes	Yes	Standard		Other Issue + CIA			
		other - please specify														
	LAND	stability and/or structure	Unlikely									No	Scoping Report			
		soil chemistry	Unlikely									No	Scoping Report			
		capability	Unlikely									No	Scoping Report			
		topography	Unlikely									No	Scoping Report			
		other - please specify														
	WATER	water quality	Unlikely										Scoping Report			
		water availability	Unlikely										Scoping Report			
		hydrological flows	Unlikely										Scoping Report			
		other - please specify														
What risks does the proposal face?	RISKS	coastal hazards	Unlikely										Scoping Report			
		flood waters	Unlikely										Scoping Report			
		bushfire	Likely		?	?	?	?	Unknown	Unknown	Standard	Yes	Other Issue + CIA + Focussed Engagement			
		undermining	Unlikely										Scoping Report			
		steep slopes	Unlikely										Scoping Report			
		other - please specify														

The next step is to assess the social impact (Table 5.3) using the NSW SIA worksheet and identify the areas where it may be necessary to conduct a standard SIA assessment. According to the social impact assessment result, a standard SIA may be required to manage the potential construction road congestion, as well as the removal of the bushland for the project.

Table 5.3 Social impact assessment for the development project

Filter results	Remove filter	Scoping results from EIS Worksheet			Is there a social impact?		What information will be required to assess the social impact?		
Social and environmental matters *Click on a matter below for brief description, or refer to full glossary*		Outline of impact *(Auto fill from EIS worksheet)*	Is a material effect on the matter expected? *(Auto fill from EIS worksheet)*	Is there community or other stakeholder concerns regarding the impact or activity? *(Auto fill from EIS worksheet)*	With regard to the matter expected to be impacted, will there be a social impact? *Select this cell for brief description, or click link above for further detail* Yes/No	If yes, outline the social impact *(Manual entry, if not already covered in column D)*	Are impacts on the matter expected to require a non-SIA specialist study? *(Auto fill from EIS worksheet, then manually enter non-SIA report*	Will the non-SIA specialist study address the social impact? *Click on link above for further detail on potential classifications* *(Select from list)*	Level of assessment for the social impact in the SIA *Click on link above for further detail on potential classifications* *(Auto fills)*
What does the proposal mean for people?	AMENITY	acoustic	It is the nature of construction, some noises may be created during the construction but manageable.	Yes	Yes	No		No		No SIA required
		visual								
		odour								
		microclimate								
		other - please specify								
	ACCESS	access to property	0	Yes	No	No		No		No SIA required
		utilities	It will be developed on the new site	Yes	No	No		No		No SIA required
		road and rail network	Only one road in and out of the area.	Yes	Yes	Yes	May create road congestion in peak hour	No	Yes - in part	Standard SIA
		offsite parking								
		other - please specify								
	BUILT ENVIRONMENT	public domain								
		public infrastructure				No				No SIA required
		other built assets								
		other - please specify								
	HERITAGE	natural				No			No	No SIA required
		cultural				No				No SIA required
		Aboriginal cultural								
		built				No				No SIA required
		other - please specify								
	COMMUNITY	health			Yes	Yes	People are trauma from previous bushfire			
		safety			Yes	Yes	People are trauma from previous bushfire			
		services and facilities			No	No				No SIA required
		housing			No	Yes	Some people do not like high density environment			
		cohesion, capital and resilience								
		other - please specify								
	ECONOMIC	natural resource use	Bushland	Yes	Yes	Yes	Remove the bushland	Yes - enter generic title	Yes - in part	Standard SIA
		livelihood			Yes	Yes	Increase housing supply			
		business opportunity			Yes	No				No SIA required
		other - please specify								
What does the proposal mean for the natural environment?	AIR	particulate matter								
		gases								
		atmospheric emissions			No	No				No SIA required
		other - please specify								
	BIODIVERSITY	native vegetation	Bushland remove	Yes		Yes	bushland remove	No	Yes - in part	Standard SIA
		native fauna	Bushland remove	Yes		Yes	bushland remove	No	Yes - in part	Standard SIA
		other - please specify								
	LAND	stability and/or structure			No	No				No SIA required
		soil chemistry			No	No				No SIA required
		capability			No	No				No SIA required
		topography			No	No				No SIA required
		other - please specify								
	WATER	water quality								
		water availability								
		hydrological flows								
		other - please specify								

The final step is to determine the positive or negative social impacts from the development project using the assessment criteria listed in Table 5.4.

Table 5.4 Assessment of positive and negative social impacts

Positive social impacts	improved livelihoods from increased jobs and business opportunities or less commuting
	improved public/community health, environment and wellbeing
	social developmetn or a stronger sense fo place and community cohesion through community investment or shared infrastructure
	community development initiatives, capacity building and stronger community institutions
Negative social impacts	decreased amenity during construction programs affecting jobs and business opportunities
	increase in dust or noise impacts affecting community health, suroundigns and wellbeing
	alterations to traffic routes and management reducing a community's ability to walk or cycle, in turn affecting community health and wellbeing
	land use changes that affect community character andpeople's sense of place, inducing a sense of cultural loss for aboriginal people.

5.4 Results

Table 5.5 lists the variables that may be affected by the development. The variables range from demographic factors, employment and income characteristics to environmental concerns, and cultural and political issues. Positive social impacts from the development, including improved jobs and business opportunities for the local area; improved public and community well-being, health and environment; improved community development and shared infrastructure; and improved capacity to build stronger community institutions, have been discovered.

Table 5.5 The impact of the development on SIA

Variables	Base Case	Construction	Operation	Reasons
Population (number)	Could be reduced	Small increase	Great increase	The bushfire may scare away some people. The development will bring in more households.
Population Change (%)	Small changes	Some changes	A big change	The shortage of housing supply. There isn't many changes if no new housing supply.
Household (number)	Small changes	Some changes	A big change	More households will be moved in after the development.
Ethnic and racial distribution (%)	Small changes	Some changes	More diversify	The increased number of households will increase cultural diversity.
Relocated populations	Less change	More	More	The existing population are aging and tends to less move location. The developed estate will bring more households relocate to the area.
Influx or outflows of temporary workers	Less change	More	More	The development will bring more temporary workers.
Seasonal residents	Small changes	Positive impact	Positive impact	The developed area will attract more residents to stay in the area.
Community and Institutional Structures	Less change	Positive impact	Positive impact	The community will be larger.
Voluntary associations	Similar as it is	Increase	Increase	The voluntary associations could be increased when more households have moved in.
Interest group activity	Similar as it is	Increase	Increase	The interest group activity could be increased when more households have moved in.
Size and structure of local government	Similar as it is	Increase	Increase	The increased population will increase the local government profle.
Historical experience with change	Less change	Some changes	Some changes	The new development brings a new experience to the local residents.
Employment characteristics	Similar as it is	Increase	Increase	The new development will bring diverse employment characteristics
Income characteristics	Similar as it is	Increase	Increase	The income profile will be altered due to the new households move in after the development.
Employment equity of minority groups	Similar as it is	Improve	Improve	The development will bring young and minority groups into the area.
Local/regional linkages	Similar as it is	Improve	Improve	The new development enhances the linkage between local/regional areas due to the raise in population.
Industrial/Commercial diversity	Less change	Increase	Increase	More households will increase the industrial/commercial diversity.
Presence of planning and zoning activity	Less change	Improve	Improve	The new development will improve the local planning and zoning activity, e.g. one way road improvement.
Political and social resources	Less change	Improve	Improve	More households moving into the area will improve the political and social arena.
Distribution of power and authority	Less change	Improve	Improve	The power and authority of local community can be distributed among the households.
Identifications of stakeholders	Less change	Positive impact	Positive impact	Stakeholders can be identified and their interests can be oberserved.
Interested and affected publics	Less change	Positive impact	Positive impact	The new development will enhance the public facility (e.g., parks) and convenience to the local residents.
Leadership capability and characteristics	Less change	Positive impact	Positive impact	The more households have moved in that will create leadership environment to the residents.
Individual and family changes	Less change	Positive impact	Positive impact	The new development will change the aging population and bring more young families to the area.
Perceptions of risk, health, and safety	No change	Improve	Improve	The quality of the newly developed houses will reduce fire risk threat and improve safety and health.
Displacement/relocation concerns	No applicable	No concerns	No concerns	Households relocate to the desire quality area.
Trust in political social institutions	Similar as it is	do not affect	do not affect	The development will not affect the trust of political social institutions.
Residential stability	Similar as it is	Less impact	Less impact	The suburb is a highly desired area for living or holiday homes. Residential stability will not be affected.
Density of acquaintanceship	Similar as it is	Positive impact	Positive impact	The increase population density could bring some households close each other.
Attitudes toward policy/project	Similar as it is	Positive impact	Positive impact	When the residents enjoy the benefit of new development, will have positive attitudes toward to the project.
Family and friendship networks	Similar as it is	Positive impact	Positive impact	More connections could be built among the newly move in households.
Concerns about social well-being	Similar as it is	Positive impact	Positive impact	The increased population will bring diverse cultural activity and community less concerns about social well-being.
Change in community infrastructure	Similar as it is	Positive impact	Positive impact	The increased population will encourage the improvement of community infrastructure.
Land use patterns	Similar as it is	Positive impact	Positive impact	The area of development has been planned long time ago. The development can be a case for the land use planning.
Effects on cultural, historical, and archaeological resources	Similar as it is	do not affect	do not affect	The development will not affect the cultural, historical and archaeological resources.
Native Australian tribes	Similar as it is	Positive impact	Positive impact	The new development will not affect the native Australian tribes, who can be a part of the diverse community.

5.4.1 Intergenerational Equity

Housing affordability is a distinct intergeneration issue in Australia. For example, many young people cannot afford to pay a deposit or purchase a home due to lack of security and income. According to the ABS (2020) statistics (Figure 5.3), the average weekly disposable income for the 15-34 age group was around $1,055, compared to $1,173 for the 35-54 age group. Regarding the median debt to asset ratio, the 15-24 age group was the highest relative to other age groups. Their debts reached 51% in 2017-18 and 43% in 2019-20 (Figure 5.3). The average house price in Manyana was 14 times higher than their income. They use 36% of their income to pay rent, the highest among all age groups (refer to Figure 5.4). The Covid-19 pandemic and subsequent inflation, with higher demand for housing in Manyana, have pushed house prices and rent up. This has made the gap of generational equity wider. It is expected that house prices will increase continuously in the future, although at varying rates, placing financial pressure on future generations. Increasing the housing supply in the area is one of the solutions to narrow the gap in intergeneration equity.

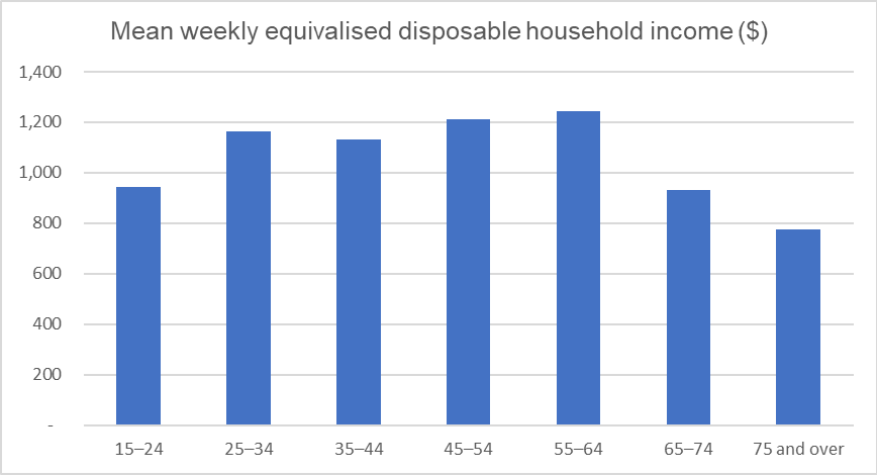

Figure 5.3 Weekly disposable household income by age group in Australia (Source: ABS)

	Median debt to asset ratio					
Age of household reference person	**2009-10**	**2011-12**	**2013-14**	**2015-16**	**2017-18**	**2019-20**
15–24	0.37	0.42	0.29	0.40	0.51	0.43
25–34	0.38	0.39	0.37	0.39	0.35	0.40
35–44	0.28	0.29	0.31	0.31	0.33	0.32
45–54	0.15	0.17	0.18	0.19	0.18	0.22
55–64	0.06	0.06	0.07	0.07	0.08	0.08
65–74	0.01	0.00	0.00	0.00	0.00	0.00
75 and over	0.00	0.00	0.00	0.00	0.00	0.00
Total 65 years and over	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Total	***0.16***	***0.17***	***0.17***	***0.17***	***0.17***	***0.18***

Figure 5.4 Median debt to asset ratio in Australia (source: ABS)

Income by age group	weekly	yearly	Price/Income	Rent/Income
15–24	944	49088	14	0.36
25–34	1,165	60580	11	0.29
35–44	1,133	58916	12	0.30
45–54	1,212	63024	11	0.28
55–64	1,243	64636	11	0.27
65_above	870	45240	15	0.39

Figure 5.5 Housing affordability by age group in Manyana in 2022

6 DISCUSSIONS AND CONCLUSION

The long-term demand prospects for Manyana are highly dependent on the availability of new supply in the form of residential subdivisions. As noted in section 2, environmental constraints and associated community concerns have resulted in the Inyadda Drive Planning Proposal being withdrawn and the Manyana Beach Estate facing a variety of issues before development can proceed.

The bushfires have implications for community well-being and safety. The large-scale bushfires in the summer of 2019/20 increased community concern and awareness of this issue. Manyana is surrounded by heavily vegetated land and has a single access point through Conjola National Park via Bendalong Road. Given the risks to life and property posed by potential out-of-control bushfires, this may have additional implications for new developments. An issue that may arise is insurers being unwilling to provide fire protection insurance for new properties or providing insurance at an unaffordable rate for owners. Banks may also be unwilling to fund new mortgages due to concerns it may impact their ability to recoup their capital.

The long-term plan for Manyana is to safely grow through residential subdivisions and respond to challenges posed by environmental constraints. A more diverse mix of housing tenure, particularly through affordable housing, will likely become more prevalent if house prices

remain at their current level. This is particularly relevant as household income relative to dwelling prices is becoming unaffordable for more households[11].

New residential subdivisions may provide relief to help alleviate some of the fire safety issues impacting Manyana. New residential development may facilitate the development of affordable housing through increased supply. Local developer contributions levied by the Shoalhaven Council will be used to fund targeted community facilities and other necessary infrastructure projects.

6.1 Main findings

The overall findings can be observed from the benefit-cost analysis in Section 3. It is projected that the demand for housing in Manyana will increase. However, this will create a housing supply shortage in the long term as environmental constraints and concerns by residents reduce the number of new developments in the locality.

The second finding relates to the economic impact of the development. Figure 6.1 displays the employment and labour force benefits from the development. The development will not only create jobs for the local areas in Shoalhaven, but also create jobs for the up- or down-stream development-related industries, i.e., building material and services industries. The developed housing will also increase domestic visitors, daily travellers and tourism (Figure 6.2) due to the improved built environment after the development and pull from the active economic activities.

The distributional benefits can be found in Section 4. The benefits and costs to stakeholders, including the developer, government, investors and residents, have been analysed. Without the development, the developer and the government will bear the costs of capital on the purchase of land and prework on the site. There would be no opportunity for the investors. The residents have to face the risk of unexpected bushfires and additional building insurance costs. However, all stakeholders will gain from the completion of the development.

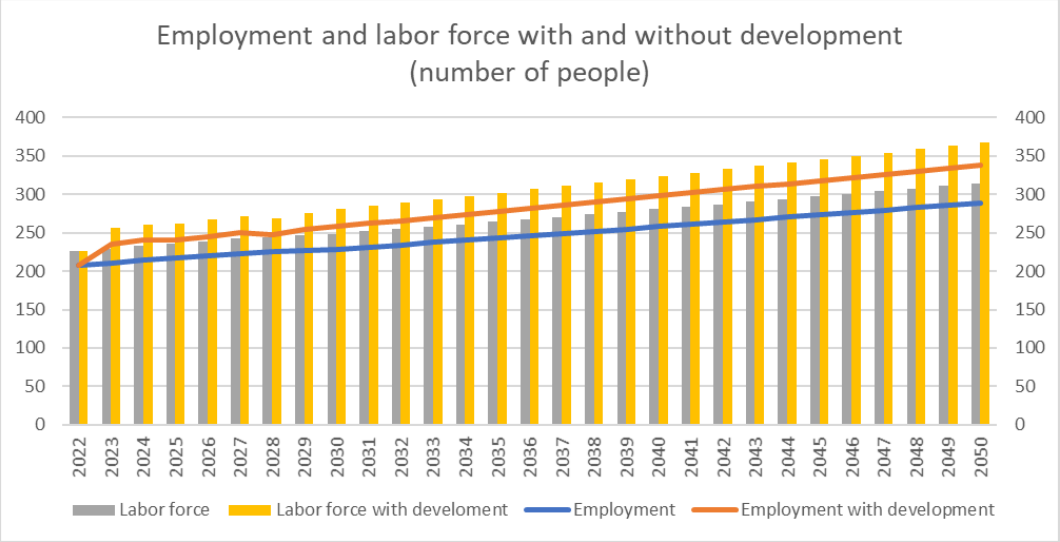

Figure 6.1 Employment in Manyana with and without the development.

[11] https://www.aph.gov.au/about_parliament/parliamentary_departments/parliamentary_library/pubs/briefingbook45p/housingaffordability

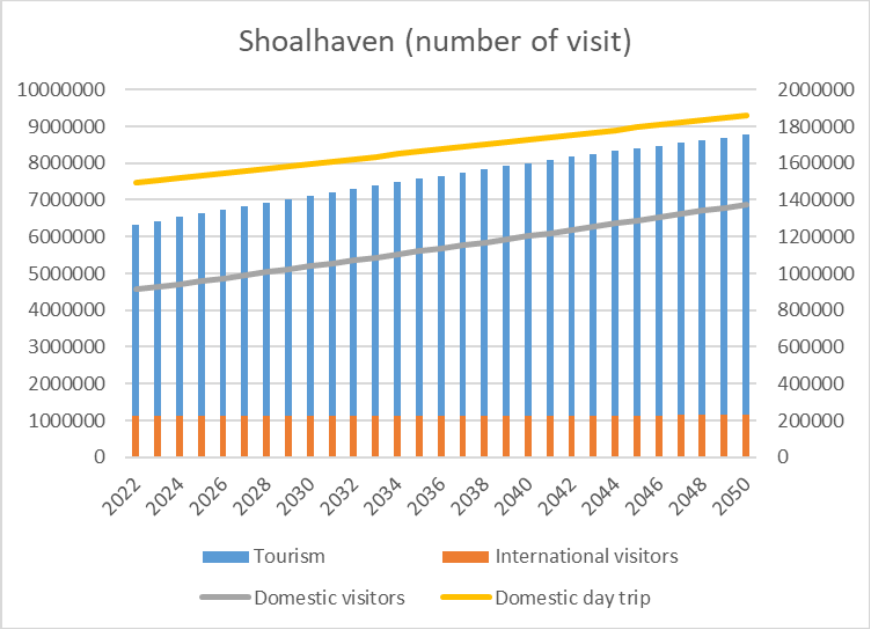

Figure 6.2 Effects of the development on tourism

The social impact analysis can be found in Sections 3 and 5. From the analysis, it is concluded that the development will not only increase the local population and the number of households, but also improve cultural and ethnic diversity, as well as enhance cohesiveness in the community. In particular, intergeneration equity is the main issue that exists in the community. Without the development, intergenerational inequity costs will be borne by the current younger generations in terms of housing supply.

Some residents claim that the development site should be left as a wildlife refuge due to the fires. However, the claims ignore the fact that fires have created adverse social and economic impacts in the region. It is not just an environmental issue. Our finding suggests that while environmental protection is one of the important elements in the ESD assessment, the social and economic impacts of the development are equally critical in undertaking the ESD assessment, perhaps even more critical. Thus, it is concluded that environmental protection of the development at the expense of economic and social benefits to the local community, is not a legitimate integration of ESD principles. Given that a comprehensive environmental report has determined that the removal of the native vegetation proposed by the development will not result in a significant impact on threatened species or their habitats (Ecoplanning, 2022), we conclude that the proposed development will create positive economic and social benefits and has minimum impact on the natural environment.

6.2 Methodological consideration

A number of approaches have been employed in this study. The benefit-cost analysis is the main approach employed in this study. Discount cash flow analysis was implemented to derive the net benefits and costs. The net present value (NPV), internal rate of return (IRR) and benefit-cost ratio methods have been applied to the assessment.

The second approach is the distributional analysis, which assesses the benefits and costs to different stakeholders, including the developer, government, investors and residents.

The demand and supply analysis was also used to analyse the housing demand and supply in Manyana. The data is derived from the Shoalhaven City Council.

Forecasting techniques have been applied to estimate the variables for long-term impact analysis.

The word cloud method was adopted to study the Manyana submission to understand the residents' claims. Econometric statistics was used to study the correlation of the claims.

Finally, the environment and social impact analysis was conducted following the NSW government guidelines.

6.3 Limitations of the study

We acknowledge the following limitations in conducting our research.

The first limitation is the lack of publicly available data for Manyana. Thus, some data have been applied in proxy, e.g., household disposable income by age groups was estimated according to the Shoalhaven trends. The assumptions made, e.g., discount rate can affect the final analytical results.

Due to the development being undertaken over six stages in future years, we have adopted different forecasting skills to derive the future data for 28 years. Appendix 1 explains the forecasting methods.

For the social impact study, the qualitative data is difficult to quantify. Thus, we have used the percent changes for some of the variables as proxy. We have also conducted qualitative analysis of the variables.

The main approach of the study is benefit and cost analysis. We have made conservative assumptions. Some of the variables were adopted from NSW government guidelines, e.g., discount rate and market growth rate.

APPENDIX

Appendix 1: Economic impact analysis and forecasting

Appendix 1.1. Introduction

Economic impact evaluation typically examines the influence of a specific economic event, such as a business, organisation, policy, programme, project, activity, or other economic events, in a given geographical area. The evaluated aspects could target individuals or the overall community over revenue, employment, profit, etc. (Weisbrod & Weisbrod, 1997). Similarly, the geographical area could vary under a different context. Economic impact evaluation is frequently used in domains like real estate construction, transportation planning, and legislation or regulatory revolution. Implementing the economic impact evaluation could assist stakeholders in understanding the policy, business, consequences, and the related induced effects.

Appendix 1.2 Literature review

This section reviews previous work on the evaluation of economic impact, focusing on the indicators of the economic impact.

1.2.1 Indicators of economic impact

Indicators should reflect specific development priorities. Indicators can be grouped into core and discretionary indicators for flexibility, where core indicators are more relevant in policy terms and discretionary indicators are used to measure specific aspects of development. Generally, the indicator selection process was stakeholder-based, and the choice of indicators should be linked to motivations and objectives. In practice, not all statistical information can be captured and measured. Therefore, the number of indicators should be limited and narrowed down to indicators with rational purposes that can be used to address the objectives (ESPON, 2013).

1.2.2 Prevalent indicators of economic impact

To investigate the indicators of economic impact, we reviewed the existing research, ranging from the macroeconomics of a country to the microeconomics of a rural area. To ensure the generosity of the economic indicators, we collected research from a wide spectrum of disciplines, including tourism, sustainable development, real estate, and rural development.

Under the tourism domain, Choi and Sirakaya (2006) developed indicators in various aspects to measure community tourism development (CTD) within a sustainable framework based on the consensus of 38 academic researchers in tourism over three round discussions. In terms of economics, they summarised 24 indicators classified into seven key themes and presented the top-rated three indicators as: (1) Availability of local credit to local business, (2) Employment growth in tourism, (3) Percent of income leakage out of the community. They also found that conventional indicators such as gross domestic product (GDP) fail to capture the crucial aspects of sustainable economic growth.

In 2018, Akinsomi et al. examined the role of macroeconomic indicators, such as GDP, unemployment, inflation, interest rate, vacancy, operating expense, and gross rent space, in explaining direct real estate returns in South Africa (SA). The results show that determinants of returns differ in the relationship (positive or negative) as well as in degree (level of

significance) and highlight the heterogeneity of total returns, capital growth, and rental growth of commercial real estate.

For the case studies on small area development, Visvaldis et al. (2013) chose indicators capable of capturing change over time for time sensitivity. The indicators were filtered from four aspects based on stakeholder assessment: (1). Addressing overall priority themes (2). Enabling assessment to be mapped to spatial patterns. (3) Reliability and regular updates. (4) Effectively providing information sensitive to change to aid timely decision-making processes.

Similarly, Dudzińska et al. (2018) did a social study in Poland. They identified the effects of consolidations on changes in the socio-economic development of the rural areas. After filtering (eliminating features with a coefficient value not exceeding 0.1), they selected six economic indicators to reflect the rural economy. These include inhabitants' revenue and expenditure, unemployment rate, the scale of entrepreneurship, and cultural protection expenditure. In another case study in Poland, Bogdański investigated the influence of the A2 motorway construction on the economic development at the local level. Five indicators, roughly categorised into entrepreneurship, employment, and local revenues, were considered. This study showed that the motorway construction has no significant influence on the local economy and the author concluded that the motorway investment should not be regarded as an essential tool for stimulating development at the local level.

Rogelj et al. (2020) systematically reviewed 15 economic indicators specific to rural areas. Apart from conventional core indicators like unemployment and GDP per capita, other discretionary indicators, such as the number of beds in rural tourism and productivity of agricultural products, were also examined. According to experts' assessment, they listed the most influential five indicators for the rural area; the unemployment rate, accessibility of agricultural infrastructure, gross domestic product per capita, education level as a prerequisite for the use of innovation, and productivity of agricultural production.

Table A1.1 presents some prevalent core indicators of economic impact and the related publications.

Table A1.1: Economic related indicators in previous works.

Indicators	**Publications**
Population	Rogelj et al. (2020); Visvaldis et al. (2013)
Gross Domestic Product (GDP)	Rogelj et al. (2020); Akinsomi et al. (2018); Choi &Sirakaya (2006)
Unemployment	Rogelj et al. (2020); Akinsomi et al. (2018); Choi &Sirakaya (2006); Bogdański (2016); Turrell et al. (2003); Visvaldis et al. (2013); Dudzińska et al. (2018)
Revenue	Rogelj et al. (2020); Akinsomi et al. (2018); Choi &Sirakaya (2006); Bogdański (2016); Turrell et al. (2003); Visvaldis et al. (2013); Agol et al. (2014); Dudzińska et al. (2018); Nevada Rural Housing Authority (2016)
Industry composition	Rogelj et al. (2020); Choi &Sirakaya (2006); Bogdański (2016); Dudzińska et al. (2018);
Commodity price	Akinsomi et al. (2018); Agol et al. (2014); Dudzińska et al. (2018)
Accommodation	Rogelj et al. (2020); Akinsomi et al. (2018); Choi &Sirakaya (2006)

Education	Rogelj et al. (2020); Turrell et al. (2003); Agol et al. (2014)

1.2.3 Summary

In this section, we examined the economic literature and enumerated the prevalent core indicators in the existing research. The relevant disciplines include tourism, sustainable development, real estate, and rural development. Based on the reviewed literature, we can conclude that unemployment and revenue are prevalent core indicators for any area, no matter the scale. GDP is frequently selected as a core indicator when investigating the economic impact on a large territory. On the other hand, when the target territory is relatively small, industry composition and commodity price are more likely to be evaluated. Population and education are commonly regarded as social or socio-economic indicators, but their economic impact is not frequently investigated in the reviewed literature.

Appendix 1.3 Methodology and Methods

The historical economic indicator data for the Manyana area is limited and very scarce. For some economic indicators without any ground truth, we will use the data in similar surrounding areas as proxies (Figure A1.1). The area, from largest to smallest, is Shoalhaven, Coastal Mid and finally Manyana. Coastal Mid (area code: 112837884) includes Bendalong, Berringer Lake, Conjola, Conjola Park, Cunjurong Point, Fishermans Paradise, Lake Conjola, **Manyana**, Mondayong and Yatte Yattah.

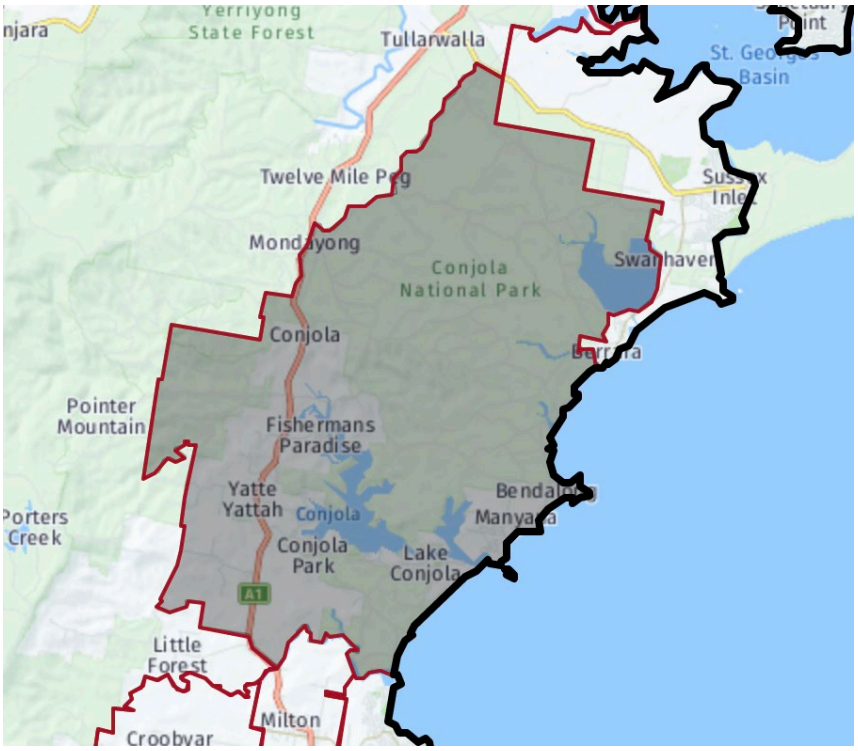

Figure A1.1: Manyana and its surrounding areas.

In this study, the primary indicators used to evaluate economic impact include:

- Population: This indicator is updated annually by ABS. A growing population can indicate a growing economy.
- Occupied private dwelling: This indicator reflects the changes in private dwellings occupied by residents.
- Tourism: Manyana is mainly a residential suburb. Tourism is one of the major industries this study focuses on. The indicators of international and domestic visitors are also related to this category.
- Employed residents: This indicator measures the estimated number of employed residents of the local area on an annual basis. Employed residents may have a workplace inside or outside the area, and a growing number of employed residents can indicate a growing economy.
- Local jobs: Persons in employment are defined as all those of working age who, during a short reference period, were engaged in any activity to produce goods or provide services for pay or profit (ILOSTAT). This indicator shows the estimated number of jobs in the local area. This indicator is used to measure the size of the local economy. Increasing numbers of jobs generally represent a growing economy.
- Unemployment: The unemployed are persons of working age who were not in employment, carried out activities to seek employment during a specified recent period, and were currently available to take up employment given a job opportunity (ILOSTAT). The unemployment rate is computed as the proportion of the resident labour force looking for work. This indicator is used to measure an area's economic success. A low unemployment rate can indicate an affluent area with a high rate of access to jobs. A high rate can indicate a declining economy with closures of key industries, or a residential area with a significantly disadvantaged population.
- Consumer Price Index (CPI): This is an indicator of the inflation rate. It gauges the overall rate of price change for a fixed basket of goods and services purchased by the average household (Frumkin, 2006) in eight capital cities around Australia.
- Housing price: This indicator measures the level of demand for housing in the area and the type of housing available. This indicator can be related to an area's desirability and its proximity to major employment destinations.
- Housing rental: This indicator shows the weekly rental of houses and units. This indicator shows the level of demand for housing in the area and the type of housing available. Similar to housing price, it can be related to the area's desirability and its proximity to major employment destinations.
- Gross Regional Product (GRP): This indicator is equivalent to GDP but for a smaller area. It is the amount of the nation's wealth generated by businesses, organisations and individuals working in the area.

Appendix 1.4 Data Collection and processing

The data used in this study were collected from various official sources. The major sources are:

- Australian Bureau of Statistics (ABS): https://www.abs.gov.au/
- Tourism Research Australia: https://www.tra.gov.au/
- .id community: An evidence base for over 250 local government areas in Australia and New Zealand, helping people make informed decisions. https://profile.id.com.au/
- PriceFinder database: A leading property intelligence platform, delivering comprehensive property data and analytics that have powered businesses across Australia since 1989. https://www.pricefinder.com.au/

Table A1.2 shows data sources used for different economic indicators evaluated in this study.

Table A1.2: Economic indicators and their corresponding data sources used in this study.

Economic Indicators	Data Source	
	Shoalhaven	**Manyana**
Population	ABS population forecast	ABS census data
Occupied private dwelling	ABS forecast	ABS census data
Employment	.id community	ABS census data
International visitor nights	Tourism Research Australia	NA
Domestic visitor nights	Tourism Research Australia	NA
Domestic day trip	Tourism Research Australia	NA
Tourism	Tourism Research Australia	NA
Local job	.id community	NA
CPI	.id community	NA
Median weekly rental house	.id community and ABS census data	ABS census data
Median weekly rental units	.id community and ABS census data	NA
GRP	.id community	NA
Labour force	.id community	ABS census data
House price	.id community and PriceFinder database	PriceFinder database
Unit price	.id community and PriceFinder database	NA
Household composition	ABS Census data	ABS Census data
Age group population	.id community	NA
Age group household income	ABS	NA

Appendix 1.5 Models and forecasting

This section reports the models and forecasting methods separately for the Manyana area and Shoalhaven.

Appendix 1.5.1 Learn with Historical Data in Shoalhaven

We first explored the correlation between these economic indicators. Most economic indicators have time trends. Therefore, we applied Gaussian Process Regression with Linear Bayesian Regression for economic indicators with a high correlation with time, since the historical data is still limited.

Figure A1.2 indicates the Pearson correlation between all valid economic indicators (with historical data). The deeper the colour, the stronger the correlation. If the correlation is close to 1, this indicates a positive correlation, while -1 indicates a negative correlation.

Figure A1.2 shows that some economic indicators are highly correlated with time. We selected several of them and plotted them against time in Figure A1.3. It is obvious that they have a linear pattern in the time trend.

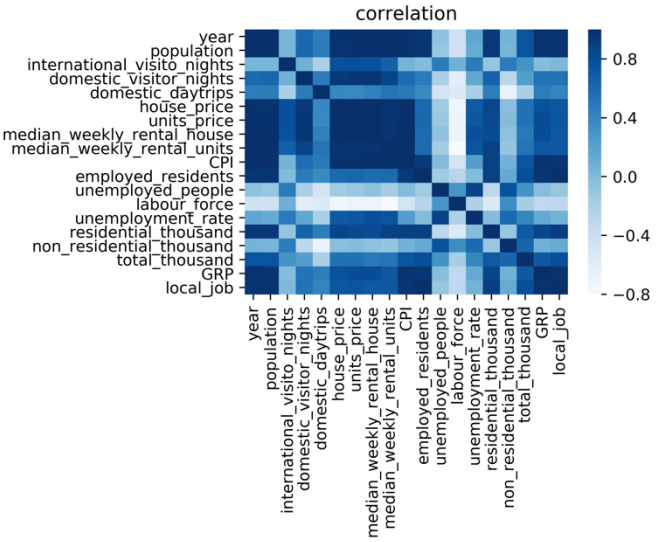

Figure A1.2: Correlation of Economic Indicators.

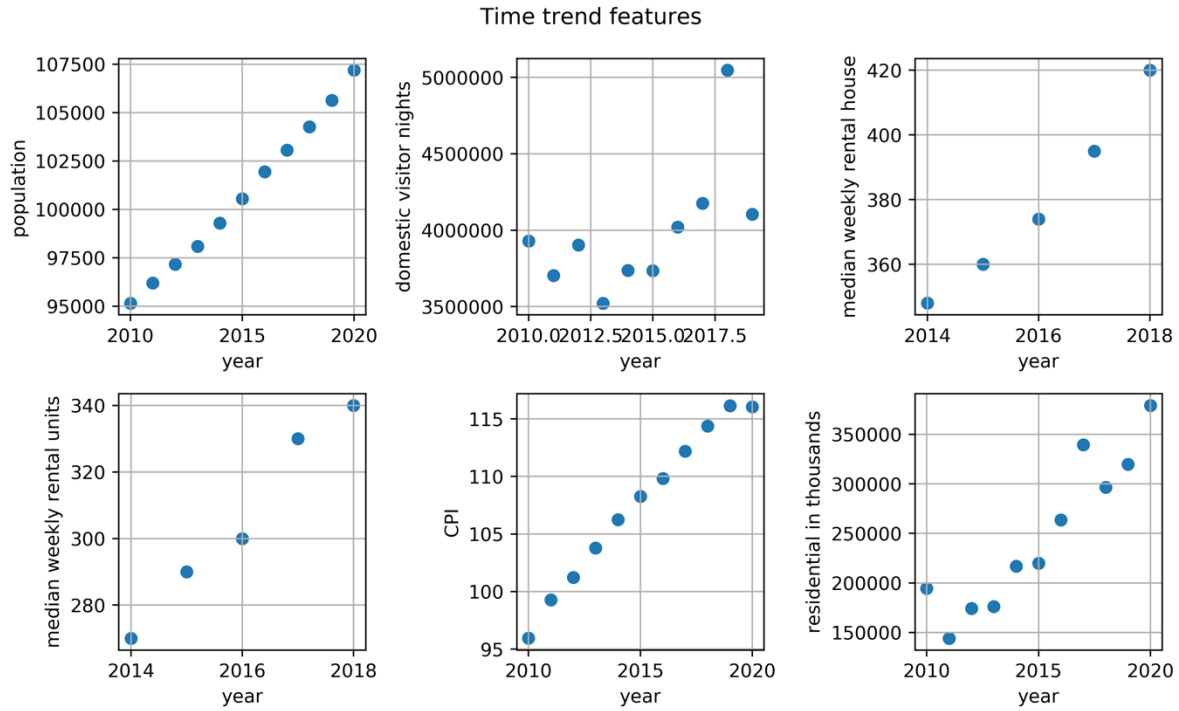

Figure A1.3: Visualisation of timely trend indicators.

According to Bishop (2006), the goal of the Linear Bayesian Regression is to find a posterior distribution $p(\boldsymbol{w} \mid \boldsymbol{t})$ and the predictive distribution $p(y \mid \boldsymbol{w}, \boldsymbol{t}, \alpha, \beta)$. If we consider a uniform prior, $p(\boldsymbol{w}) = \mathcal{N}(\boldsymbol{w} \mid \boldsymbol{m_0}, \boldsymbol{S_0})$ where $\boldsymbol{m_0} = \boldsymbol{0}$ and $\boldsymbol{S_0} = \alpha^{-1}\boldsymbol{I}$ and assume the noise is also Gaussian and iid, the posterior also follows a Gaussian, which is denoted as, $p(\boldsymbol{w} \mid \boldsymbol{t}) = \mathcal{N}(\boldsymbol{w} \mid \boldsymbol{m_N}, \boldsymbol{S_N})$, where $\boldsymbol{m_N} = \beta \boldsymbol{S_N} \boldsymbol{\Phi_x^T} \boldsymbol{t}$ and $\boldsymbol{S_N} = \left(\alpha \boldsymbol{I} + \beta \boldsymbol{\Phi_x^T} \boldsymbol{\Phi_x}\right)^{-1}$. Therefore, the predictive distribution is given by $p(y \mid x_q, \boldsymbol{x}, \boldsymbol{y}, \alpha, \beta) = \mathcal{N}(\mu_q, \sigma_q^2)$, where $\mu_q = \boldsymbol{m_N^T} \boldsymbol{\Phi_{x_q}}$ and $\sigma_q^2 = \beta^{-1} + \boldsymbol{\Phi_{x_q}^T} \boldsymbol{S_N} \boldsymbol{\Phi_{x_q}^T}$. We scale the year by dividing 100 and scale the target economic indicator into the range of [0,1]. For hyperparameters, we set $\alpha = 0.1^{-1}$ and $\beta = 0.01^{-2}$ (narrow prior distribution) for the prediction.

To capture the non-linearity and time trend, we also apply Gaussian Process Regression with Radial Basis Function (RBF) Kernel. Gaussian Process are mathematically equivalent to models including Bayesian linear models, spline models, neural networks (Rasmussen and Williams 2006). A standard presentation of a Gaussian process is denoted as $\boldsymbol{f} \sim GP(m(\boldsymbol{x}), k(\boldsymbol{x}, \boldsymbol{x'}))$, where $m(\boldsymbol{x})$ is a mean function and $k(\boldsymbol{x}, \boldsymbol{x'})$ is a covariance function. In this project, we let $m: \boldsymbol{x} \to \boldsymbol{0}$ and we use the Squared Exponential (SE) Kernel $k(\boldsymbol{x}, \boldsymbol{x'}) = \sigma_f^2 \exp\left(-\frac{(x-x')^2}{2l^2}\right) + \sigma_n^2 \delta_{pq}$ for the covariance function. Then the sampling from GP prior becomes $\boldsymbol{f} \sim \mathcal{N}(0, K(\boldsymbol{X^*}, \boldsymbol{X^*}))$, where $\boldsymbol{X^*}$ is the test data. After that, the prediction can be obtained from the posterior distribution, which is denoted as $\boldsymbol{f^*} \mid \boldsymbol{y} \sim \mathcal{N}(E[\boldsymbol{f^*}], Cov(\boldsymbol{f^*}))$, where $E[\boldsymbol{f^*}] = K(\boldsymbol{X^*}, \boldsymbol{X^*})[K(\boldsymbol{X}, \boldsymbol{X}) + \sigma^2 \boldsymbol{I}]^{-1} \boldsymbol{y}$, and $Cov(\boldsymbol{f^*}) = K(\boldsymbol{X^*}, \boldsymbol{X^*}) - K(\boldsymbol{X^*}, \boldsymbol{X})[K(\boldsymbol{X}, \boldsymbol{X}) + \sigma^2 \boldsymbol{I}]^{-1} K(\boldsymbol{X}, \boldsymbol{X^*})$. In this project, we set the initial hyperparameters in the SE kernel as $\sigma_n = 0.2, l = 3.0$ and $\sigma_f = 1$, and we optimise the log marginal likelihood to find the optimised hyperparameters.

The following list shows the primary methods and models used to evaluate different economic indicators for Shoalhaven:

- **Population**. The population forecast for the Shoalhaven area is directly obtained from the Estimated Resident Population from the Australian Bureau of Statistics. For the population after the property is constructed in Manyana, we assume that other factors remain the same, and add the increased population (prediction outputs from the population after the property is constructed in Manyana).
- **Occupied private dwelling.** This indicator forecasting is directly obtained from the Australian Bureau of Statistics. For the occupied private dwellings after the property is constructed in Manyana, we assume that other factors remain the same, and add the increased occupied private dwellings (prediction outputs from the occupied private dwelling after the property is constructed in Manyana).
- **Employment.** This indicator is predicted by stacking the outputs from the Linear Bayesian Regression and the Gaussian Process Regression. For the employment after the property is constructed in Manyana, we assume that other factors remain the same, and add the increased employment (prediction outputs from the employment after the property is constructed in Manyana).
- **International Visitor.** This indicator is predicted using Gaussian Process Regression.
- **Domestic Visitor Nights.** This indicator is predicted using Gaussian Process Regression.
- **Domestic Day Trip.** This indicator is predicted using Gaussian Process Regression.
- **Tourism.** This indicator is computed as the sum of estimated international visitor nights, estimated domestic visitor nights and estimated domestic day trips.
- **Local Job.** This indicator is predicted using Linear Bayesian Regression.
- **CPI.** This indicator has a strong, timely trend and is predicted using Linear Bayesian Regression.

- **Median weekly rental house.** This indicator is predicted by stacking the Linear Bayesian Regression and Gaussian Process Regression outputs.
- **Gross Regional Product (GRP).** This indicator has a strong, timely trend and is predicted using Linear Bayesian Regression.
- **Labour force.** This indicator is predicted by stacking the Linear Bayesian Regression and Gaussian Process Regression outputs.
- **House Price.** This indicator is predicted by stacking the Linear Bayesian Regression and Gaussian Process Regression outputs.
- **Unit Price.** This indicator is predicted by stacking the Linear Bayesian Regression and Gaussian Process Regression outputs.
- **Median Weekly Household Income.** We only have three-year historical data (2006, 2011, 2016), so we first obtain the constant yearly growth rate r and compute the median weekly household income based on r from 2006 to 2016 to get 11-year historical data. Then, this indicator could be predicted using Linear Bayesian Regression.
- **Household composition.** We only have three-year historical data (2006, 2011, 2016), so we first obtain the yearly growth rate r and compute the household composition based on r from 2006 to 2016 to get 11-year historical data. Then, this indicator could be predicted using Linear Bayesian Regression.
- **Age group population.** We obtain the forecast directly from .id community. The forecast is made in the years 2016, 2031 and 2051. We then compute the yearly growth rate and compute the prediction from 2022 to 2050. We scale the population after property construction using the ratio of $\frac{Base\ Population_{Shoalhaven}}{Construction\ Population_{Shoalhaven}}$.
- **Age group income.** We focus on Adjusted lowest income quintile of equivalised disposable household income among different age groups. The historical data is from 2013 to 2019. This indicator is predicted using Linear Bayesian Regression.

Appendix 1.5.2 Approximations in Manyana

Since the historical data of Manyana is very limited, we use the scale ratio to approximate the predictions.

1.5.2.1 Population. The historical data for population is very limited. The prediction is made by combining the results from two scale ratios. The first one is the population ratio in Manyana with the population of Costal Mid in 2016, which is around 0.223. The other approximation ratio is derived from the occupied dwelling. We compute the ratio of $ipp = \frac{N_{occupied\ dwelling}}{N_{people}}$, which constantly increases at approximately 1.01 per year. We consider that this ratio will be saturated at 0.47 (Costal Mid-Level). The prediction is then made based on these two scaling methods, and the final output for the base level is computed as the average outcome. In Figure A1.4, we plot the estimated population approximated by these two methods with forecast time. We use the light blue (the upper line) colour to denote the approximation method using ratio 0.47, and the light purple colour (the lower line) to denote the approximation method using ipp. The final output is indicated in the black crossed point. For the population after the property is constructed, we add $N_{property} \times r_{people\ per\ house}$ on the base value and use Gaussian Process Regression for the future prediction after the construction is done.

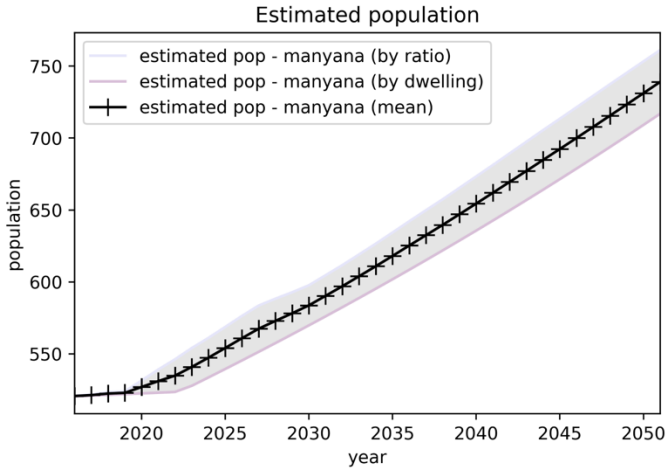

Figure A1.4: Estimated population in Shoalhaven using two approximation methods

1.5.2.2 Occupied private dwelling. Similar to how we predicted population, this prediction was also made by combining the results from two scale ratios. The first one is the average ratio scale from the Costal Mid data, which is around 0.2114. The other ratio is derived from the limited historical data in Manyana, which approximately increases by a ratio of 1.021 per year. We then take the average of predictions from these two scaling methods. In Figure A1.5, we plot the estimated occupied private dwelling approximated by these two methods with forecast time. We use the red (the upper line) colour to denote the approximation method using the increase ratio of 1.021, and the blue colour (the lower line) to denote the approximation method using the scale ratio of 0.2114. The final output is indicated in the black crossed point. For the occupied dwelling after property construction, we add $N_{property}$ on the base value and use Gaussian Process Regression for the future prediction after the construction is done.

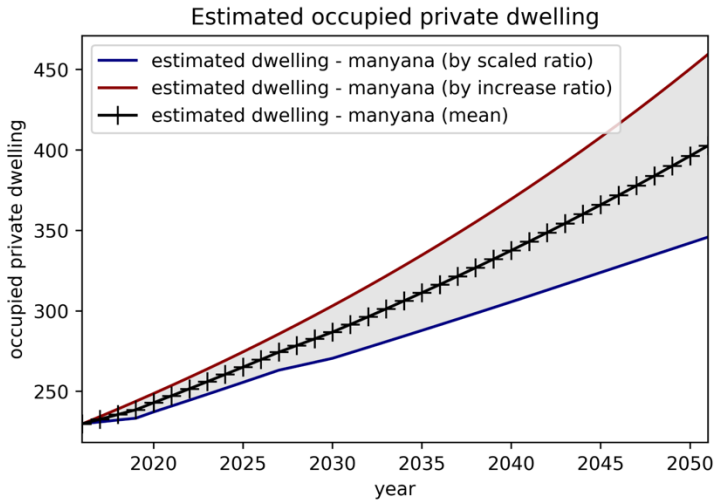

Figure A1.5: Estimated occupied private dwelling using two approximation methods

1.5.2.3 Employment. We computed the historical employment rate, which is constantly at 0.39. So, this prediction is done by scaling the estimated population by 0.39. After construction, we change the base value as the estimated population for the prediction.

1.5.2.4 Median weekly rental ratio. The prediction is made using the rental increase ratio in Manyana. We assume that the increase ratio starts from 1.039 and decreases 0.9% per year until it saturates at 1.003% in 2051. We plot the estimated weekly rental house in Shoalhaven (red line) and the estimated weekly rental house in Manyana (blue line) in Figure A1.6.

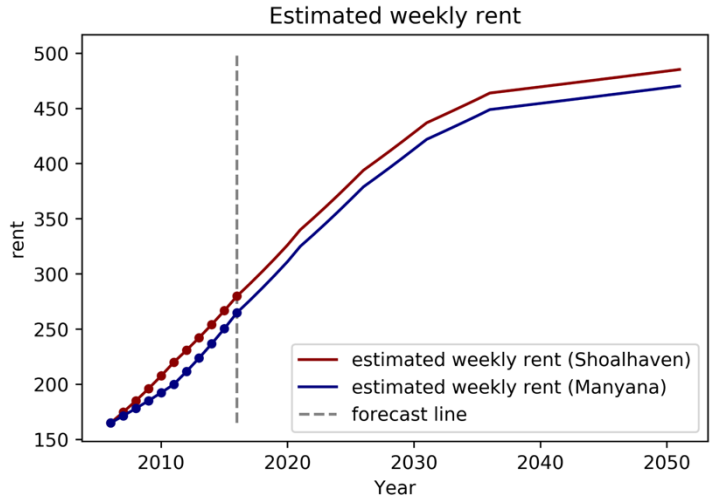

Figure A1.6: Estimated median weekly rental house in two areas

1.5.2.5 Labour force. We computed the historical employment rate and the unemployment rate to be 0.39 and 0.034, respectively. So, this prediction is made by scaling the estimated population by (0.39+0.034). After construction, we change the base value as the estimated population for the prediction.

1.5.2.6 House price. This indicator is predicted by stacking the outputs from Linear Bayesian Regression and Gaussian Process Regression.

1.5.2.7 Median Weekly Household Income. We only have three-year historical data (2006, 2011, 2016), so we first obtain the constant yearly growth rate r and compute the median weekly household income based on r from 2006 to 2016 to get 11-year historical data. Then this indicator could be predicted using Linear Bayesian Regression.

1.5.2.8 Household composition. We only have three-year historical data (2006, 2011, 2016), so we first obtain the yearly growth rate r and compute the household composition based on r from 2006 to 2016 to get 11-year historical data. Then this indicator could be predicted using Linear Bayesian Regression.

1.5.2.9 Age group population. No historical data can be found for this indicator. Therefore, we use the ratio of $\frac{Population_{Manyana}}{Population_{Shoalhaven}}$ to approximate this prediction. For the population after property construction, we scale it using the ratio of $\frac{Base\ Population_{Manyana}}{Construction\ Population_{Manyana}}$.

1.5.2.10 Age group household income. We assume that Manyana has the same age group household income prediction as Shoalhaven.

Appendix 2: Social impact analysis and estimation

A2.0 Introduction

This literature review is based on Google Scholar. We searched for "social impact indicators" between 29th April 2022 and 3rd May 2022. The search yielded 955 results, with 13 of them setting out the indicators used and their measurement relevant to an assessment of the social impact on a specified region or locality.

The review will summarise the findings of these 13 articles or theses, first by listing the social impact indicators used in the assessments and then their measurement, and finally by highlighting the methodology to obtain the data for measurement.

A2.1 Social impact indicators

A2.1.1 Towards Indicators of Social Capital for Regional Development Issues: The Case of French Rural Areas

The class of indicators in this article included social norms and social homogeneity (social homogeneity, trust and reciprocity, collection action and conservatism), local social networks (formal sociability and informal sociability), and outer links and openness (personal links, business networks and political networks).

A2.1.2 Characterizing Community Impacts of Small Dam Removal: A Case Study of the Brownsville Dam

In a case study of a dam removal project in Oregon (the dam removal study), Elston (2009) considered how the project affected the community's social and economic conditions and used indicators to monitor the impacts. The indicators included health and well-being (uncertainty from the project and hazard to public safety), economic (access to public goods and services), cultural (change in cultural traditions), family and community (community identification and social tension), and institutional, legal, political and equity (participate in decision-making, meeting agency objectives and equitable impact distribution) indicators.

A2.1.3 Social impact assessment of the proposed Dodds-Roundhill coal gasification project: project report

In a social impact assessment of an open-pit coal mine in Alberta, Canada (the Dodds-Roundhill study), Parkins (2009) shortlisted 12 indicators of social-economic indicators. They include (1) community identification and connection, attachment to place, (2) community cohesion (actual and perceived), (3) social tension, divisions within the community, (4) feelings about the project, (5) natural and cultural heritage, (6) standard of living, (7) economic resilience, (8) employment, (9) quality of the physical living environment (actual and perceived), (10) aesthetic quality, (11) integrity of government agencies (how well they protect people) and (12) participation in decision making.

A2.1.4 Deriving sustainability measures using statistical data: A case study from the Eisenwurzen, Austria

In a study of public data of 99 municipalities based on data from the Austrian government (Eisenwurzen study), Putzhuber and Hasenauer (2010) identified five social impact indicators: population, population trend, women opportunities, public social service and unemployment. Further, the study developed functions from public data as a diagnostic tool for future studies on what drives sustainability in a region.

A2.1.5 Social Impact Assessment of the Natural Forest Protection Program on forest-dependent communities and households in Western China-Case studies in Gansu Province and Chongqing Municipality

In assessing the social impacts of a forest protection programme on forest-dependent communities and households in Gansu and Chongqing, China (the forest protection study), Wang (2010) selected the following indicators: population size, proportion of people under the poverty line, size and structure of the local government, local economy or industrial diversification, infrastructures (including transport, education and healthcare), land-use changes, household income structures, household labour time distribution, public health or safety and perceived forest value.

A2.1.6 A methodology for ex-post assessment of social impacts of an affordable housing project

In an impact assessment of an affordable housing project in Nanjing, China (the affordable housing study), Li et al. (2014) proposed a methodology with 24 indicators, adopted the analytical network process to determine their respective weights, and adopted the methodology on a housing project. The group socio-economic effects included employment rate, income growth rate, crime cases around the project, poverty population, coverage of medical insurance, per capita living space, the average price of nearby lands, ratio of students to residents, and occupancy rate of the project. The mutual adaptability group included indicators like degree of public participation, regional air condition, regional water quality, and residents' acceptance of the project. Finally, the social risk group included the satisfaction of those relocated for the project and the occupiers, frequency of mass incidents concerning the project, and degree of public satisfaction with the affordable housing threshold.

A2.1.7 Estimating the social impacts of change: Exploring a psychological approach to capturing social impact data for cost-benefit analysis

In a thesis to quantify the social impacts for use within or alongside cost-benefit analysis (the drought thesis), Greig (2015) proposed a framework based on agency and communion indicators and adopted those indicators in three NSW towns to analyse how the indicators would perform in drought. The agency indicators included main occupation, financial security, time control, social contract control, ability to take time out, community infrastructure, and public housing and transport. The communion indicators included personal relationships, coming together in hardship, "feel" of the community, community leadership, and participation in the community.

A2.1.8 Developing an Indicator System for Measuring the Social Sustainability of Offshore Wind Power Farms

In assessing the social sustainability of offshore wind power farms in Taiwan (the offshore wind power farm study), Shiau and Chuen-Yu (2016) selected 35 initial indicators, including 11 indicators on impacts on the external population and five on macro-social performance. The external population indicators included human resources, production resources, community resources, community acceptance, tourism and related business and air quality. The macro-social performance indicators included job creation, socio-economic performance and socio-environmental performance. Representatives from the industry, the government, the academia, the fishing industry and the public participated in the indicator construction process, which narrowed the indicators to human resources, community acceptance, job creation, and others.

A2.1.9 Mega-event and urban sustainable development

In an urban sustainability assessment of a 2010 flora exposition in Taipei (the flora expo study), Liang et al. (2016) selected 13 social impact indicators. They include community

consciousness, pride of residents, community development, public affair participation, quality of life, activity participation and satisfaction with facilities. Agol, et al. (2014) evaluated the impacts of development and conservation project using sustainability indicators.

A2.1.10 Social Impacts of Dam-Induced Displacement and Resettlement: A Comparative Case Study in China
In a social impact assessment of the displacement and resettlement plans of a dam project in China (the dam displacement study), Huang et al. (2018) used a dozen indicators, including employment, income, consumption, recreation, residence conditions, social networks, and social insurance and well-being.

A2.1.11 Impacts of Tourism Development on Coastal Communities in Cha-am Beach, the Gulf of Thailand, through Analysis of Local Perceptions
In a tourism impact assessment for coastal communities in Cha-am Beach, Thailand (the coastal community study), Unhasuta et al. (2021) evaluated the perceptions of the economic, environmental, social and cultural impacts. The social impact indicators included community attachment (kinship relation, community members' involvement in the community-tourism events and community participation in community business), healthy social life (improvement in living from the recreational facility development, preservation of community gathering space and tourism interference in the community), and contribution of community autonomy (community's capability for tourism operation, financial provision from the local government to support community activities and tourism knowledge provided to the community).

A2.1.12 The Role of Major Sports Events in Regional Communities: A Spatial Approach to the Analysis of Social Impacts
In a social impact assessment of the spatial framing of the 2019 Alpine and Biathlon World Championships in Sweden (the championships study), Wallstam & Kronenberg (2022) selected four indicators: quality of life, social capital, sense of pride and sense of community.

A2.1.13 Using 'soft' and 'hard' social impact indicators to understand societal change caused by mining: a Western Australia case study
In a social impact analysis of mining in the town of Boddington in Western Australia, which was primarily pastoral and agricultural before mining development (the Boddington study), Munté-Pascual et al. (2022) explored the areas of change within the local social environment. Whilst the study did not measure social impacts against set indicators, it grouped the indicators into demographic, quality, and operational attributes. The demographic attributes included demographic structure (ageing and stability), project-induced in- and out-migration, mobility, and transiency. The quality attributes included trust, social mixing and cohesion, participation in community life, voluntary work done within the community, number of active community groups, and identity sense of place and culture. Finally, the operational attributes included social services and amenities, infrastructure and housing, local business environment and (not analysed in the study) health and safety.

A2.2 Measurement of social impact indicators

A2.2.1 Towards Indicators of Social Capital for Regional Development Issues: The Case of French Rural Areas
The French rural study used the following statistical data to measure the indicators: a Gini index on household income for social homogeneity; the number of telephone users in the directory per household and people who claimed tax deductions for charity for trust and reciprocity; average farm size and fiscal integration coefficient for collective action and the results of conservative parties in conservatism; the number of associations per capita for formal sociability; average household size, number of bars per capita, number of sports

equipment per capita and the proportion of people working in another municipality for informal sociability; the number of natives and immigrants for personal links; head office and back office indicators for business networks; and local election turnout and subsidies received per transfer from the central government for political networks.

As for the survey, the French rural study referred to the proportion of people agreeing that most people can be trusted, the proportion who gave money to charity in the past twelve months, and the average number of people to whom they would lend “an important sum of money” for trust and reciprocity. The study also used the average number of associations they were a member of to measure formal sociability; the average number of people they had a weekly conversation with, the proportion going to bars monthly, the proportion going to matches or cultural events, and average distance to the workplace to measure informal sociability. In addition, the study measured the proportion of natives of the locality, the average number of people outside the locality they had a weekly conversation with, the average number of days in the year spent outside the locality, and the proportion of people who immigrated from elsewhere in the last decade for personal links; and finally, stated local election turnout for political networks.

A2.2.2 Characterising Community Impacts of Small Dam Removal: A Case Study of the Brownsville Dam

In the dam removal study, the uncertainty indicator was measured by the frequency of relevant announcements in local and regional newspapers. Hazard was measured by editorials, letters to the editor and police, and hospital reports in the local newspaper. Similarly, the study also operationalised the social tension indicator by counting concerns of conflicting views about the dam removal project in the local newspaper’s letters to the editor and editorials and Watershed Council’s minutes. As for access to public goods and services, the study estimated the additional fuel costs of visiting another park. In addition, the study measured the number of events unique to the locality, the number of opportunities for the community to come together, and the number of opportunities in the public forums to estimate the cultural, community identification and participation indicators. Meeting agency objectives was measured by the extent to which the project met the agencies’ mission statements. Finally, the perceived impact was used to measure impact distribution.

A2.2.3 Social impact assessment of the proposed Dodds-Roundhill coal gasification project: project report

The Dodds-Roundhill study used the following questions to measure the shortlisted indicators. For (1) attachment to place, the study gauged the period living in the community. For (2) community cohesion) and (3) social tension, it investigated what the community lacks, how it has changed since the proposal and the community division. For (4) feelings related to the project, the study considered the perceptions of the project’s impacts (in general and for various groups) and how it could be more beneficial. Finally, for (11) the integrity of government agencies and (12) participation in decision-making, the study asked about the perceptions of the proponents and the sighting process, feelings of compensation, public participation in the project, and perceptions of representations by elected officials at all levels. Not all indicators were measured.

A2.2.4 Deriving sustainability measures using statistical data: A case study from the Eisenwurzen, Austria

In the Eisenwurzen study, the population trend relies on birth and migratory balance and shows the projected population changes in the next decade. Women’s opportunities were based on the number of employed women and their professional sector contributions. Lastly, public social service was contingent on the education workplace and health workplace.

A2.2.5 Social Impact Assessment of the Natural Forest Protection Program on forest-dependent communities and households in Western China-Case studies in Gansu Province and Chongqing Municipality

Callois and Aubert (2007) developed indicators for social capital development in regional areas. In the forest protection study, the size of local governments was measured by the number of staff, and the local economy or industrial diversification was divided into industrial, agricultural, forestry, pastoral, construction, transportation and restaurant/hotel/other services and measured by their proportion to total income. The infrastructure (in transport, education and healthcare) were measured by their number and quality on a three-point scale. The use of land was divided into agricultural, forest, pastoral, homestead and public land and measured by their proportion to total land area. Similarly, household income structure was measured in proportion to total income and expenditure. The household labour time distribution was measured in days per year, and the perceptions of public health safety were measured on a seven-point scale on the opinion of ecological condition, perception of public health and perception of future security. Finally, the perceived forest value was measured by the proportion of households with economic, ecological or cultural values for the forest.

A2.2.6 A methodology for ex-post assessment of social impacts of an affordable housing project

In the affordable housing study, the mutual adaptability group indicators and social risk indicators were all measured by perception levels.

A2.2.7 Estimating the social impacts of change: Exploring a psychological approach to capturing social impact data for cost-benefit analysis

The drought thesis then developed the agency and communion indicators into 20 items and measured those items by satisfaction ratings on a seven-point scale. In particular, the measurement of the main occupation indication was employment opportunities. Personal relationships depended on closeness and connection, and relationships that involve supporting each other. Moreover, the infrastructure indicator was measured by health services, childcare and education options, mobile and internet services and community safety. Lastly, the public housing and transport indicator was measured by affordable public housing and access to public housing.

A2.2.8 Developing an Indicator System for Measuring the Social Sustainability of Offshore Wind Power Farms

In the offshore wind power farm study, human resources were measured by local employment, industrial development and community acceptance. Job creation was gauged by a parameter using an input-output model.

A2.2.9 Mega-event and urban sustainable development

The indicators in the flora expo study were measured by the respondents' perceptions using a five-point Likert scale.

A2.2.10 Social Impacts of Dam-Induced Displacement and Resettlement: A Comparative Case Study in China

The dam displacement study measured the employment indicator by occupation types, income by income level and sources, consumption by consumption level and attitudes using a five-point scale. Recreation was measured by the amount of leisure time, and residence conditions depended on residential areas and types. Family relationships and neighbourhood relationships determined social networks. Finally, well-being was measured by satisfaction before and after the project using a three-point scale.

A2.2.11 Impacts of Tourism Development on Coastal Communities in Cha-am Beach, the Gulf of Thailand, through Analysis of Local Perceptions
The indicators in the coastal community study were measured based on the perceptions on a five-point scale. For example, the perception of the involvement in community-tourism events was based on active interactions of the community members while working on tourism events duties, while that of the preservation of community gathering space was based on the perception of its sufficiency. Meanwhile, the perception of tourism knowledge provided to the community was based on support from other organisations to the community through tourism knowledge programmes. Also, some indicators were not entirely based on perception but facts, having kin in the community, the proportion living in traditions, and participation in coastal environmental impacts.

A2.2.12 The Role of Major Sports Events in Regional Communities: A Spatial Approach to the Analysis of Social Impacts
The indicators in the championships study were measured by the respondents' perceptions on a five-point Likert scale.

A2.2.13 Using 'soft' and 'hard' social impact indicators to understand societal change caused by mining: a Western Australia case study
The Boddington study used population size to measure the demographic structure, and the proportion of the population who kept the same address for place of usual residence for one to five years to measure demographic mobility and transiency. It also measured the level of trust by counting how many felt that the trust level within the community had improved, remained the same or deteriorated and whether they cared about its general well-being instead of individual welfare. In addition, the study measured the voluntary work done within the community by measuring the population who have done voluntary work within the community. As for operational attributes, the study measured the local business environment by looking at the turnover, the number of local shops and the number of participants who reported whether they had thought of or considered undertaking any entrepreneurial activities. If so, whether they were willing to do so in Boddington. Finally, it also looked into the local community's expectations on who, mining or the government, to provide jobs, support community events, improve infrastructures, and contribute to economic diversion.

A2.3 Methodology to obtain data for social impact indicators

A2.3.1 Towards Indicators of Social Capital for Regional Development Issues: The Case of French Rural Areas
The French rural study did not specify how the statistical data was obtained other than stating their respective years. As for the survey, questionnaires were distributed to 50 inhabitants in each rural area with stratification by age and zone types.

A2.3.2 Characterising Community Impacts of Small Dam Removal: A Case Study of the Brownsville Dam
Most of the dam removal study measurements involved counting the number of relevant passages in the newspapers and the activities and reviewing the councils' documents. In addition, for access to public goods and services, Elston reviewed the local county park information. Elston also reviewed the missions of eight listed organisations most involved in the project for agency objectives. Lastly, 29 interviews about the impact distribution of all other indicators on a three-point level were conducted with respondents, including the council, the canal company, the City of Brownsville and community residents.

A2.3.3 Social impact assessment of the proposed Dodds-Roundhill coal gasification project: project report
The researchers of the Dodds-Roundhill study considered it an ethnographic case study and adopted qualitative inquiry methods. The measured values were from interviews with 15 respondents.

A2.3.4 Deriving sustainability measures using statistical data: A case study from the Eisenwurzen, Austria
All data in the Eisenwurzen study were from the Statistical Office of Australia for each municipality in 1991 and 2001.

A2.3.5 Social Impact Assessment of the Natural Forest Protection Program on forest-dependent communities and households in Western China-Case studies in Gansu Province and Chongqing Municipality
The forest protection study used key informant interviews and community focus group discussions. In addition, information about changes in land uses was obtained by participatory village mapping. Meanwhile, the household income structure data was from the household survey. Lastly, the perceived forest values were obtained from the household survey and the community focus group discussion. Eighty households were surveyed in 1998 and 2007.

A2.3.6 A methodology for ex-post assessment of social impacts of an affordable housing project
In the affordable housing study, the socio-economic group indicator data were all from the government, while the perception levels of other indicators were obtained from a survey with 96 valid responses.

A2.3.7 Estimating the social impacts of change: Exploring a psychological approach to capturing social impact data for cost-benefit analysis
The drought thesis received 202 responses to a questionnaire distributed to three small rural Australian communities in Western NSW.

A2.3.8 Developing an Indicator System for Measuring the Social Sustainability of Offshore Wind Power Farms
The offshore wind power farm study did not provide how the results of the indicators were obtained, other than that they were evaluated by the representatives and weighted to generate a social impact index.

A2.3.9 Mega-event and urban sustainable development
In the flora expo study, a survey of 1,628 residents was conducted after the expo.

A2.3.10 Social Impacts of Dam-Induced Displacement and Resettlement: A Comparative Case Study in China
The dam displacement study collected the data through a questionnaire distributed to people who resettled and the control group before and after the resettlement. The study received 256 responses.

A2.3.11 Impacts of Tourism Development on Coastal Communities in Cha-am Beach, the Gulf of Thailand, through Analysis of Local Perceptions
In the coastal community study, 116 households in the locality were surveyed to obtain their perceived levels of the measurements of the indicators.

A2.3.12 The Role of Major Sports Events in Regional Communities: A Spatial Approach to the Analysis of Social Impacts
A survey was distributed via SMS in the championships study to more than 36,000 registered telephone numbers. The sampling excluded those under 18 and above 75 and stratified the results based on the municipalities in the region.

A2.3.13 Using 'soft' and 'hard' social impact indicators to understand societal change caused by mining: a Western Australia case study
The Boddington study adopted a mixed research approach, combining qualitative and quantitative methods. The study obtained Boddington's population and the proportion of the population who kept the same address and those who did voluntary work from ABS; the data on project-induced migration from the Company; the level of trust, the population's view on service provision and local business environment from the community survey. It had 56 respondents and conducted semi-structured interviews with 14 stakeholders and local opinion leaders.

A2.4 Government SIA documents

The Social Impact Assessment Guideline for State Significant Projects (DPIE, 2021a) ("Guideline") has listed categories to help identify social impacts. The Guideline includes variables of the way of life, community, accessibility, culture, health and well-being, surroundings, livelihoods, and decision-making systems.

Further, in the Technical Supplement to the Guide (DPIE, 2021b) ("Technical Supplement"), a table provided examples of social impacts for different development types. Although no provision has been made for a rural housing project, the examples of a redevelopment of an urban estate, a wind farm in rural areas, and transportation infrastructures in rural areas provide some guidance.

Criteria in selecting indicators
Indicators need to correspond to the research area and cannot be transplanted from another study area. For example, in analysing the quality of life in urban, intermediate and rural regions with a fuzzy set approach, Dionisio (2021) found that factors contributing to rural areas' well-being differ from those in urban areas. Similarly, Rybakovas (2016) concluded that individuals in big cities, local areas and rural areas perceive the quality of life differently, with those in rural areas more affected by the attitude towards a local social environment.

Breakdown by categories
In light of the policy guidelines and the criteria for selecting the indicators, this literature review has selected the following indicators and grouped them into the categories set out in the Guideline (2021).

Way of life	Access to housing
	Access to employment
	Use of road infrastructure
Community (and fears and aspirations)	Social cohesion and social capital
	Demographic stability or sense of place
	Quality of life
	Social resilience
Accessibility	Use of road infrastructure
	Accessibility of critical social infrastructures
Culture	Locals' natural heritage
	Existing residents' views of and association with the locality

Health and well-being	Physical health
	Mental health
Surroundings	The amenity of the properties nearby.
	The aesthetic value of the new structures
	Access to the natural environment
Livelihoods (and personal and property rights)	Distribution of the impacts
	Infringement of personal and property rights
Decision-making systems	Adequacy of consultation with existing residents
	Adequacy of participation mechanisms

Measurement of determinants

The community determinants are intertwined. For example, in a proposal to measure social cohesion in the Canadian arctic communities, Duhame et al. (2004) proposed a social cohesion model amalgamating six indices: social capital, demographic stability, social inclusion, economic inclusion, community quality of life and individual quality of life.

Jenson (1998) defined social capital as the existence of trust, confidence and willingness to participate in civic institutions and voluntary associations. Woolcock (1998) believed that trust was an outcome of the existing social capital. To measure social capital, Duhame et al. (2004) measured qualitative perception of satisfaction with regional government, local police and regional courts, and behavioural measures such as voter turnout and participation in local community meetings or sports events. Petrova and Marinova (2014) also measured trust level and the proportion of the population participating in community life in a case study of the societal impacts of a Western Australian mine.

Demographic stability is another critical index. Duhame et al. (2004) enquired about the number of moves and the time in the community of the respondents and their reasons for moving or staying and considered the population growth rate from the census. In Australia, the index was measured by the proportion of the population changing their statistical area and the perceived social and natural environment attachment (Petrova & Marinova, 2014).

For the other indices proposed by Duhame et al. (2004), perception of quality of contacts in informal social support and participation in the subsistence economy was used to gauge social inclusion, and perceptive measures were considered in the quality-of-life factors.

Lastly, in an examination of individual and community resilience in southeast Queensland, Buikstra et al. (2010) adopted a resilience toolkit, identified and assessed 11 resilience concepts, including social networks and support, environment and lifestyle, infrastructure and support services, the sense of purpose, diverse and innovative and the economy, from an interview process.

Health and well-being

In less developed parts of the world, physical health indicators are measured by infant mortality rate and life expectancy (Aghajanian et al., 2007; Prasad et al., 2013). However, in assessing the health indicators of the rural areas of more affluent nations, subjective self-evaluation is often used (Boncinelli & Casini, 2013; Leeves et al., 2015; Wojewódzka-Wiewiórska et al., 2020). In addition, data on chronic diseases have also been gathered (Boncinelli & Casini, 2013; Leeves et al., 2015).

Again, for mental health, information about self-perceived mental health and stress levels was obtained (Wojewódzka-Wiewiórska et al., 2020; Yakınlar & Akpınar, 2022).

Livelihoods and decision-making systems

There is limited literature on the measurement of livelihood and decision-making determinants. An exception is an openness assessment of the participation, assessment, and policy-making process in impact assessment by Pohjola and Tuomisto (2011). A framework that includes five dimensions; scope of participation, access to information, the timing of openness, scope and impact of contribution, was used to evaluate participatory models and techniques and the policy-making processes. Nonetheless, the evaluation is not on the stakeholders' level and is not suitable for an ad hoc determination of the decision mechanisms.

Other discussions on the impacts on the affected stakeholders and the adequacy of participatory mechanisms remain on a project level and relate to how the project obtains qualitative data and information on the stakeholders' perceptions (Dutta & Islam, 2016; Colombo et al., 2021).

Nevertheless, in a study of a transportation project in Turkey, in which the consultation process began only after the construction, Varlıer and Özçevik (2015) assessed whether the residents were informed about the potential effects, their approval level of the project and their expectations of how the project would change their livelihoods. The responses could help estimate the adequacy of the consultation and participation mechanisms.

A2.5 Methodologies of determinant measurement

Criteria in selecting methodologies
On the one hand, the current SIA practice is considered not sufficiently deliberate and needs to invite more public participation (Esteves et al., 2012). Similarly, there is a call to incorporate human well-being indicators and psychological and social capital factors in assessing neighbourhood well-being (Corrigan, 2017).

On the other hand, and as explained further below, human subjectivity may affect the assessment of the determinants. For example, Hajimirrahimi (2017) found that perception of the impacts of rural second homes was strongly correlated to the job type and gender of the respondents. This result shows the potential inherent bias of surveys and the importance of objective quantitative analysis.

Community
The proportion of the population changing their statistical area and doing voluntary work within the community can be obtained from the ABS (Petrova and Marinova, 2014). However, the majority of other measurements of community determinants, e.g., satisfaction level, trust level, reasons for moving or staying, and quality of life, are qualitative. Therefore, they were measured using surveys or interviews (Duhame et al., 2004; Buikstra et al., 2010; Petrova and Marinova, 2014). In addition, interviews and workshops were conducted in some studies to grasp the potential impacts on the impacted population (Colombo et al., 2021; Taylor et al., 2021).

Health and well-being
Since the health measurements relate to subjective assessment or personal data on chronic disease, a survey was used to assess the health of respondents (Boncinelli & Casini, 2013; Leeves et al., 2015; Wojewódzka-Wiewiórska et al., 2020; Yakınlar & Akpınar, 2022).

Livelihoods and decision-making systems
In the social impact and public participation study by Varlıer and Özçevik (2015), a survey was used to assess whether affected stakeholders were informed and their approval and understanding of the project.

A2.6 Social impact assessment (SIA)

Background
SIA first appeared as an extension of social indicators (Olson,1969) and was accepted as part of environmental impact assessment in the 1970s (Morgan et al., 2912). Since then, SIA has gained prominence and has a more comprehensive application (Alomoto et al., 2021). Private organisations use SIA to assess and validate their impacts (Ormiston et al., 2011), while the public sector uses it to formulate new policies (Reeves, 2016).

In light of SIAs' wide application, this literature review has excluded SIAs on the social impacts of research, a specific product, an organisation or a government policy. In addition, the social impacts of the above events have a different time and geographical scope of impacts than those of a development project. As a result, their methodologies and assessment indicators are different and are less relevant.

Methodologies
In addition to the scope and usage, SIA has also proliferated in assessment methods. Some studies have attempted to classify the methods based on different criteria (Perrini & Vurro, 2013; Grieco et al., 2014; Nicholls, 2015; Bengo et al., 2015; Li, et al., 2014). However, the most prominent classification method is Clark et al. (2004). It divided the methods into process methods, impact methods, and monetisation.

Process methods monitor the efficiency and effectiveness of the operational process and do not provide an absolute measure of the returns. Impact methods identify and measure the operating result and their impact on society. Lastly, monetisation methods assign a monetary value to the outcomes (Maas and Liket, 2011; Cerioni and Marasca, 2021).

A2.7 Limitations

The ambiguity of "social impact"
Attempts have been made to define "social impact." In 1996, Burdge and Vanclay defined it as "consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organise to meet their needs and generally act as a member of society." The words impact, output, effect, and outcome have also been used (Maas and Liket, 2011). More recently, the Expert Group on Social Economy and Social Enterprises defined it as *"The reflection of social outcomes as measurements, both long-term and short-term, adjusted for the effects achieved by others, for effects that would have happened anyway, for negative consequences, and for effects declining over time*" (Clifford et al., 2014).

From the attempts to define the above-named word, there is no clear consensus on the word's meaning. Therefore, any assessment must involve the exercise of discretion (Corvo, 2021), and measurement, including inputs, outputs, and their qualitative or quantitative nature, poses significant difficulty in developing objective assessment frameworks in an SIA (Polonsky, 2016).

Lack of standards
As an extension of the inherent ambiguity of the phrase "social impacts," models for social impact assessment have been developed without a single classification system (Greico, 2014; Montesi, 2015). Also, there are no standard or specific procedures and measurements, resulting in SIAs with different conclusions (Greig et al., 2015; Tavanti, 2017). As a result, it is typical for literature investigating lists of social impacts with surveys and other quantitative methodologies to be partially or poorly reported (Greig et al., 2015).

Due to different methodologies across the SIAs, prevalent subjectivity in the evaluation, and difficulty quantifying the impacts in the SIAs that rely on qualitative indicators, it is not easy to even evaluate the SIAs. For example, the results of SIAs that adopt a contingent valuation method may vary (Schweinsberg, 2007). The method often asks the respondents to provide hypothetical estimates. However, the respondents do not have the ability or knowledge to provide a reliable value (Ajzen & Driver, 1992). In addition, individuals in a population may respond differently (Barrow, 1997).

Lack of further analysis and coordination

Some SIAs do not espouse how the impacts will be distributed among the stakeholders and neglect cumulative effects (Dendena & Corsi, 2015). There is also little literature on cross-referencing and collaboration of SIAs at the local level (Dendena & Corsi, 2015).

A2.8 Word cloud of Social Impact

This word cloud is generated from the summary of complaints related to social aspects. According to this figure, the main topics in the complaints include the value of the unburned bushland to the community and residents' mental health, the shortage of infrastructure and transportation to support the new construction, and doubts about dwellings' location. The frequencies of these mentioned topics are generally consistent with the statistical histogram results as shown previously, and we can see a considerable proportion of words related to psychology, which indicates that the local community is suffering from the bushfire and they need the forest to recover and recreate.

Besides the above-identified complaints, we also noticed other concerns that are not presented in the figure. For example, the frequent complaints by the residents include the importance of the unburned bushland to future generations, the influence on the community's faith, morale and recreation, the concerns of target customers and the vacancy rate of the proposed dwelling.

Figure A3.1: Word cloud of claims related to social aspects

This word cloud is generated iteratively by manually filtering out the meaningless stop words from the social-related aspects. We checked the output word cloud at the end of each iteration and added the meaningless words to the stop words set so that these words will not show up in the next iteration.

Appendix 3: Statistics of the claims

The purpose of this statistics is to investigate main points the residents' concern and the relationships of variables (economy, ecology, social, and general submissions) with regards to the development project. Eight models were found statistical significances from the multiple regression analysis (MRA). The results suggest that the main concerns of the residents are

1) bushfire, species and climate changes.

2) local economy and a need for environmental assessment, infrastructure and housing.

3) intergeneration benefits in their claims.

		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
	Dependent variable	Intergeneration	Housing	Economics	Bushfire	Ecological	Species	Long-Habitat	Climate
Independent variables									
General Submissions	Expert					.193 (3.033)	.270 (3.537)		
	Positive								
	Late								
	Project Design								.201(3.314)
	Environmental Assessment			.072 (3.325)			.243 (4.210)	.166 (2.837)	
	Site Situation								
	Bushfire					.138 (4.915)			
	Strategic Needs (Infrastructure, Roads, etc.)		.322 (15.075)	.150 (6.276)					
	General Comments Other	-0.100 (-4.104)			-.501 (-17.651)	-.126 (-4.198)	-.353 (-11.168)	-.345 (-10.696)	-.083 (-4.424)
Economy	(Contribution to) Housing			.242 (8.056)					
	(Contribution to) Local Economy (Incl. Tourism & Jobs)		.231 (8.308)						
Ecology	Precautionary Principle (incl. Climate Change)					-.123 (-3.023)			
	Impact on Vulnerable, Threatened, Endangered, Critically Endangered Species							-.092 (-3.063)	
	Ecological Refuge				.156 (5.090)				-.065 (-3.045)
	Long Term Sustainability (Incl. Gradual Habitat Reduction)				.071 (2.793)		-.095 (-3.255)		
Social	Intergenerational Equity								
	Miscellaneous Considerations	.287 (2.606)							
	Public Interest								
	Constant	.185 (14.532)	.010 (2.017)	.013 (2.433)	.748 (37.708)	.140 (5.156)	.481 (22.961)	.491 (23.182)	.116 (10.592)
	R-square	0.21	0.271	0.163	0.294	0.083	0.124	0.098	0.031
	F test	0.009	209.788	72.979	156.922	25.417	40.042	40.657	11.844
	Sig.	.000	.000	.000	.000	.000	.000	.000	.000
	DW	1.881	2.001	1.968	1.867	1.967	1.922	1.848	2.007

Appendix 4: Comparison of this report with previous reports

	PPM Consulting	Cameron K. Murry	Alison Ziller Macquarie U	MMEA	This report
Report Content					
Social impact analysis	Yes	No	Yes, the report focuses on social impact analysis	No	Yes. Two sources were used for the social impact analysis. The first is the 703 valid submissions from the residents and the second is the NSW government social impact analysis tool. Data from different sources such as ABS were used for the social impact analysis.
Economic impact analysis	Yes	No	No	No	Yes. From the identified economic indicators, the report shows the estimation of benefit and cost of the development. Data from different sources such as ABS and PriceFinder were used for the economic impact analysis.
Ecologic imapct analysis	No	No	No	Yes. The report focuses on the fire and environment impact	No. A separate report analyses the ecologic impact of the development.
With and without develoment analysis	No	No	No	No	Yes. The benefit and cost of the development can not be analysed without conducting the "with and without" development analysis.
Benefit and cost analysis	No	No	No	No	Yes. The benefit and cost analysis is commonly used for the impact study in academic, industry and governments.
Benefit and cost distribution analysis	No	No	No	No	Yes. The analysis includes the esimation of benefit and cost for the developers, government, investors and residents for the with and without development scenarios.
Research methodology and methods					
Evidence based	Some	Comments only	No. The analysis is a purely descriptive only	No. The report is a descriptive claim only.	Yes, the report has drawn on the literature about the factors that consist in the social and economic impact analysis. The report further conducts qualitative and quantitative analysis. The qualitative analysis was based on the 703 valid submissions to the public exhibition of Preliminary Documentation and found the main concerns of residents in the area using wordcloud. Data from various sources were collected for the quantitative analysis, estimating the housing demand and supply, the benefit and cost of development with or without the development. The benefit and cost of stakeholds including the developers, government, investors and residents have also been studied.

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Turrell, G., Hewitt, B., Patterson, C. and Oldenburg, B. (2003). Measuring socio-economic position in dietary research: is choice of socio-economic indicator important? *Public health nutrition*, *6*(2), pp.191-200.
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Visvaldis, V., Ainhoa, G. and Ralfs, P. (2013). Selecting indicators for sustainable development of small towns: The case of Valmiera municipality. Procedia Computer Science, 26, pp.21-32.
Weisbrod, G. and Weisbrod, B. (1997). Measuring economic impacts of projects and programs. Economic Development Research Group, 10, pp.1-11.
Wallstam, M., & Kronenberg, K. (2022). The role of major sports events in regional communities: a spatial approach to the analysis of social impacts. *Event Management*.
Wang, Y. (2010). Social impact assessment of the natural forest protection program on forest-dependent communities and households in Western China-case studies in Gansu province and Chongqing municipality.

RESEARCHERS' PROFILE

See Attachments

Associate Professor **Dr. Xin Janet GE** BCom MBA PhD; MGKAP MRICS CPP(Ed) AAPI

PERSONAL DETAILS

Address: School of the Built Environment, Faculty of Design, Architecture & Building, University of Technology Sydney, City Campus. P O Box 123 Broadway, NSW 2007, Australia.
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ORCID ID: 0000-0002-2252-7829

EDUCATION and TRAINING

Feb 2001- 2004 PhD *House Price Models for Hong Kong*, The University of Newcastle, NSW, Australia
Feb 1997 – 1999 MBA - *Financial Management*, Murdoch University, WA, Australia
Feb 1994 – 1997 Bachelor of Commerce – *Banking and Finance*, double majors, Curtin University, WA, Australia
Feb 1992 – 1995 Associate Diploma of Business Administration, TAFE Perth, Australia
Feb 2008 – Dec 2008 Graduate Certificate in Higher Education Teaching and Learning, University of Technology Sydney Australia
Dec 2005 Certificate in Higher Education (CertHE), Unitec, New Zealand
Aug 2001 Certificate in Teaching Enhancement, City University of Hong Kong, China
Dec 2002, Independent Director Certificate, China SEC and Tsinghua University, Beijing, China

PROFESSIONAL AFFILIATION

MRICS, Royal Institution of Chartered Surveyors (Since 2014)
CPP(Ed), Australian Property Institute (Since 2011)
AAPI, Australian Property Institute (Since 2007)
MGKAP, Life Member, Golden Key National Honor Society of Australia (since 1996)
MPRRES, Member of Pacific Rim Real Estate Society (Since 2007)
MAsRES, Member of Asian Real Estate Society (2007 – 2010, 2016 – 2017, 2018 - now)
ICIOB, The Chartered Institute of Building Australasia (2007- 2010)
Fellow, Institute of Financial Accountants (FFA) (23 September 2002-2006)

EMPLOYMENT

19.05.2022 – now University of Technology Sydney, Faculty of Design, Architecture and Building, Associate Professor.
- Program Director
  - Master of Property Development
  - Master of Real Estate Investment

Jan 2022 – 18.05.22 University of Technology Sydney, Faculty of Design, Architecture and Building, Associate Professor.

2020 – 2021 University of Technology Sydney, Faculty of Design, Architecture and Building, Associate Professor.
- Head of Property Discipline
  - Bachelor of Property Economics, Bachelor of Property Economics and Bachelor of International Study, Bachelor of Property Economics Honor Program.
  - Master of Property Development, Graduate Diploma of Property Development, Graduate Certificate of Property Development

2009 – 2019 University of Technology Sydney, Faculty of Design, Architecture and Building, Senior Lecturer.
- Course Director, Bachelor of Property Economics (01 January 2018 – 31 December 2019)
- Acting Course Director, Bachelor of Property Economics (10 December 2016 – 10 July 2017)
- Course Director, Bachelor of Property Economics (Course restructuring, Developing course graduate attributes (01 Jan 2013 – Feb 2014)

2007 – 2009 University of Technology Sydney, Faculty of Design, Architecture and Building, Lecturer.
- Course Director, Postgraduate Property Programs include Master of Property Development, Graduate Diploma in Property Development, Graduate Certificate in Property and Planning courses (July 2008 – June 2010)

2005 - 2007 Unitec New Zealand, School of the Built Environment, Lecturer.
2001 - 2005 City University in Hong Kong, Department of Building and Construction, Instructor.
- Program Co-ordinator for Master of Science in Construction Management – Real Estate Project Management at the Department of Building and Construction (2002-2005)

1999 - 2005 SCOPE, City University of Hong Kong, Lecturer.

AWARDS

2020 Outstanding Academic Leadership as Course Director, 2020 DAB Awards for Excellence, 04 December 2020.
2015 Most Innovative Paper Award, Pacific Rim Real Estate Society Conference 2015 for the paper "Measurement of house price bubbles: a case in Sydney", The award was presented at the 21st Annual Pacific-Rim Real Estate Society Conference, at Kuala Lumpur Malaysia on 18 – 21 January 2015.
2012 Highly Commended Award, Emerald Group Publishing Limited – Property Management for Paper *"Sustainable housing: a case study of a heritage building in Hangzhou China"*. The award was presented at the 18th annual Pacific Rim Real Estate Society Conference, Adelaide Australia in January 2012.
2008 Selected Paper Award for the paper "A study into the demand for apartments in central Auckland" at the 13th Asian Real Estate Society Annual Meeting and International Conference, July 2008.
2008 Selected Paper Award for the paper "House price trigger and infusion trap" at the 13th Asian Real Estate Society Annual Meeting and International Conference, July 2008.
2005 CIOB Australia 2005 Excellent Building Research Postgraduate Award.
2004 AIB Australia, Professional Excellence Awards for the Outstanding Graduate of PhD.
1995 The Vice-Chancellor's List, top 1 per cent of undergraduate students, Curtin University Australia.

TEACHING

Undergraduate program

Property Investment and Valuation (year 2): Bachelor of Property Economics, School of Built Environment

Postgraduate program

Property Development Finance (year 2): Master of Property Development, School of Built Environment

RESEARCH GRANTS

I have been awarded and involved in various grants from a number of bodies including the Australia NSW Government, Australia-China Council, University of Technology Sydney, Unitec New Zealand, University of Hong Kong and the City University of Hong Kong and industries such as Landcom NSW and a development company in China. The projects include house price forecasting, biodiversity impact on the housing market, finance strategies, an early warning system for the housing market, demolition methodology with BIM, 3D environment reconstruction, measuring historic building performance, and a virtual lab on teaching.

Chief Investigator Ge, X.J., (Aug 2022 – July 2024), Increasing the supply of affordable rental housing through greater institutional investment in build-to-rent projects: An analysis of key strategies and mechanisms, James Martin Institute for Public Policy (JIMPP) Grant, pending approval. Application ID: 2022-0829544139.

Chief Investigator Ge, X.J., Zhou, J.L., Chen, F. and Baddeley, M. (28 March – 13 June 2022), Social and economic impact analysis for a development project, funded by Deep River Group Pty Ltd.

Investigator Ge, X.J. (Oct 2019 – Dec 2019). *An international perspective: a comparative analysis of the main government housing programs for low-mid income households*, ARBE Fund 2019, UTS.

Investigator Christensen, P. Shirazi, A. Ge, X.J. (Oct 2019 – Dec 2019). Micro-units: a sustainable supply solution for the housing affordability crisis in Australia? ARBE Fund 2019, UTS.

Investigator Plant, R., Kim, Y., Ge X.J., Lee, A. (July 2018 - Oct 2018). *Cumberland Plain Conservation Plan - Economic Appraisal of Strategic Conservation Planning Options.* Report prepared for the NSW Government Department of Planning & Environment by the Institute for Sustainable Futures: Sydney. PROC-2002269, together with A/P Roel Plant & Dr Yohan Kim in UTS IFS and Dr Adrian Lee in UTS Business School.

Investigator (2018 - 2022), *Management of real estate development and financial risks for real estate enterprises in China, UTS IDP project*, Funded by Guangzhou Longmen Xian Dao Real Estate Development Company, Project Number: PRO17-4439.

Investigator (May 2018 - Nov 2018), *How can an Australian 'build to rent' product contribute to urban renewal and affordable housing supply*? Together with Asso Professor Vince Mangioni from UTS, Professor Hal Pawson, Professor Bill Randolph from UNSW, and members from Landcom NSW, funded by Funding Cities Community of Practice.

Chief Investigator (2018 - 2020), *Review and development of a predictive housing price model for the Sydney housing market*, together with Asso Prof. Vince Mangioni and Asso Prof. Song Shi from UTS, Professor Fethi Rabhi and Dr Rachida Ouysse from UNSW and Dr Shanaka Herath from University of Wollongong, and members from Urban Growth NSW, funded by Funding Cities Community of Practice.

Investigator (2017), *Development of mathematics self-administered test for the new students in the BPE program*, funded by DAB on the development of Learning. Futures strategies and/or resources.

Coinvestigator (Sep 2016 – Dec 2016), *3D Environment Reconstruction using Fetch Robot and Multi-Sensor Data Fusion*, funded by 2016 UTS FEIT Data Arena Research Exhibit Grant Proposal, together with A/P SD Huang, Prof CQ Zhang and XJ He.

Chief Investigator (Aug 2016 – Nov 2016), *Demolition Methodology with BIM: Case Study of UTS Building 2*, funded by UTS DVC (Resource), together with UTS Prof CQ Zhang, XJ He, P Livesey and XY Wang (Curtin University).

Chief Investigator (Apr 2016 – Dec 2016), *The Built Environment and Ethnicity: Case Study in Sydney*, funded by Faculty of Design, Architecture and Built Environment.

Investigator (2015) *Influence of Financing Facilities on House Prices in Australia,* funded by Centre for Contemporary Design Practices, DAB, UTS.

Investigator (2015) *Ethnic changes and house prices in Sydney suburbs,* funded by Built Environment Design and Management (BEDM) Research Funding, DAB UTS.

Investigator (Aug 2012 – Dec 2013) *Assessing the impact of rail infrastructure on property prices in north-west Sydney: a case study on Epping and Chatswood*, Funded by BEDM, with Investigator, Dr Heather MacDonold and Dr Sumita Ghosh at the School of the Built Environment, DAB, UTS.

Co-Investigator (Sep 2010 – Mar 2013) *Heritage and sustainability - Modelling the environmental performance of historic buildings in Hong Kong*, Small Project Funding, with principal investigator, Dr DCW HO at Department of Real Estate & Construction, University of Hong Kong. http://www.hku.hk/local/rss/urc/203-806_regulations.doc.

Chief Investigator (2009 - 2010) *Heritage and sustainability - Modelling the environmental performance of historic buildings in Xiao He Zhi Jie.* [this project is, together with Dr Grace Ding, Mr Peter Philips, and Professor Shenghua Jia, funded by Australia-China Council Grant]

Chief Investigator (2009 - 2010) *Alternative models of course delivery to maintain student satisfaction in large group masters programs.* [This project is funded by UTS learning and teaching performance fund initiatives - Small learning and teaching improvement grants 2009].

Chief Investigator (2009 - 2010) *Leading through effective management system - Developing a Course Director Manual for Postgraduate Property Programs.* [This project is funded by UTS Vice Chancellor's learning and teaching grant at IML on the course of "Academic Leadership for Course & Major Co-coordinators undertaking Curriculum Review and Renewal 2009"].

Investigator (01.03.2006-28.02.2007) *A model for predicting the probability of a crisis in residential prices in Auckland* [This research project was funded by the Unitec Research and Advanced Practice Committee (URAPC), Project No: RI05222].

Co-investigator (2004-2006) *Developing a safety climate survey tool for the construction industry in Hong Kong* [This research project, together with Dr Ivan Fung, was granted by the Strategic Research Grant (SRG), Project No: 7001600].

Co-investigator (2003-2004) *Web-Based Learning Centre for Diagnosis of Geotechnical Engineering Problems* (This research project, together with Dr KC Lam, was granted by the Teaching Development Grants, Project No: 6980008).

Co-investigator (2002-2003) *Developing of a Web-based Virtual Soil Laboratory for Triaxial Test* (UU, CU, CD methods (This research project, together with Dr KC Lam, was granted by the Quality Education Fund, City University of Hong Kong, Project No: 8710218,).

Co-investigator (2001-2002) *Developing A Web-based Virtual Soil and Rock Mechanics Laboratory* (This research project, together with Dr KC Lam, was granted by the Quality Education Fund, City University of Hong Kong, Project No: 8710197).

Research Assistant (2001-2004) *Neuro-Cognitive Science for Language Education* (This research project, with Dr Albert So, was granted by the Quality Education Fund, Hong Kong Government, Project No: 9420006).

Research Assistant (2001) *A Background Study of Old Buildings in Hong Kong* (This project was provided by Johnson Controls Hong Kong Limited).

RADIO BROADCASTING

03 August 2021, together with the Australian Institute Senior Economist Matt Grudnoff, Independent Economist Saul Eslake, I have joined an interview discussing housing policy for affordable housing by Toby Hemmings for 2SER 107.3 Think: Business Futures program https://2ser.com/thinkbusinessfutures/.
Here is the link to the discussion: https://player.whooshkaa.com/episode?id=864341

PUBLICATIONS

Book Chapter

Ge, X.J. and Mak, M.Y. (2015), Case studies: Feng Shui integrated applications for built environment analysis, IN: Michael Y. Mak and Albert T. So (Eds.), Scientific Feng Shui for the Built Environment: Theories and Applications (ISBN: 978-962-937-236-1), City University of Hong Kong, pp. 165-176.

Mak, M.Y. and Ge, X.J. (2011), Case study: a six-star office building in Sydney, IN: Michael Y. Mak and Albert T. So (Eds.), Scientific Feng Shui for the Built Environment: Fundamentals and Case Studies (ISBN: 978-962-937-178-4), City University of Hong Kong, pp.148-153.

Social Science Research Network (SSRN) http://www.ssrn.com/

Chen, J. and **Ge, X.J. (2013)** Will tax credit increase housing supply? Experience from US and prospect for Australia (March 25, 2013). Available at SSRN: http://ssrn.com/abstract=2294715 or http://dx.doi.org/10.2139/ssrn.2294715 (Downloaded 83 and viewed 504 on 01 July 2018), and Housing Finance Information Network (HOFINET0 at http://hofinet.org/documents/doc.aspx?id=2046

International Refereed Journal Papers

Mangioni, V., **Ge, X.J.,** Shi, S. and Herath, S. (2022), Factors impacting regional residential and rural land values in New South Wales, ***Australasian Journal of Regional Studies***, submitting.

Swanzy-Impraim, S. **Ge, X.J.** and Mangioni, V. (2022), Is Build-to-Rent an Affordable Housing Product? Stakeholder Perceptions in Australia, ***The International Journal of Housing Policy,*** under review, submitted on June 2022

Ge, X.J., Mangioni, V., Shi, S. Herath, S. (2022), House Price Forecasting using the Multi-level Modelling Method in Sydney (IJHMA-06-2022-0083), ***International Journal of Housing Markets and Analysis***, submitted 02 June 2022, Accepted 18 August 2022.

Zhang, Y.C., So, A. **Ge, X.J.** (2022), A comprehensive mathematical ming tang model for designing shopping malls' entrance with case studies, ***Architecture and Urban Planning*****,** submitted on 02 June 2022, under review.

Chen, J.X. and **Ge, X.J.** (2022), Market responses to horizontal and vertical M&A – evidence from Chinese real estate industry, ***Group & Organization Management***, Submitted on July 2020. **(IF: 2.627 in 2017)**

Ge, X.J. and Liu, X. (2021), Urban Land Use Efficiency Under Resource-Based Economic Transformation—A Case Study of Shanxi Province. ***Land*** 2021, *10, 850*, pp.1-19. https://doi.org/10.3390/land10080850 **(IF: 3.395 in 2020)**

Ge, X.J. and Zhang, J.S. (2021), Development of an ontology-based visual approach for property data analytics, ***International Journal of Real Estate Studies,*** Vol 15(1), pp. 1-15. Accepted on 27 December 2020, published online 23 June 2021 on **https://intrest.utm.my/index.php/intrest/issue/view/1.**

Zhang, Y., So, A. **Ge, X.J.** (2021), A mathematical method to assess yin-yang balance of commercial complexes' entrances, ***International Journal of Real Estate Studies***, 15:2, pp. 95-102, Submission: 27 August 2021, Revised: 15 Oct 2021, Accepted 17 December 2021, Published 31 December 2021. E-ISSN:2231-7643 intrest.utm.my.

Shi, S.; Mangioni, V.; **Ge, X.J.**; Herath, S.; Rabbi, F.; Ouysse, R. (2021), House Price Forecasting from Investment Perspectives. ***Land*** 2021, 10, 1009. https://doi.org/10.3390/land10101009, Academic Editor: Sarel Cilliers, Received: 20 August 2021, Accepted: 23 September 2021 Published: 26 September 2021.

Swanzy-Impraim, S., **Ge, X.J.** and Mangioni, V. (2021). Barriers to institutional investment in rental housing: a systematic review of market risks. ***International Journal of Real Estate Studies***, 15:2, pp. 1-15, submitted 18 May 2021, revised: 31 July 2021, paper accepted on 22 August 2021, Published online on 31 December 2021.

Shilling, J.D.; Lee, J.M. and **Ge, X.J.** (2021), Estimating the Vulnerability of Households to Rent Increases, AREUEA-ASSA 2021, Submitted on 16 April 2020 and accepted on 15 May 2020. Two reviewers and only 38.5% papers were accepted out of 221 submissions.

Wu, W.Y. and **Ge, X.J.** (2020), Communal space design of high-rise apartments: a literature review, ***Journal of Design and the Built Environment***, 20(1), pp 35-49. Submitted on 30 March 2020, Final version submitted on 28 April 2020, publication accepted on 29th April 2020.

Antwi-Afari, MF, Li, H, Wong, JKW, Oladinrin, OT, Ge, JX, Seo, JO & Wong, AYL (2019), Sensing and warning-based technology applications to improve occupational health and safety in the construction industry: A literature review, ***Engineering, Construction and Architectural Management*****,** vol. 26, no. 8, pp. 1534-1552. **(IF: 1.561),** paper accepted 24 July 2018 and publication accepted on 28 Dec 2018.

Zhan, J, Ge, XJ, Huang, S, Zhao, L, Wong, JKW & He, SXJ (2019), Improvement of the inspection-repair process with building information modelling and image classification, ***Facilities*****,** vol. 37, no. 7-8, pp. 395-414. Accepted 11 October 2018 **[SJR: 0.34]** [ISSN: 0263-2772]**.**

Ge, X (2018), Effects of ethnic changes on house prices: Sydney cases, ***International Journal of Housing Markets and Analysis.*** Vol. 13, No. 1, pp. 96-119. https://doi.org/10.1108/IJHMA-12-2016-0083.

Wong, Johnny, K.W., **Ge, X.J.** and He, X.J. (2018), Digitisation in facilities management: a literature review and future research directions, ***Automation in Construction***, 92:312-327. Accepted on 15 April 2018. DOI: 10.1016/j.autcon.2018.04.006 **[IF: 4.032]**.

Ge, X.J. and Wong, Johnny K.W. (2017), Application of Combined BIM and 3D Point Cloud on Building Deconstruction. ***Civil Engineering Research Journal***, 1(4): 555-567.

Ge, X. J., Livesey, P., Wang, J., Huang, S., He, X., & Zhang, C. (2017). Deconstruction waste management through 3d reconstruction and bim: a case study. ***Visualization in Engineering*****,** *5*(1), 13. Accepted 30 June 2017, Published on 14 July 2017, https://doi.org/10.1186/s40327-017-0050-5

Ge, X.J. (2016), Effects of Immigration on Housing Price: Australian Major Cities, ***Pacific Rim Property Research Journal***, under revision.

Yan, S.Q, **Ge, X.J.** and Wu, Q. (2014), Government intervention in land market and its impacts on land supply and new housing supply: Evidence from major Chinese Markets, ***Habitat International***, Vol. 44, pp. 517-527 [IF: 2.029] [ISSN: 0197-3975].

Ge, X.J. and Mak, M. (2014), Decision making to purchase family homes: Feng Shui versus sustainability, ***Project Perspectives,*** Vol. XXXVI, pp.64-69.

Ge, X.J. (2014) Did The Introduction of Carbon Tax In Australia Affect Housing Affordability? ***Advanced Materials Research,*** Sustainable Development of industry and Economy, PTS 1 and 2, Vol. 869-870, pp. 840-843.

Ding, G.K., **Ge, X.J.** and Phillips, P. (2012), Cradle-to-gate analysis of materials used in historic and modern housing, ***Advanced Materials Research***, Vol. 374-377, pp. 2029-2036.

Ge, X.J. (2009), An alternative financing method for affordable housing, ***Housing Finance International*****,** December, Vol. XXIV, No, 2, pp. 34-38.

Ge, X.J. (2009), Determinants of house prices in New Zealand, ***Pacific Rim Property Research Journal,*** 15 (1), pp. 90-121 (ISSN 1444-8921) http://www.prres.net/.

Karantonis, A. and **Ge, X.J.** (2007) 'An empirical study of the determinants of Sydney's dwelling price', ***Pacific Rim Property Research Journal,*** 13(4), December, pp. 493-509 (ISSN 1444-8921) http://www.prres.net/.

Ge, X.J. and Runeson, G. (2005) 'Modeling property prices using neural network model for Hong Kong', ***International Real Estate Review,*** 8(1), pp.121-138. http://cbeweb-1.fullerton.edu/finance/irer/papers/past/Vol7/vol7_page121_138.htm

Ge, X.J., Lam, K.C. and Cheung, S.O. (2004), 'Virtual Soil Laboratory: An Exemplar of E-learning in Construction', ***International Journal of IT in architecture, Engineering and Construction*** - Special issue on E-learning in Construction, 2(1), pp. 61-71. http://www.lboro.ac.uk/it-aec/itaecvol2.htm#ge

Ge, X.J. and Lam, K.C. (2002), 'Building a House Prices Forecasting Model in Hong Kong', ***The Australian Journal of Construction Economics and Building***, Vol. 2, No 2, pp. 57-70.

Refereed International Conference Proceedings

Swanzy-Impraim, S., **Ge, X.J.** and Mangioni, V. (2022), The emergence of REITs in Ghana: a shift towards listed property trusts, 28th Annual Pacific-Rim Real Estate Society Virtual Conference, Beyond 2022: facing tomorrow's challenges today: the role of the built environment, 19th January 2022.

Swanzy-Impraim, S. **Ge, X.J.** and Mangioni, V. (2021), The great reset: resurgence of indirect real estate investment real estate markets, 2021 Virtual Joint Real Estate Conference by AsRES, GCREC and AREUEA – Future of Real Estate: Impacts of Technologies and Global Changes, July 18 – 21, 2021. Paper accepted for presentation on 14 May, 2021, presentation on 21 July 2021.

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- New Housing Supply, Housing Price and Land Supply in China, University of Technology, Sydney. The student has been awarded UTS IRS under the joint UTS-CSC PhD Scholarship and will start in July 2011.
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Now is the digital era. In this time of innovation and change, big data analytics have helped industries harness the power of data: more efficient operations, more cost savings, higher profits, and higher customer satisfaction. Data science has extraordinary impact in real world applications, and has the capability to rapidly revolutionise not only traditional solutions, but ways of thinking in the industry.

To this end, Distinguished Professor Fang Chen is a prominent leader in AI and data science, with an international reputation and industrial recognition. She has created and deployed many innovative solutions using AI and data science to transform industries worldwide.

Distinguished Professor Chen has been appointed to the inaugural NSW Government AI Advisory Committee. In addition, she serves as co-chairperson on the National Transport Data Community of Practice (NTD-CoP) at ITS Australia, the Expert Panel for National Science Foundation (NSF) Singapore, Public Interest Technology Advisory Committee for Economic Development of Australia (CEDA), and as strategic advisor on AI/Data Science for several companies.

Distinguished Professor Chen is the NSW Water Professional of the Year 2016, and won the National and NSW Research and Innovation Award by the Australian Water Association (AWA) in 2018.

In 2018, Distinguished Professor Chen won the Australian Museum Eureka Prize for Excellence in Data Science – the equivalent of an Oscar in Australian science. She is also the Winner of Women in AI Australia and New Zealand Award (2021). She has also been awarded NSW Premier's Prizes for Science & Engineering: Excellence in Engineering and Information and Communications in 2021.

Personal achievement notwithstanding, Fang has spearheaded teams towards and through impactful successes. She and her team gained many recognitions for their work: the ITS Australia National Award (2014, 2015 and 2018), the NSW iAwards (2017), and the VIC iAwards (2019 and 2020).

Distinguished Professor Chen has more than 300 publications and 30 patents in 8 countries. She delivered many public speeches, including a TEDx talk on building trust between human users and AI.

Currently, Distinguished Professor Chen is the Executive Director Data Science at University of Technology Sydney (UTS).

- **Track record in research and innovation**

Professor Chen's track record in science and engineering is well-documented – she has more than 300 refereed publications, including books and top journals and conferences. She has filed more than 30 patents in eight countries and regions, including Australia, US, Canada, Europe, Japan, Korea, Mexico and China.

Professor Chen and her team won the 2018 Australian leading science prize Australian Museum Eureka Prize for Excellence in Data Science. The winning endeavour used new Bayesian nonparametric and nonhomogeneous stochastic processes methods – methods which have proven impact in a suite of applications in the water industry – to address machine learning predictions with high-dimensional, sparse and class-imbalanced data. Professor Chen was the architect of the innovative machine learning algorithms that interpret and predict complex interactions between the material, age, weather, soil and operating environment of water pipelines. The algorithm utilises huge amounts of nonhomogeneous spatial-temporal data input: asset attributes and performance, operational water pressure and work orders with natural language notes, CCTV footage, weather and soil information, traffic information, and millisecond-based event-sensing information. Professor Chen's methods allowed her and her team to resolve complex problems in large-scale complicated water networks.

Professor Chen was the pioneer of the theoretical framework of measuring cognitive load through multimodal human behaviour. Her work provided much of the empirical evidence on using human behaviour signals (such as speech, language, eye movement and manual/pen gesture) and physiological responses (such as EEG and skin conductance) to measure and monitor cognitive load. For this enormous contribution, Professor Chen received the Brian Shackle Award from the International Federation for Information Processing (IFIP) in 2017. This was given in recognition of the most outstanding contribution with international impact in the field of human interaction with, and human use of, computers and information technology. This work has been applied worldwide in emergency management centres, including transport management centres, air traffic control centres, bushfire management centres, and paramedic services, as well as in military training, elite sports training, and education.

In recent years, Professor Chen has also worked in human and machine trust measurement, trust calibration and decision making. This work is centred on exploration of AI and ethics for human-centred AI. She co-authored the Springer book "Human and Machine Learning" – since publishing in June 2018, it has attracted 73,000 downloads. It is the first dedicated source of state-of-the-art advances in theories, techniques and applications of trustworthy and transparent machine learning. The most recent Springer book "Humanity Drive AI" was published in December 2021 and it has attracted 3,200 downloads in the first month.

- **Transformations to industry with practical impact and industrial recognition**

Professor Chen has created world-class solutions and products throughout her career. She leads myriad task forces with the goal of utilising data analytics and computational platforms in a manner where their scales and impacts extend to the national and international. She has helped many industries worldwide advance towards excellence in better, newer solutions.

Professor Chen's work is in providing practical solutions of tremendous impact, utilising cutting edge scientific and engineering discoveries. Her task forces focus on helping industries increase their productivity, innovation, profitability, and customer satisfaction. Her career in data analytics spearheaded transformations to the water industry, transport, and civil infrastructure.

Water and civil Infrastructure management

In her many years working in the water sector, Professor Chen has created and implemented data-driven predictive maintenance solutions. She has successfully created advanced data-driven analytic solutions based on patented non-parametric machine learning algorithms, working with water utilities and research organisations worldwide. These data-driven solutions not only increase safety, but also avoid social and economic waste, and interruptions to society. Professor Chen has extensive experience in transforming industry, and this has proved key.

Professor Chen's "Data-Driven Pipe Failure Prediction" solution led to the creation of the most accurate prediction method in the world for urban water infrastructure pipeline failure prediction. Working with more than 30 utility providers globally – more than 10 million pipes, and over 1 million failure records – her novel solution has been through robust resting, and has been shown to be 5 to 10 times more accurate than industry standard.

Her pioneering techniques have provided excellent decision support tools for owners and maintainers of civil and industrial assets both. Estimated by Deloitte, the benefits of failure prediction technology created by her and her team include potential cost reductions of approximately $298 million per year in Australia. This technology has the potential to deliver approximately $2.7 billion in economic benefits over the next ten years.

In NSW, we experience around 6,500 annual leaks and breaks, resulting in a staggering 8% of unaccounted water loss. Since December 2019, in 18 months since implementation, the tool developed by Professor Chen and her colleagues has saved a total of 3,500 megalitres of water by detecting leaks and breaks in Sydney Water's pipe network – the equivalent of around 1,400 Olympic swimming pools. This solution has already resulted in $8 million worth of savings, and the long-term benefits continue to grow.

Professor Chen's water quality awareness solutions provide predictions of water quality and optimise it chemically through utilising data analytics. By constantly providing high quality water, this is a long-lasting solution for improving community health conditions. The enhanced water quality is also leading to a reduction in disinfection residual from water catchment and treatability impacts and network impacts, which will be significantly beneficial to the environment.

In sewer data analysis, this solution streamlines and optimises the lengths of time between inspections and renewals, increasing the efficiency of repairing compromised infrastructure. This has resulted in a 5% lower investment cost, saving $40 million per annum.

For her exceptional leadership and achievements of enormous impact for the water sector, she was named the "Water Professional of the Year" by the Australian Water Association (AWA) NSW in 2016. She is the 2017 iAwards winner in pipe failure predictions. The collaborative work of data

analytics with Sydney Water also won the AWA NSW "Research and Innovation Award" 2018. The collaborative work with Western Water won the AWA VIC Award 2019.

The patented technologies also find their use in other infrastructure assets, such as the maintenance of Sydney Harbour Bridge. Further use of the methods continues to penetrate into other industries, such as maintenance for gas and oil pipes, and infrastructure assets for transport, energies and telecommunications.

Transport

At this current turning point for machine learning and AI, extensive research and existing data can be transformed into new algorithms. This enables safer, quicker, and smarter analysis of transport networks – it also allows for a more comprehensive evaluation of transport policy, projects, and pricing schemes, for large-scale metropolitan areas.

Professor Chen's solutions in this area are targeted and practical, utilising dynamic traffic pattern analysis. These solutions predict traffic patterns, provide decision support, ensure road safety, validate performance metrics, and create social benefits. Her work directly impacted transport planning for the Sydney Light Rail project, where innovative data-driven methods were used to understand commuter demand and how demand reacted to infrastructure provision. In the form of smart motorway solutions for the M4, her work reduced corridor travel time by 40%. Another project was the RMS Roads Report, an online service to provide the first international real-time travel time distribution to the general public. Finally, she created incident prediction services for Transport NSW, as well as monitoring for incidents, bushfires and major events using analysis of social media.

She also led a team winning the NSW Premier's Innovation Initiatives, working on reducing congestions for NSW and building the first system of this kind in the world business intelligence service. This initiative harnesses real-time and historical feeds from Opal cards, traffic signals and GPS trackers on state buses, as well as anonymised data from in-vehicle GPS devices, to compute the best traffic management options and deliver real-time travel time estimates. The team built the tool to include multi-modal data fusion and real-time simulation, again the first of its kind in the world. A staggering $5 billion is incurred annually in traffic congestion, and Professor Chen's projects assist NSW transport tremendously in mitigating this.

In addition to governmental industry work, Professor Chen has also worked with multibillion-dollar corporations to create joint solutions, using new technology to cater to industry needs. A current technological trend is Mobility as a Service (MaaS), where Professor Chen has worked in partnership with the Keolis Downer group to deliver an on-demand transport service to the Northern Beaches.

Professor Chen's work is widely recognised by the transport industry, and she has won the ITS (Intelligent Transport System) Australia National Award twice, in 2014, 2015 and 2018. The collaborative work with Sydney Trains was nominated as the finalist of for ITS Australia Research and Innovation Award 2020. Her work in smart cities was also named as a finalist for the National SmartCity Award 2020.

Customer Demand and Supply Chain Management

Professor Chen has been working on various analyses on customer behaviour and demand. That includes shopping behaviour and demand, behaviour in water and energy consumptions, transport demand including Mobility as a Service, and customer demand in telecommunication products and services.

Her work with a telecommunication company established a spatiotemporal forecast model to automatically cluster and forecast customer demand – and customer take up behaviour accordingly with both demographic and historical factors considered. She also used clustering and data mining algorithms to identify cohorts of unsatisfied customers and areas. This deepens the understanding of inactive customer behaviour and increases customer satisfaction. Her method not only reduced 62.5% of the prediction workload of analysts, but also improved the prediction accuracy by 30%. Such models also provided an accurate forecast for individual regions as informative guidance for workforce management.

As of May 2020, 96% of homes and businesses were connected within agreed timeframes with phone and internet providers – up from 87% in January 2019, respectively. Similarly, the customer satisfaction from the connection experience has improved by approximately 12%, and 2.8 million new customers have connected to a plan since the new model-based planning has been used. This success made her as the winner 2020 iAward for Government and Public Sector Solution of the Year.

Professor Chen also practiced widely in supply chain management, inventory management and process automation and optimisation with companies such as DHL and Acer Australia.

- **Extensive experience with strategy; leadership in creation and execution**

Professor Chen is passionate about digital transformation, particularly on using data science to influence evidence-based decision making in industry and governments. She has actively led in developing new strategies with innovative forward thinking and led teams to achieve outstanding outcomes.

With vast experience in many segments of industry and governments, she is also dextrous with external factors shaping advances in technology. A keen understanding of trends in technology, and where technology fits within the social, political, and economic landscape, allow her to formulate strategies for research, development, products and adoption with impact.

- **Global experience**

Professor Chen's extensive experience means she has worked with more than 80 different entities cross North America, Europe and many parts of Asia. She has worked in many industries, but as a water professional alone, she has achieved great success in the creation of advanced data-driven analytic solutions, serving more than 30 worldwide water utilities.

Her large-scale data collections and projects across different continents and judiciaries also gives her considerable understanding in global regulations and policy. She has been actively working with research communities and serving various roles in top international conferences – within industrial and technological events, she has extensive involvement. Of particular note is that from 2015 Professor Chen has been the main rapporteur of the ITS (Intelligent Transport Systems) – a world congress which summaries major technology trends in transport industry, and publishes global industrial guides, particularly on big data and its innovative use and disruption in the transport industry.

- **Multidisciplinary holistic approaches**

Professor Chen has had the opportunity over her career to increase her skills in multiple settings, having excelled in work across academia, industry, and government. This means she is a highly adaptive and skilled individual, having had success working in extremely varied circumstances, from early stage R&D, to product development and deployment, from education, to policy evaluation.

She has broad experience working with various disciplines – AI, machine learning, Data mining, IoT, civil engineering, including structure engineering and transport engineering, material science, chemical engineering, design, neuroscience, human machine interaction, and cognitive and organisational psychology.

The extensive experience of running multidisciplinary teams formulated her strong base of architecting innovative solutions to resolve complex problems in large-scale complicated systems or networks.

- **Public engagement and industrial relationships**

Professor Chen is socially savvy when it comes to working with people, establishing relationships and maintaining them.

She has done exceptional work to bridge industrial requirements and innovative technological solutions, creating value in research and business that is accessible to government and industry users. Some example clients are Sydney Water, Yarra Valley Water, Queensland Urban Utilities, Transport NSW, Transurban, DHL, VicRoads, MainRoads (WA), Telstra, Sydney Trains, V/Line, Western Water, Telstra, NBN, ANZ, AEMO, Salmat; Energy Safe Victoria, NSW Public Service Commission; multinational clients include GE, Acer, Downer, Cubic, WSP, AECOM, Thales, CAE, Boeing, Data Spark, Navantia, Isle Utilities and Dolby. She has led many scoping workshops with relevant business owners to sketch out business requirements, data availability, technical approaches and avenue to impact. Those discussions then turned into industry transformational practice.

She has also established relationships and served many government agencies, including the Department of Education, Department of Planning Industry and Environment, NSW Infrastructure, various transport agencies, the Department of Immigration and Border protection, NSW Public Service Commission, ATO and the DSTg. She is also a sought-after speaker for international events and technological advertisers for SMEs. She delivered a TEDx talk on “How can we design AI that we trust?” in 2019 for an audience of more than 5,500.

She is an active advocator for AI and its impact, potential issues and ethical approaches through numerous public speaking keynotes and panels. She has also had many media presences.

RECOGNITION AND AWARDS

- NSW Premier's Prizes for Science & Engineering: Excellence in Engineering and Information and Communications, 2021
- Women in AI Australia and New Zealand Award, AI in Infrastructure, 2021
- Best Overall Paper at the 25th Pacific-Asia Conference on Knowledge Discovery and Data Mining (PAKDD-2021), May 11-14, 2021, Delhi, India. Title “Weak Supervision Network Embedding for Constrained Graph Learning”.
- Australian Museum Eureka Prize for Excellence in Data Science, 2018
- iAward Victoria for Government and Public Sector Solution of the Year: “nbn Broadband demand forecasting”, 2020
- Research and Innovation Merit Award, Australian Water Association (AWA) VIC 2019, for collaborative project on data driven water pipe failure prediction with Western Water.

- NSW and National Research and Innovation Award, Australian Water Association (AWA) NSW 2018, for collaborative projects on data analytics with Sydney Water.
- "Brian Shackle Award" in 2017 in recognition of the most outstanding contribution with international impact in the field of human interaction with, and human use of, computers and information technology, Awarded by “International Federation for Information Processing”(IFIP)
- iAwards, 2017 on Water Pipe Failure Prediction.
- Water Professional of the Year 2016, a Water Award from the Australian Water Association (AWA) NSW. As a water professional, she spent years of her career in promoting data science in the water sector and has achieved great success in the creation of advanced data-analytics solutions, serving more than 30 worldwide water utilities. With extensive experiences and influences spanning the technical and organizational aspects, she is helping the water industry achieve ground-breaking approaches for the improvement of risk analysis and reactive maintenance, as well as significant economic benefits. Through the integration of a wide range of creations, she is now actively leading efforts that are expand the contributions beyond the water industry to the wider community, providing increased social benefits. The efforts include energy saving, environmental sustainability maintenance, and community health improvement nationally and internationally.
- 2014, 2015 and 2018 intelligent Transport Systems (ITS) Australia National Research Award. This is a recognition of the NICTA team’s advanced position in utilising machine learning in conjunction with transport science to achieve new cutting edge approaches on transport modelling, which brings efficiency in transport management and safety for communities.
- 2014 NICTA impact award.
- CeBIT2011 Innovation Awards Runner Up, 2011
- Highly Commended at Engineers Australia Awards, 2011
- OZCHI best Paper Award, 2007
- Innovation Award from Motorola, 2002 & 2003
- Engineering Award for Commercial Secret Motorola,2002
- Bravo Award for excellent performance, Motorola 2001
- Long-term Retention Award Motorola, 2001
- Award of “Next Generation Leader” Motorola, 2000
- Golden Award of Women Star, Motorola 2000
- Award for outstanding contribution, Intel 1999
- Award for youth academic leader in higher education, Beijing Municipal Commission of Education, 1997 (30 leaders elected from over 100 universities)

KEYNOTES/INVITED SPEECHES SINCE 2017

1. Data Driven future, Global woman in data science conference organized by Stanford University. March 2017
2. Data Driven Utilities, OzWater leadership forum, Apr 2017 Sydney
3. Transformation of asset management, International Asset Management Conference, June 2017, Melbourne
4. AI in transport, AI and machine Leaning Summit, Aug 2017, In conjunction with ICML 2017
5. Big Data Analytics, Big Data Forum, in conjunction with IJCAI 2017, Aug 2017.

6. AI and our future life, opening keynote, AI for education forum organized by NSW department of education Nov 2017
7. Big Data and infrastructure management, Asset Management Council Annual National Symposium 17th November 2017 Melbourne
8. Machine learning with impact, Downer group leaders innovation forum, Dec 2018
9. Automation and AI, Opening keynote speech, Applying Artificial Intelligence and Deep Learning for Enterprises Conference | 5 - 6 February 2018, Melbourne Convention and Exhibition Centre.
10. AI and smart city, WSP global leadership forum, Feb 2018
11. The impact of new wave technologies, TEDx, March 2018
12. AI and autonomous transport, WSP global innovation forum, March 2018
13. AI technologies for the future transport, the 2018 Australian Academy of Technology and Engineering (ATSE) National Technology Challenges Dialogue on the theme of Shifting gears: Preparing for a transport revolution, Melbourne on 9 May
14. AI and productivity, CeBIT's Artificial Intelligence & Machine Learning conference, May 2018
15. AI with impact, OSX Forum, Transport for NSW, May 2018
16. Advanced Data Analytics, International conference of Innovation in infrastructure and asset management, June 20 2018
17. AI in transport, Data Driven and Intelligent Mobility Conference in June 2018
18. AI and Trust, TEDx Sydney annual conference 2018
19. AI and Digital Economy, Entrepreneurs' Programme Annual Forum, Organised by The Department of Industry, Innovation and Science, Australian Government, July 2018
20. Using Data Analytics For Better Infrastructure Management Decisions, Smart Infrastructure Summit, Aug 2018
21. AI in transport, ITS summit, Aug 2018
22. Monitoring the Health of Structures with AI, AI and ML summit, Sep 2018
23. IoT and AI, Panel discussions, 16th International Conference on Business Process Management, Sep 2018
24. AI - research trend and future business, Australian Institute of Company Directors, Oct 2018
25. AI and Future, South Start-up annual conference, South Australian Government, Nov 2018
26. " Disrupt the gender gap in Artificial Intelligence", Hall & Wilcox 26 Feb, 2019
27. "Harnessing AI for future insights & informed decision making", Data Management and Security for Government Summit 27-28 Feb, Canberra, 2019
28. "AI for Insurance", HiVE 2019, Hong Kong Apr 2019
29. "AI and our future", Asia Business Link Annual Conference Apr 2019
30. "Impact of AI", Knowledgexchange Annual Conference (for accounting and advisory practices), Gold coast June 2019
31. "AI for smart infrastructure", 3rd Annual Emerging Technologies for Public Infrastructure Conference 19-20 June
32. "AI for future education", Annual conference on Blended Learning & Digital Campus, July 2019
33. "AI and our future", Cyber Security Network Annual Event, 26 July
34. "AI for Health", to NHMRC board July 2019
35. "AI in Education", AI for government 2019 conference, August 12-14.
36. "Big Data and Cities" , "The Shadow of Big Data - An Interdisciplinary Colloquium on Big Data's Human Impact", September 10th
37. "Data Driven Future for Water", Horizon 2020, Water Research Australian Annual Planning Conference 11 Sep 2019

38. “Data trust & privacy”, CEBIT Australia Oct 2019
39. “AI for education”, CIVICA Forum, Sydney Oct 2019
40. “AI and our Future”, AI in Libraries and Museums Symposium, Melbourne Oct 2019
41. “IoT and AI with Impact”, Industrial Internet Consortium Annual Conference, Nov 2019
42. Data Driven Predictive Maintenance for Water Utilities, Digital Maintenance and Field Service Automation Forum, March 2020, Melbourne.
43. “Data Science with Impact”, Communicating Uncertainty Conference, Sydney July 2020.
44. Data Driven Urban Design, 12th International Smart City Expo Mar 2020, Sydney.
45. “Data and Data Science for Mobility”, Mobility 2020 conference, September 2020.
46. “Intelligent Water Management Systems Using AI and IoT”, ASEAN Australia Smart Cities Trust Fund, November 2020
47. “AI and our future”, AI for public sector, November 2020.
48. “Ethical AI: from principles to practice”, UTS Ethical AI Webinar, Dec 2020.
49. Ethical AI Assurance Framework, NSW Government AI Summit, Feb 2021
50. Technologies in Secondary Education, ACCE annual conference, Digital Learning and Teaching Victoria, March 2021
51. AI and Women in AI, Women in AI APAC Datathon
52. Machine Learning with Impact, Mysuru IEEE Student Branch in association with IEEE Bangalore Section and IEEE Mysore Sub Section
53. Rise and risks of Talent AI, REEJIG and ATC Event & Media, Apr 2021
54. AI in reinventing construction, Webinar by UTS Boral Centre for Sustainable Buildings, Apr 2021.
55. Machine Learning for Infrastructure Maintenance, Field Service ANZ conference, Sydney July 2021
56. Evidence Based Decision Making with Big Data and Machine Learning, AI for Government Summit, Oct 2021
57. Machine Learning for infrastructure maintenance, ANZ field services annual conference, Oct 2021
58. Engaging with Industry, ATSE Industry Mentoring Network in STEM NSW annual event, Oct 2021
59. AI with Impact, Thought Leaders Series: Engineering smart cities leveraging AI innovation, Engineers Australia, Feb 2022.

Panels

60. “Future of Utilities”, SAP round table, March 2019
61. “Future of Work and Automation”, National HR Summit March 2019
62. “ REALISING 2030”, Dell event for industry CXOs
63. “ CityTalks Sydney: Our Future with AI and Its Rise in China”, City of Sydney annual event, Apr 2019
64. “The Reality behind AI in Business” , ZDNet's Next Big Thing, May 2019
65. “ Ethical dilemmas around AI adoption”, NSW AI Ethics Summit (panel with Human Rights Commissioner)
66. “Can/Should AI be trusted for decision making in Government?”, Government AI debate, June 2019
67. Served as a judge for National Final of the AI For Good Schools Challenge (together with Deputy Secretary, Department of Education) August
68. Leader’s panel: The evolution of AI uptake in Business and Government, AI for Business Summit, Sep 2019.

69. Co-creating the Smart City Roundtable - Planning for Sydney to 2050, Nov 2019
70. Panel discussion “Data Science Revolution in Government: Informing Better Decisions, Fostering Collaboration and Automating Public Services”, FSTGov NSW Digital Summit, November 2020.
71. Panel “The Future of AI in Government”, NSW government, November 2021.
72. Pioneering your career in STEM, Australian Computer Society Panel Session Oct 2021.
73. Panels on The Riding the Digital Wave Summit: Celebrating the 70 years birth of Computer Science in Australia, The Pearcey Foundation, Feb 2022
74. Panel discussion of Demystifying and Democratising Data to Build Clear Citizen-Centric Services, Public Service Network Data Management & Analytics Roadshow (NSW), Feb 2022

SELECTED MEDIA ARTICLES

1. 1/2/2022: UTS, Data science keeps the trains on track
2. 19/10/2021: Two cities one community, Policy another cross-border first
3. 20/09/2021: Create, Teaching artificial intelligence to spot when people need space to think
4. 16/09/2021: UTS, A data deep dive to deliver for Regional Australia
5. 29/03/2021: Women in AI Awards ANZ: Winners 2021
6. 17/03/2021: https://www.zdnet.com/article/nsw-artificial-intelligence-advisory-committee-inaugural-members-named/
7. 16/12/2020: ZDet, Australia gets a national guide to help assess effectiveness of STEM initiatives
8. 17/03/2021: Itnews NSW govt names inaugural AI committee members
9. 14/12/2020,The Australian,Afterpay’s growth ‘easier in Australia’
10. 09/12/2020, News8Plus World first for moral AI and office fairness
11. 08/12/2020: EurekAletert, World first for ethical AI and workplace equity
12. 08/12/2020: TechXplore, World first for ethical AI and workplace equity
13. 08/12/2020: Scimex, A world first for ethical AI addresses equity in HR hire
14. 08/12/2020, Techstreet, World first for ethical AI and workplace equity
15. 08/12/2020, Ethical Editor, World first for ethical AI and workplace equity
16. 07/12/2020: The Australian, World first for Ethical AI
17. 14/10/2020: iTnews, UTS trains AI to predict Sydney Trains' pandemic performance
18. 03/09/2020: The Mandarin, Eight experts on the risks and benefits of artificial intelligence in government and the public sector
19. 18/08/2020: ABC News, Are you really making your own decisions? The influence of algorithms, explained. | The Drum
20. 22/05/2019: The Australian, Student tracking to reveal keys to learning.
21. 11/04/2019: itNews, Acer, UTS partner for attention span boosting analytics pilot.
22. 10/04/2019: ZDNet, Acer and UTS trial classroom program that monitors student movements.
23. 10/04/2019: WHICH-50, UTS and Acer to track students eyes in education engagement study.
24. 21/03/2019: Fortescue, Fortescue to establish Future of Mobility Centre in Karratha.
25. 21/11/2018: SouthStart2018, AI with Impact.
26. 08/09/2018: news.com.au, Tech guru says Sydney Harbour Bridge is way smarter than most people think.
27. 01/05/2018: AFR Smart Cities, Population growth the challenge.
28. 03/09/2018: Water Source, Water pipe failure prediction tool takes out Eureka Prize.
29. 03/09/2018: Roads & Infrastructure, Predictive water pipes project wins top science award.
30. 24/07/2018: Australian Museum, Smart Infrastructure Team - WINNER, 2018 Eureka Prize for Excellence in Data Science.

31. 15/06/2018: TEDxSydney 2018, How can we design AI that we trust.
32. 09/11/2017: NSW Government, Education for A Changing World Symposium 2017.
33. 03/10/2017: itnews, Australian Navy trials sensor analytics on ship engines.
34. 22/10/2015: Roads & Infrastructure, New prediction system targets water pipeline failure.
35. 21/05/2015: Global Water Intelligence, NICTA's A$700 million promise to utilities.
36. 26/03/2015: ComputerWorld, Turnbull embraces the Internet of Things.
37. 2015: Deloitte Access Economics, "The implementation of the Smart Pipes technology could deliver $2.6 billion in economic benefits over the next ten years. The benefits from the cost reductions was be approximately $298 million a year in 2013-14."
38. 09/12/2014: ANT, ITS RECOGNISES TRANSPORT TECHNOLOGY INNOVATORS
39. 11/08/2014: The Australian, A big data fix for leaky pipes.
40. 13/02/2013: Government news, NICTA called-in to plumb depths at Sydney Water
41. 11/06/2012: The Sydney Morning Herald, Technology gives voice to worker brain strain.
42. 22/06/2011: The Conversation, I um therefore I ah: workplace stress and how to manage it.

PROGRAM COMMITTEES AND PROFESSIONAL SERVICES

- Advisory Board of Data for Social Good Hackathon, Data Science and Ai Association of Australia | DSAi, 2021
- Board Director, ITS (Intelligent Transport Systems) Australia, 2021
- Member, NSW Government AI Advisory Committee, 2021
- Member, "Public Interest Technology"(PIT) Advisory Committee, Committee for Economic Development of Australia CEDA, 2021
- Expert Panel member, National Science Foundation Singapore, 2021
- General Co-Chair, International Conference on Advanced Data Mining and Applications (ADMA) 2021
- General Co-Chair, 34th Australasian Joint Conference on Artificial Intelligence (AI2021)
- Chair (Elected), Steering Committee, ACM Intelligent User Interfaces, 2021
- Chair, National Transport Data Community of Practice (NTD-CoP), ITS Australia 2020. It is to foster collaboration and shared query into the potential opportunities and challenges transport data analytics offers our industry and community. The NTD-CoP includes representatives from government, industry and academia to investigate research opportunities, pilots and tests, and analysis of deployments.
- Editorial Board Member, MDPI. A pioneer in scholarly open access publishing, MDPI has supported academic communities since 1996 based in Switzerland, MDPI has 283 diverse, peer-reviewed, open access journals.
- Associate Editor, The ACM Transactions on Interactive Intelligent Systems (TiiS) publishes cutting-edge research in Human-Centred AI, in particular, concerning the design, development, and evaluation of interactive intelligent systems with two distinct characteristics: machine intelligence and user interaction.
- Australian Delegate representing Standard Australia, International working group on Smart City 2020.
- 2018 IJCAI Program Committee
- 2023 General Chair, International Conference on Intelligent User Interfaces (IUI)
  Have a winning bid to host the conference in Australia in 2023
- 2017 Program Co-Chair, International Conference on Intelligent User Interfaces (IUI)

- 2015 Senior Program Committee Member, International Conference on Intelligent User Interfaces (IUI)
- 2014 Senior Program Committee Member, International Conference on Intelligent User Interfaces (IUI)
- 2013 Senior Program Committee Member, International Conference on Intelligent User Interfaces (IUI)
- 2013 General Chair, International Conference on Multimodal Interfaces (ICMI)
- 2012 Area Chair, International Conference on Intelligent User Interfaces (IUI)
- 2011 Program Committee Member, International Conference on Intelligent User Interfaces (IUI)
- 2007 Publicity Chair, International Conference on Intelligent User Interfaces (IUI)
- 2007 Corporate Liaison Chair, Int. Conf. on Multimodal Interfaces (ICMI)

EMPLOYMENT HISTORY

UNIVERSITY OF TECHNOLOGY SYDNEY Dec 2018 – present

Executive Director Data Science/Distinguished Professor

Executive Director, UTS Data Science Institute

The responsibility of the Executive Director of UTS Data Science is to provide thought leadership and vision. It's to provide strategic direction across UTS in the area of data science. The Executive Director must develop and lead a UTS-wide plan to build UTS's national and international profile in data science research, engagement and innovation. This position leads UTS data science and plays a central role in developing strong links into industry and impact to society.

Internally, the Executive Director works with Faculties to mentor academics working in data science, working towards growing a new generation of leaders who can lead world-class research in data science.was

As executive Director of UTS Data Science Institute, Distinguished Professor Chen led key industry projects:

- **Reducing Leaks and Breaks in Water:** Professor Chen was the leading research partner of a $3 million project to deliver smart sensing and analytics solutions to the Australian water industry through the NSW Smart Sensing Network. Working with leading Australian water utilities such as Sydney Water, Hunter Water, SA Water, Melbourne Water, Queensland Urban Utilities and Intelligent Water Networks (IWN) – as well as collaborating with five utility provides in the United Kingdom – Professor Chen has delivered sensing and data analytics for preventing leaks and breaks in water infrastructure. The data-driven models and analytics platform help water utilities and community to save water and improve customer satisfaction. It improves operational reliability and achieves operational efficiency through improved planning and execution.

- **Predicting Fire Incidents Triggered By Electrical Network:** Fire accidents often cause substantial economic and ecological damage and endanger the lives of people. In Australia, there are approximately 100 fatalities and 3,000 injuries each year due to structure fires.

Although the data is incomplete, bushfires have accounted for at least 800 deaths since 1851, and incurred costs of at least 1.6 billion dollars. Therefore, it is meaningful to develop effective early prediction methods.

Victoria has a history of electricity assets causing bushfires. As the independent technical regulator responsible for electricity, gas and pipeline safety in Victoria, Energy Safe Victoria (ESV) plays an active role in reducing the loss of electricity distribution infrastructure that cause bushfires. UTS is collaborating with ESV in predicting electrical network-related fire incidents based on daily weather factors. We are exploring the weather patterns driving the number and size of network-related fire incidents. ESV can use this collaboration to significantly improve network safety.

- **Sydney Trains Passenger Flow:** Public transport systems are most keenly assessed by their users on on-time performance. Professor Chen has worked closely with Sydney Trains to develop new machine-learning-based vision processing systems that translate existing CCTV footage feeds into data streams. These describe passenger flow throughout the terminal, count passengers at each platform, and assesses the number of passengers boarding and exiting trains. This system has already been trialled with an inner-city section of the Sydney rail network and will ultimately facilitate real-time customer impact analysis, dynamic delay propagation estimation, and advanced (dynamic) timetabling and scheduling.

- **Timetable Delay Analysis:** The performance of a contemporary public transport system depends on profoundly complex interactions across passenger demand, network design, maintenance scheduling, incident reports, timetabling, vehicle availability and more. As such, Professor Chen and her team have developed software solutions that fuse these types of data streams,then leverage machine learning to deliver concrete and clear insight into the key predictors of public transport performance.

  For Sydney Trains, the team used historical train performance, customer data, and incident data to unlock new methods for realistic stress testing of timetable designs.

  For V/Line, a regional train service provider in Victoria, the team utilised a massive historical dataset capturing performance information from across the V/Line rural rail network to identify the root causes of delays. The project was able to provide quantified impact assessments and highlight likely emergent delay risks.

  https://www.itnews.com.au/news/uts-trains-ai-to-predict-sydney-trains-pandemic-performance-554237

  The Daily: UTS trains AI to predict Sydney Trains' pandemic performance

- **Automatic Train Track Inspections:** Working with Sydney Trains, an exciting new approach to track inspections was delivered. Historically, these inspections were completed manually, with a team of expert engineers reviewing *millions* of images per fortnight to identify potential track faults. The task is laborious, scales poorly, and is inherently prone to human error. Utilising contemporary machine-learning-based vision processing techniques, we have developed a system that automatically filters out safe track images, removing 99.9% of

images that an expert reviewer would be required to examine. The result is that reviewers can spend longer focused on the images that have higher importance, and a larger portion of the rail network can be examined each fortnight. Overall safety is improved while cognitive load for inspectors is also reduced.

- **Spare Parts Inventory Planning:** Original Equipment Manufacturers (OEMs) of electronic products often offer service warranties for system support to their customers. When a product has fault(s) within the warranty period, OEM is obligated to replace or repair the product with spare part(s) in a reasonable time span. To achieve high-level customer service and brand reputation, spare parts must be maintained at a sufficient inventory level and be provided to the customer in a timely manner. In a collaboration with Acer, based on information such as failure rate, accidental damage, and customer behaviour, an inventory planning system using predictive analytics was created. The system mitigates the risk of running out of stock for the remaining service period of a product. It also helps to balance between an out-of-stock and overstocking. Finally, the created system provided real-time analytics, through a dashboard on customer behaviour, failure rate and sector performance, among other indicators.

- **Using Machine Learning for Student Learning:** With machine learning techniques, we are taking a new approach to understand students' learning progress and experience. We do this via multimodal data analytics – utilising interaction signals like mouse movements, keyboard tapping and digital pen writing, together with detected eye gaze direction from the embedded camera, it is feasible to identify in real time where and what the students are looking at, to work out their respective attention levels. It is also possible to build the link between their attention and the learning outcome using data analytics techniques, which is essential for finding new ways to improve learning efficiency, develop innovative assessment method to enhance student wellbeing, create positive learning cycles and encourage lifelong learning.

  The Australian: Student tracking to reveal keys to learning

  Education HQ: University of Technology Sydney and Acer set to revolutionise the future of learning.

- **Ethical AI: Assessment of Non-biased Talent Shortlisting Algorithm:** The project is to develop a functional and defensible framework for assessing a talent platform performance in assessing and shortlisting candidates for roles.

  Based on a thorough review of international literature on fundamental ethical principles and guidelines for AI, we proposed a framework for the implementation of these principles: transparency, fairness, accountability, and privacy. These are aligned with mandatory ethical principles for the use of AI proposed by the NSW Government.

  An open online platform has facilitated the assessment of AI-based HR talent selection solutions – the solutions are being tested against core ethical principles before its delivery to users such as professional firms, banks, and governments.

  The Australian: World First in Ethical AI

ZDNet: Australia gets a national guide to help assess effectiveness of STEM initiatives

- **NBN Demand Forecast:** NBNco is designing, building and delivering the next generation of telecommunication networks to Australia. Close to $2 million service activations have been achieved since NBNco was established in 2009.. The corporate goal is for this to increase to $8 million, which implies that the growth rate will be doubled every six months for the next thre years.

  To reach the goal at this scale and speed, NBNco *needs* efficiency in connecting customers to the network. A timely and accurate service activation forecast is required to guide the workforce management – predictions that put the correct staff at the correct location, at the correct time of service activation – so that disappointing customer expectation, losing revenue, and wastefully reallocating workforce resources can be avoided.

  A spatiotemporal forecast model has been worked out to automatically cluster spatial regions based on their similarity in demand and provide forecast accordingly with both demographical and historical factors considered. Such model can provide an accurate forecast for individual regions as informative guidance for workforce management.

- **Kiwi Fruit Yields Prediction**
  Australia and New Zealand are significant world producers of many agricultural products, of which fruit is one of the top ten exports. The accurate estimation of fruit yields and sizing plays a significant role in the allocation of labour and equipment, as well as in the planning of international trading and supply chains. However, complex interactions in the environment, such as weather and plant wellbeing, cause costly uncertainty in yields and sizing in products .

  An innovative data-driven approach to accurately predict kiwi fruit yields was incorporated with expert commercial solutions and delivered to end users. The developed approach is currently being utilised by Zespri International in New Zealand; Zespri is the world's largest marketer of kiwi fruit, exporting to more than 60 countries and managing 30% of the global volume. The solution allows the client to predict the yields and sizing of their kiwi fruit before the harvest to realise their market price objectives and plan supply chain operations with high confidence. It also significantly saves staff cost for manual counting and provides timely access to the growth information.

- **Data-driven Pro-active and Predictive Care for Seniors**

  The Medical Technology, Biotechnology & Pharmaceutical Sector Competitiveness Plan notes in its assessment of medical megatrends that "between 2015 and 2030, the proportion of the population aged 60 or over is projected to grow by 56%" and that such profound and rapid growth will bring "an ever-increasing cost to the public health system".

  Professor Chen led data analytics of the development, trialling and testing of innovative, unobtrusive sensor technologies that collect and transmit a diverse set of real-time health data metrics, which are of direct relevance for the early diagnosis and assessment of health issues in the elderly.

- **Pilot Training Quality Assessment in Simulation**

  Pilot training is an expensive and lengthy exercise. The core of the training system is a large data store that constantly records the necessary data from the simulator and stores it for future reference. This data is automatically labelled with tags for common events, like starting a training session, repositioning, pausing/freezing the simulator etc.

  Using machine learning, steps and alerts are generated automatically to determine if a manoeuvre should be performed without input from the instructor.

  This work is the first step on a pathway to a building block that can be incorporated, firstly into helicopter simulators, but eventually into a wide variety of training devices. It can be incorporated into the training syllabus to improve the training outcomes – both reducing the cost of training through a reduction in retesting, and increasing the quality of the training through raising the retainment rate of vital information.

NATIONAL ICT AUSTRALIA (NICTA), Data61 (CSIRO) Jan 2004 – Nov 2018

Research Group Leader/Senior Principal Researcher

Main Accomplishments:

RESEARCH

Professor Chen created research excellence on Bayesian non-parametric, large scale inference, imbalance/sparse data, non-homogeneous stochastic process, spatiotemporal modelling, collaborative filtering, data fusion, uncertainty, user behaviour analytics and adaptive data modelling.

She led the team and developed a unified analytics platform for smart infrastructure, providing data analytical solutions, achieving significant industrial impact. The platform can gain holistic and dynamic views of urban systems from disparate datasets, and to provide urban recommendations for policy making and business innovation.

She pioneered the theoretical framework of measuring cognitive load through multimodal human behaviour, and provided much of the empirical evidence on using human behaviour signals (such as speech, language, eye movement and manual/pen gesture) and physiological responses (such as EEG and skin conductance) to measure and monitor cognitive load. This work has been applied worldwide in emergency management centres, including transport management centres, air traffic control centres, bushfire management centres, paramedic services, as well as in military training, elite sports training, and education.

Professor Chen has also been a recipient of various research grants from the US Air Force Office of Scientific Research for more than 10 years, and has maintained a close relationship with US Air Force Research Labs.

Her research has resulted in more than 300 Publications and many patents. It also attracted significant media attention, resulting in TV interviews by ABC 7PM news, The Australian, Channel 7 Beyond Tomorrow and many articles in newspapers and magazines.

IMPACT

She leads multiple industry-transforming taskforces in data analytics technology, and is engaged in projects of national and international scale and impact. She has been revolutionising industries by better utilising the data they have, increasing their productivity and innovation through business intelligence. She has achieved great success in many projects in advanced data analytics in asset management, infrastructure maintenance, performance monitoring and failure prediction. Estimated by Deloitte, the benefits of failure prediction technology created by her and the team include potential cost reductions of approximately $298 million per year in Australia, and may deliver $2.7 billion in economic benefits over the next ten years.

She is also leading the effort on Data Driven Transport Modelling, to use machine learning and data analytical algorithms in solving real-world transport problems, leading to solutions for predicting traffic patterns, providing decision support, ensuring road safety, validating performance metrics, and creating social benefits.

The following are sample externally funded projects she led and is leading, some current and some delivered to in the last five years, within transport and civil infrastructure.

TRANSPORT

- Professor Chen led the **NSW Premier's Innovation Initiative** on congestion priority. Sponsored by Transport NSW and working with Premier's office, this project aims to tackle NSW's $5B annual cost in traffic congestion, by compiling data from Opal, GPS devices, traffic signals, and buses to provide better information for the Transport Management Centre. The project is creating a data analytics platform for Transport NSW to better provide multimodal transport and better manage congestion on transport networks. The platform aims to reduce congestion, which costs billions of dollars for NSW's economy.

- Led the partnership with Downer group to deliver an **on-demand transport trial** in the Northern Beaches, where she leads demand estimation and occupancy requirements. Mobility as a Service is a trend for future mobility.

- **RMS Roads Report System:** The report services are among the first internationally to produce travel time distribution in real-time for the general public. This was achieved by developing a data analytics module for SCATS and GPS data. As of now the service has been online for more than 3 years, and covers 128 Key routes across NSW. Incidents and major events are described to help understand changes in traffic situations.

- **Sydney CBD mobility:** The CBD and south east light rail was a major effort by the NSW government to mitigate congestion in and around the Sydney CBD. Professor Chen worked with RMS, to create innovative machine learning based algorithms and simulations, which help to understand traffic demand across the CBD and its reaction to infrastructure provisions.

- **Sydney M4 Smart Motorway Evaluation:** Requested by Infrastructure NSW, a smart motorway solution was evaluated using data science and an analytical tool for traffic data. The travel time during the most congested period has been reduced by more than 40%, which can save NSW millions of dollars, even without accounting for the additional social

and environmental cost.

- **Kwinana Freeway widening (Perth):** Using real data of vehicle flow on an increasingly congested four-lane freeway, Professor Chen led the team using RAMP metering technology and smart algorithms to pace cars into available gaps in freeway flows. This solution increased capacity and flow of the freeway by 41% in peak periods (evaluated using real data). The WA government was imminent in spending $300M to add an additional lane on each side – the solution has close to the same impact for a faction of the cost.

- **VicRoads:** Reviewed VicRoads' data structure, and used crash data and social media data to create real-time awareness of the road network. The performance of road intersections are also being objectively evaluated, based on traffic control signals and throughput of the intersections and links.

- **Traffic Watch:** Social media has become a valuable source of real-time information. These web-based machine learning algorithms provide a spatial and temporal display of Twitter information that is potentially related to transport issues, major events, and emergency situations such as bushfires. The mobile app was developed for Transport for NSW.

- **Decision Support for Incident Management:** This project identified existing traffic and transport incident issues to assist the Transport Management Centre NSW. It provided real-time estimation of clearance time for traffic incidents.

- **Large Scale Traffic Simulation for Sydney Metropolitan Area:** Initiated by NSW Trade & Investment, this project developed a large-scale traffic simulation platform to assist transport planners and traffic engineers in evaluating the holistic impact of their proposals or solutions to urban traffic as a whole. The key is to utilise machine learning technologies to solve problems in a city-scale traffic simulation platform in Sydney, in order to conduct real-world surveillance and planning.

- **Structural Health Monitoring for Sydney Harbor Bridge:** Analytical techniques provide information for specific situations such as damage detection, condition assessment, loading assessment, and maintenance prioritisation. The developed technology enables more informed maintenance decision-making, and provides asset managers and engineers with situational awareness. More than 3,000 sensors are installed on the Sydney Harbor Bridge, and 24/7 monitoring is supplied by via web and mobile applications and database services.

CIVIL INFRUSTRUCTURE AND ASSET MANAGEMENT

The rapid emergence of big data in the infrastructure sector has unlocked a range of exciting new opportunities for transforming the way that risk assessment, maintenance scheduling and fault analysis is conducted. However, to deliver on these opportunities, systems must be developed which can collate and fuse incredible volumes of data and which can translate those volumes into concise, genuinely insightful and practically actionable information.

Water Utilities

- **Water pipe failure prediction:** Professor Chen created the most accurate prediction method in the world for urban water infrastructure pipe failure prediction. The method has been validated worldwide through datasets coming from more than 30 utilities, including many key utilities in Australia, and others in UK, Netherlands and Hong Kong. Based on new algorithms Prof Chen and the team created, the analysis on more than 10 million assets and more than 1 million failure records cross the global utilities proved more than double of discovery rate on failures than industry standard methods.

- **Predictive Analytics for Sewer Corrosion:** With four utilities across Australia and three research organisations (including universities), the machine learning approach has been used in predictive analysis for sewer corrosion. The resulting predictions will lead to more effective chemical dosing, sewer pipe rehabilitation, and sensor deployment based on dynamic demands, rather than over arbitrary time periods and based on guesswork.

- **Intelligent Network Operation:** Systematically studied the impact of network operations on energy costs, water quality, and minimum water loss. It provided water quality situation awareness tool and effective chemical dosing monitoring.

- **Water Demand Analysis:** the analysis provided crucial for water utilities to make a financially sustainable plan in creating water pricing and infrastructure investments. The outcome of the analysis can also be used for accurate marketing, efficient customer survey and customer behaviour monitoring.

- **Water leakage detection:** Leakage is a concealed failure that occurs underground unnoticeably before developing into an observable state, resulting in high economic loss. Therefore, leakage prediction and the corresponding maintenance strategy optimisation is of great significance. Water utilities have invested tremendous resources on actively tackling leakage and repairing pipes. This project outcome shows an industry paradigm that is shifting towards using data to make more informed decisions.

- **Wastewater Pipe (Sewerage) Blockage Prediction:** For water utilities, wastewater pipe blockages pose a great challenge to the daily operation of water pipe network. Not only could it cause high economic costs in emergency repairs and lost revenue, but it could also cause great social impacts in service disruption, pollution, and road and amenity closure. The outcome of this project provides data driven decision support to water utilities for a more efficient and predictive maintenance strategy. Interestingly, the data from vegetation coverage, climate, soil and demography plays a significant role in the solution. The prediction result is under trialling with Sydney Water under a new agreement.

- **Long-term Reticulation Water Pipe Failure Prediction:** The reticulation water main (RWM) network is one of the most valuable assets to water utilities. However, due to structural degradation, corrosion, hydraulic shock and third party damage, a considerable number of failures occur on RWMs every year, which cause significant economic and social cost. A stochastic point process-based statistical model has been created to provide accurate long-term failure prediction for RWMs. The experimental results demonstrate its superiority over the previous industrial approaches.

Telecommunications

- **Telstra Predictive Maintenance:** This project focuses on power and facilities management. The objective is to investigate the related data and explore the potentials of data analytics techniques, with the aim of a more efficient, proactive, and customer-experience-centric power and facilities management model.

  As the cornerstone of this project, 14 internal and external datasets covering the site characteristics, asset conditions, incident records, environmental conditions, maintenance records, and usage characteristics of more than 60,000 sites have been investigated. A predictive maintenance model is developed to proactively targeting high-risk sites for maintenance. An evaluation conducted on the 2016-17 financial year data suggested that the effectiveness of the maintenance expenditure could be improved by 40-60% by adopting this predictive model's prioritisation recommendation. This verifies the feasibility and potential of a customer-experience-centric maintenance model fuelled by data analytics techniques.

Energy

- **Power Load Disaggregation:** This project uses IoT technologies and data driven techniques to improve intelligent power load disaggregation in both residential and commercial environments. This research on intelligent energy disaggregation helps businesses understand where their energy is used, conserved, and wasted. Collaborating with an Energy start up, Professor Chen's team designed and developed next-generation technologies to revolutionise the energy ecosystem. The application module recognises changes in device's states, then tracks the operation pattern and power consumption of the individual appliance. Based on this, personalised and useful suggestions are provided. The prediction can also help electric power companies accurately calculate energy demand.

- **Solar photovoltaic (PV) gross generation estimation:** Machine learning algorithms were investigated to identify how much solar gross generation is produced, based on net metering, solar irradiance, temperature, and other weather features. The aim is to precisely estimate the regional solar gross generations for the optimisation of the grid management.

- **Fault detection and diagnosis (FDD):** In this project, FDD algorithms were used to monitor building HVAC systems (heating, ventilation, and air conditioning) to detect system performance changes, and to diagnose possible equipment failures that could explain it. Machine learning algorithms were used to build a model to sense normal behaviour data patterns, and then used to detect variations reflecting abnormal operation. This is part of a collaborative work with Honeywell.

- **Residential and occupancy analysis:** Working with an energy company based on data from UK and Australia, machine learning models were investigated to analyse residential and occupancy status in households or regions, based on energy consumptions, weather features and other information.

Other Government Departments and Enterprises

- **Manuka Smart Parking Data Analysis:** With the increasing demand and expectation for public parking spaces, smart parking systems are being adopted in many parking lots. They utilise sensing devices to monitor occupancies in real-time, then distribute the information via various channels, such as signboards, Internet websites and mobile applications. They help reduce parking time, ease traffic load burden, and better utilise the parking spaces.

  Professor Chen collaborated with the ACT government on a smart parking system – using parking patterns from the sensor data, a prediction model for future occupancy rates was developed. The outcomes of this data analysis and prediction model provide decision support for both policymakers and motorists.

- **Dwelling Production Prediction:** Understanding the dwelling production trend is of significant importance to policymakers for efficient urban planning. In this study, Professor Chen collaborated with the NSW Department of Planning and Environment to understand the impact of influential factors on dwelling production, and then to build a prediction model which could forecast where and when new dwelling production will appear. The study investigated the impact of macroeconomic indicators and demographical factors for each local government area (LGA). Finally, a machine learning-based prediction model was built to accurately forecast the dwelling production for the overall greater Sydney area, and each individual LGA.

- **Department of Infrastructure:** performing data extraction and analysis of key existing road-related data to support heavy vehicle road reform (HVRR) using a commercial data analytics system. The analysis includes various data types from jurisdictions and other relevant sources, and extracts meaningful information in support of road reform. This provides a costed methodology on how an analytics platform could be used nationally.

- **Cognitive Load in Emergency Management Centres and Bushfire Management Centres:** Cognitive load is important to maintain effectiveness and performance of operators. Various projects were carried out with bushfire management centres, air traffic control centres, ambulance dispatch centres and transport management centres in key Australian states and overseas (Canada, US and Philippines). To provide measurement of an individual's cognitive load levels in real-time unobtrusively and automatically through physiological (e.g. skin conductance, pupil dilation and EEG) and behavioural patterns (e.g. speech/language, eye-movement, mouse movement, and pen-gesture/handwriting), factors which affect cognitive load such as stress, trust, and environmental factors were all extensively studied. Furthermore, dynamic workload adjustment and real-time CLM with data streaming were evaluated to make CLM accessible by more widespread applications and users.

- **Human-machine interaction trust calibration:** Professor Chen has conducted projects with organisations such as DSTg and ANZ. Trust has been realised as one of the most important factors in management and organisational behaviour, for all personal and business decision making, as well as for efficiency and task performance. It is also a critical factor Professor iving human behaviour with automation systems in modern complex high-risk domains, such as aviation, and the military command and control. This project developed automatic, real-time, and implicit methods of assessing human-machine interactions, analysed multimodal and social behavioural features to provide dynamic measure of trust, and performed uncertainty-aware trust calibration. The research outcomes will help achieve adaptive

system response according to users' current trust perception, and can be used as a strategy to improve the user's trust and the effectiveness of communication between the user and the system.

- **Gas pipe predictive maintenance:** Woodside Petroleum owns an asset network of 125km of gas/oil pipes. Typically, 30 years of observation data with multiple (up to 126) features, including pipe attributes and environmental factors, such as pipe material, size, humidity, temperature and geometry, are available for pipes of 50 years old. The project worked on corrosion based pipe failure prediction, especially focusing on the impact of various features on pipe failure and the prediction model on pipe failure.

- **Predictive maintenance for naval engines:** Naval Engine developed an application that processes data from Navy engines captured from sensors and use advanced machine learning to predict future failures, reduce fuel burn and improve engine performance. Data is captured initially from Navy vessels, which will then be used to help improve and manage the performance of marine turbines used more broadly across the fleet.

MOTOROLA 2000 – 2004

Lab Manager/Chair of Patent and Publication Committee/ Principal Researcher

Main Accomplishments:

- Created the R&D lab in speech and language generation in Motorola China Research Centre and established strategic plan and roadmaps for the lab
- Actively contributed to the global R&D roadmap for Motorola's future mobile phones and network services
- Oversaw and led market product evaluation and new product function design for speech and handwriting products in China.
- Promoted technologies, in her capacity as Account Manager for Motorola Labs, into the Great China region.
- Successfully created new speech recognition, text-to-speech and handwriting recognition systems into Motorola A760 and other mobile phone models, which delivered to the global market.
- Created the best-in-class embedded Text-To-Speech system for Motorola products and won the award of "Female Star" for quickly establishing the team and delivering the best systems.
- Established and led architecture design for five projects, including embedded text-to-speech Systems, text summarization systems, the talking head system, and spoken dialogue systems, with more than 50 staff.
- Coordinated three large data collection programs for product fine-tuning, with over 10,000 subjects involved across 10 provinces, and dealing with more than 30 partner institutes.
- Architected test plans and completed product tests in Taiwan, Hong Kong, Beijing and Shanghai for handwriting recognition technology, with over 10 organisations and 5,000 test subjects.

- Delivered a speech with the Motorola CTO to an audience of 4,000 people about the next generation of human-machine interfaces on mobiles, at the annual meeting of the Chinese Academy of Science.
- Led the human-machine interface design in the digital media content management research throughout the scenario design, requirement extraction, system design and implementation, and system evaluation.
- Managed the marketing study project regarding future trends for human-machine interfaces in various handheld products with a local consultancy company; valued deliverables have been produced.
- Established solid connections with business parties within Motorola and successfully promoted self-produced technologies into mobile phones, such as image processing algorithms for future Motorola mobiles.
- Led the patent and publication committee in Motorola's Australian Research Centre to evaluate more than 100 patent applications and 100 papers per year.

INTEL 1999 – 2000

Team Leader/Senior Researcher

Main Accomplishments:

- Created the strategic plan and technology roadmap for the team with research direction aligned with the company's business objectives.
- Created the best-in-class PC-based computer-synthesizer with the team
- Was actively involved in chipset library design for special speech functions.

BEIJING JIAOTONG UNIVERSITY, CHINA 1995 – 1999

Dean of Faculty of Electronic and Information Engineering/ Director of Institute of information science

The faculty was composed of the School of Telecommunication and Information Engineering, the School of Electrical Engineering, the School of Computer Science, the Institute of Information Science, the Institute of Optical Wave Technology, and the National Teaching Base of Electrical and Electronics –altogether, this represented approximately one-third of the whole university, with over 1,000 staff members, 5,000 undergraduate students, 5,000 correspondent students and 1,000 graduate students.

Main Accomplishments:

- Strategic planning for the faculty to grow in research and education
- Active maintenance of the relationships with the Ministry of Education, Ministry of Railway and other organisations.
- Fundraising for research projects ($A10 million annually), project management, budget planning, human resource management and establishment of research infrastructure within the research labs.

- Being extensively involved in establishing joint-labs with best-in-class enterprises such as TI, Microsoft, Dell etc.
- Being actively involved in the joint project between EU and Beijing Municipal government to establish Intelligent Transport Systems, as a member of the steering committee.
- Overseeing the education programs for undergraduate and graduate students (enrolments, examinations, curriculum design, accreditation, quality control) and the establishment of laboratories.
- Chaired the committee of Chinese Institute of Electronics for Youth and organised the Institute's annual conferences.

ACADEMIC QUALIFICATIONS

Doctor of Philosophy (Computer Science)

Beijing Jiaotong University, China

Title of Thesis: *The Modeling and Realisation of Natural Speech and Language Generation System* (One of 100 PhD theses nominated for a nationwide excellent thesis award by the Ministry of Education).

Master of Science (Electrical Engineering)

Beijing University of Aeronautics and Astronautics, China

Bachelor of Science (Electrical Engineering)

Beijing University of Aeronautics and Astronautics, China

SELECTED PATENTS (30+ GRANTED AND FILED PATENTS IN TOTAL)

1. J. Huang and F. Chen, “Concatenative Text-to-speech Conversion”, application No. CN1471025A, granted on Jun. 14, 2006 (CN1259631C).
2. Text-to-Speech System with Prosodic Control, China patent application No. ZL02127007.4 Huang, J., Chen, F, 25 July 2002. Granted 14 June 2006. Patent number : 02127007.4
3. F. Chen and G. Chen, “Chinese Segmenting Method”, application No. CN1471024A, granted on May. 17, 2006 (CN1256688C).
4. F. Chen and G. Chen, “Method for Synthesizing Speech”, application No. CN1604182A, granted on Jun. 21, 2005 (CN1260704C).
5. F. Chen and G. Chen, “Method for Synthesizing Speech”, application No. KR20060066121A, granted on Oct. 22, 2007 (KR100769033B1)
6. F. Chen, B. Yin, and K. MacDonald, “Verifying a User,” application filed on Dec. 18, 2012 (AU 2012265559).
7. F. Chen, K. Yu, “Measuring Cognitive Load”, application filed on Feb. 13, 2012 (AU 20122008812).

8. F. Chen, B. Yin, and K. MacDonald, “Verifying a user,” Application No. US13551313, filed on Jul. 18, 2013 (US20130185071A1).
9. F. Chen, N. Ruiz, and E. Choi, “Measuring cognitive load,” Application no. US20100217097A1, granted on Nov. 17, 2015 (US9189596B2).
10. F. Chen, N. Ruiz, and E. Choi, “Measuring cognitive load,” Application no. CA2655189A1, granted on Jan. 26, 2016 (CA2655189C).
11. F. Chen and K. Yu, “Measuring cognitive load,” Application No. US20120282577A1, granted on May. 16, 2017 (US9652996B2).
12. F. Chen, M. Asif Khawaja, and E. Choi, “Measuring cognitive load,” Application No. US20110207099A1, granted on Aug. 22, 2017 (US9737255B2).
13. F. Chen, M. Asif Khawaja, and E. Choi, “Measuring cognitive load,” Application No. 2008905089 AU, granted on Aug. 22, 2017 (AU 2009299102).
14. Bang Zhang, Yang Wang, and Fang Chen, “Extended Hawkes process for infrastructure failure prediction,” application filed (N14 012-PROVAU), 2014.
15. Z. Li, Y. Wang, and F. Chen, “Bayesian nonparametric method for infrastructure failure prediction,” application filed on Oct. 29, 2015 (US20150310349A1)
16. Zhidong Li, Yang Wang, and Fang Chen, “Bayesian nonparametric method for infrastructure failure prediction,” WO2014085849A1, 12/6/2014.
17. Bang Zhang, Zhidong Li, Yang Wang, and Fang Chen, “Determining a health condition of a bridge,” WO2014176625A1, 16/11/2014.
18. “System and method for determining a service demand in a service network”, Fang Chen, Yan Xu, Chen Cai, Australian patent application 2015904699, filed on November 13, 2015
19. “System and method for determining a service demand in a service network”, Fang Chen, Yan Xu, Chen Cai, PCT/AU2016/051086, filed on November 11, 2016
20. B. Li, Y. Wang, F. Chen, and Y. Wang, “Group Infrastructure Components,” WO2016119012A1, 4/8/2016
21. B. Zhang, Y. Wang, and F. Chen, “Infrastructure working behaviour characterisation,” WO2016090428A1, 16/6/2016

SELECTED REFERREERED PUBLICATIONS IN PAST 10 YEARS (300+ CAREER PUBLICATIONS IN TOTAL)

Books and Refereed journal papers:

- ***Human-Computer Interaction***

1. L. Wen, J. Zhou, W. Huang, and F. Chen, “A Survey of Facial Capture for Virtual Reality", IEEE Access, 2022.
2. F. Chen, C. Duarte, and W.-T. Fu, eds, “Highlights of ACM IUI 2017”, ACM Transactions on Interactive Intelligent Systems (TiiS), 2019.
3. S. Oviatt, K. Hang, J. Zhou, K. Yu, and F. Chen, “Dynamic Handwriting Signal Features Predict Domain Expertise”, ACM Transaction on Interactive Intelligent Systems, vol. 8, no. 3, article no. 18, 2018.
4. F. Chen, J. Zhou, and K. Yu, “Multimodal and Data driven Cognitive Load Measurement”, in R. Zheng, editor, Cognitive Load Measurement and Application: A Theoretical Framework for

Meaningful Research and Practice, chapter 10, pages147-163, Routledge, New York and London, 2018.

5. J. Zhou, K. Yu, F. Chen, Y. Wang, and S. Z. Arshad, “Multimodal Behavioural and Physiological Signals as Indicators of Cognitive Load”, in S. Oviatt, editor, Handbook of Multimodal-Multisensor Interfaces, Morgan & Claypool Publishers, 2018.
6. B.-W. Hsu, M.-J. J. Wang, C.-Y. Chen, and F. Chen, “Effective Indices for Monitoring Mental Workload While Performing Multiple Tasks”, Perceptual and Motor Skills, vol. 121, no. 1, pp. 94-117, 20 Y. Uemura, Y. Kajiwara, J. Zhou, F. Chen, and H. Shimakawa, “Estimating Human Physical States from Chronological Gait Features Acquired with RFID Technology”, Sensors & Transducers, vol. 194, no. 11, pp. 76-83, 2015.
7. M. A. Khawaja, F. Chen, and N.Marcus, “Measuring Cognitive Load using Linguistic Features - Implications for Usability Evaluation and Adaptive Interaction Design”, International Journal of Human-Computer Interaction, vol. 30, no. 5, pp. 343-368, 2014.
8. M. S. Hussain, R. A. Calvo, F. Chen, Automatic cognitive load detecting from face, physiology, task performance and fusion during affective interference, Interacting with Computers, 25(4), 2013. Elsevier.
9. P. Zarjam, J. Epps, F. Chen, and N. H. Lovell, “Estimating cognitive workload using wavelet entropy-based features during an arithmetic task”, Computers in Biology and Medicine, vol. 43, no.12, pp. 2186-2195, 2013. Elsevier.
10. F. Chen, N. Ruiz, E. Choi, J. Epps, A. Khawaja, R. Taib, B. Yin, and Y. Wang, “Multimodal Behaviour and Interaction as Indicators of Cognitive Load”, ACM Transactions on Interactive Intelligent Systems, vol. 2, no. 4, 2012.
11. M. A. Khawaja, F. Chen, and N. Marcus, “Analysis of Collaborative Communication for Linguistic Cues of Cognitive Load”, Human factors, International Journal of Human Factors and Ergonomic Society, vol. 54, no 4. pp 518-529, August 2012.
12. P. Zarjam, J. Epps, F. Chen, and N. H. Lovell, “Classification of Working Memory Load Using Wavelet Complexity Features of EEG Signals.” Lecture Notes in Computer Science, vol. 7664, pp. 692–699, Nov. 2012, Springer-Verlag Berlin.
13. Khawaja, M. A., Chen, F., Marcus, N., “Analysis of Collaborative Communication for Linguistic Cues of Cognitive Load”, International Journal of Human Factors and Ergonomic Society, vol. 54, no 4. pp 518-529, August 2012.
14. Ruiz, N., Chen, F. and Oviatt S., “Multimodal Input”, in Multimodal Signal Processing: Theory and Applications for Human-Computer Interaction. Edited by Thiran, J.P., Marques, F. and Bourlard, H., Academic Press, 2010, Chapter 12, pp. 231-255.
15. F. Chen, N. Ruiz, E. Choi, J. Epps, A. Khawaja, R. Taib, B. Yin, and Y. Wang, “Multimodal Behaviour and Interaction as Indicators of Cognitive Load”, ACM Transactions on Interactive Intelligent Systems, vol. 2, no. 4, 2012.
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- ***Machine Learning***
    - ***General Machine Learning***

19. Iman Rahimi, Amir H. Gandomi , Kalyanmoy Deb, Fang Chen, and Mohammad Reza Nikoo, “Scheduling by NSGA-II: Review and bibliometric analysis”, Processes, 10(1), 98, 2022.
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21. J. Zhou, W. Huang, and F. Chen, “Facilitating Machine Learning Model Comparison and Explanation Through A Radial Visualisation”, Energies, 13(21), 7049, 2021.
22. Z. Zhang, Q. Wu, Y. Wang, and F. Chen, “Exploring Pairwise Relationships Adaptively from Linguistic Context in Image Captioning”, IEEE Transactions on Multimedia, 2021.
23. F. Zhou, S. Luo, Z. Li, X. Fan, Y. Wang, A. Sowmya, and F. Chen, “Efficient EM-Variational Inference for Nonparametric Hawkes Process”, Statistic and Computing, 2021.
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26. I. Rahimi, A. H. Gandomi, P. G. Asteris, and F. Chen, “Analysis and Prediction of COVID-19 using SIR, SEIR, and Machine Learning Models: Australia, Italy, and UK Cases”, Information, 2021.
27. I. Rahimi, F. Chen, and A. H. Gandomi, “A review on COVID-19 forecasting models”, Neural Computing and Applications, 2021.
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- ***Transport and Structural Health Monitoring***

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- ***AI Ethics***

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217. J. Zhou, S. Verma, M. Mittal, and F. Chen, " Understanding Relations between Perception of Fairness and Trust in Algorithmic Decision Making", International Conference on Behavioral and Social Computing (BESC 2021), 2021.

218. J. Zhou, F. Chen, A. Berry, M. Reed, S. Zhang, and S. Savage, “A Survey on Ethical Principles of AI and Implementations”, 2020 IEEE symposium on the ethical, social and legal implications of artificial intelligence (ETHAI), Canberra, Australia, 2020.

219. J. Zhou, W. Huang, and F. Chen, "A Radial Visualisation for Model Comparison and Feature Identification", PacificVis 2020, Tianjin, China, 2020.

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233. J. Zhou, Z. Li, Y. Wang and F. Chen: Transparent Machine Learning – Revealing Internal States of Machine Learning. In IUI2013 Workshop on Interactive Machine Learning.

CURRENT AFFLIATIONS

THE UNIVERSITY OF NEW SOUTH WALES

Conjoint/Adjunct Professor

Professor Chen has been appointed as a conjoint professor since 2004. She has taught several university courses and supervised more than 30 PhD students to finish.

Prof Michelle Baddeley

Staff no.: 146999

Associate Dean (Research And Development), The Dean's Unit

Web

ORCID: orcid.org/0000-0001-7884-0374

Google Scholar: scholar.google.co.uk/citations?user=085IGIgAAAAJ&hl=en

Other: theconversation.com/profiles/michelle-baddeley-434298

ResearchGate: www.researchgate.net/profile/Michelle_Baddeley

Overview

Michelle is an expert in behavioural economics and behavioural finance. She has a Bachelor of Economics (First Class) from the University of Queensland and a Masters/PhD in Economics from the University of Cambridge. She has held appointments at the Commonwealth Treasury in Canberra; Gonville and Caius College and the Faculty of Economics at the University of Cambridge; University College London; and the Institute for Choice (University of South Australia). She is currently a Professor in Economics, the UTS Business School's Associate Dean Research and the Director of the Centre for Livelihoods and Wellbeing (CLAW). She is also President of the Society for the Advancement of Behavioral Economics and Editor-in-Chief of its Journal of Behavioral Economics for Policy. Her other affiliations include Honorary Professor - UCL Institute for Global Prosperity; Adjunct Professor - University of South Australia; Associate Fellow - Cambridge Centre for Science and Policy; and Associate Researcher – Cambridge Energy Policy Research Group.

In her research, she specialises in the application of behavioural insights across a range of themes relevant to people's economic and financial decision-making. She has collaborated with neuroscientists and experimental psychologists on behavioural finance research projects – including around health themes. She has published across a wide range of top-ranked journals in economics and science and her recent books include Behavioural Economics – A Very Short Introduction (Oxford University Press), Behavioural Economics and Finance (Routledge, 2nd edition in 2018) and Copycats and Contrarians – Why We Follow Others and When We Don't (Yale University Press). She has been a research investigator on projects funded by over $12 million of research grant funding from a wide range of sources - including the ARC, the UK Research Councils and the UK's Leverhulme Trust. Amongst her current research projects, she is lead Chief Investigator on research partnerships with the National Heart Foundation, the Innovative Manufacturing CRC (just-in-time bone implants) and a Chief Investigator on the ARC Linkage Project "Rebuilding Life After Migration - Settlement Experiences of Refugee and Migrant Youth" (led by Professor Tahereh Ziaian, UniSA Justice and Society, University of South Australia).

Experience

Academic Appointments

Interim Director, UTS Business School, Centre for Business and Social Innovation	2021
Director, UTS Business School, Centre for Livelihoods and Wellbeing (CLAW)	2021-present
Professor in Economics, UTS Business, University of Technology Sydney	2019-present
Associate Dean (Research and Development), University of Technology Sydney	2019-present
Adjunct Professor, Business School, University of South Australia	2019-present
Director, Institute for Choice (I4C), University of South Australia	2018-2019
Honorary Professor, Institute for Global Prosperity, University College London	2017-present
Research Professor, Institute for Choice (I4C), University of South Australia	2017-present
Associate Fellow, Cambridge Centre for Science and Policy (CSaP), University of Cambridge	2014-present
Associate Researcher, Energy Policy Research Group, University of Cambridge	2012-present

Education

Degrees

PhD (Economics) University of Cambridge

MPhil (Economics) University of Cambridge

Bachelor of Economics (1st Class Honours) University of Queensland

Bachelor of Arts (Psychology) University of Queensland

Professional Activity

Editorial Roles

Editorial in Journal of Behavioral Economics for Policy 2018-present

Offices Held

President, Society for the Advancement of Behavioral Economics 2020-2022

Grants

Deep River Group Pty Ltd, Social and Economic Impacts of A Development Project, $115,089 2022

Business Council of Australia, Business Council of Australia Indigenous Engagement Survey Analysis (CLAW), $14,000 2021-2022

The Council of the City of Sydney, How Gig Work Works: Building Sydney's Gig Economy evidence base, $39,920 2021-2022

IFM Investors Pty Ltd, Developing Global Labour Rights Leadership (CBSI), $60,000 2020

Australian Research Council, Rebuilding Life After Migration for Young Refugees and Migrants (Economics), $0 2020-2023

National Heart Foundation of Australia, National Heart Foundation and UTS Partnership (CBSI), $509,070 2020-2023

Innovative Manufacturing Cooperative Research Centre, IMCRC: Just-In-Time Patient-Specific Tumour Implants (CBSI), $262,500 2017-2022

Publications

Book Reviews

Baddeley, M. (2021). A Community of Advantage: A Behavioural Economist's Defence of the Market, by RobertSugden (Oxford University Press, 2018).. *Economic Record*, *97*(316), 123-125. doi:10.1111/1475-4932.12591

Books

Baddeley, M. (2019). *Behavioural Economics and Finance* (2 ed.). UK: Routledge. doi:10.4324/9781315211879

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Baddeley, M. (2017). *Behavioural Economics: A Very Short Introduction*. UK: Oxford University Press. doi:10.1093/actrade/9780198754992.001.0001

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Baddeley, M., & Barrowclough, D. (2012). *Running regressions: A practical guide to quantitative research in economics, finance and development studies*. doi:10.1017/CBO9780511814839

Baddeley, M. C. (2003). *Investment*. Macmillan Education UK. doi:10.1007/978-1-4039-1864-2

Chapters

Baddeley, M., & Altman, M. (2021). Behavioural Methods for Macroeconomics. In *Handbook of Research Methods and Applications*. Cheltenham: Edward Elgar.

Baddeley, M. (2020). Retrenced renters vulnerable to long-term inequality. In E. Baker, & L. Daniel (Eds.), *Rental Insights: A COVID-19 Collection* (pp. 9-10). Australian Housing and Urban Research Institute. doi:10.18408/ahuri3125402

Baddeley, M. (2018). Daniel Kahneman. In T. Hoerber, & J. Conlin (Eds.), *Great Economic Thinkers*. Reaktion/Chicago University Press.

Baddeley, M. (2018). Nudging for India. In *The State of India's Environment - A Down to Earth Annual* (pp. 36-39). New Delhi: Centre for Science and Environment.

Baddeley, M. (2018). Financial instability and speculative bubbles: Behavioural insights and policy implications. In *Alternative Approaches in Macroeconomics: Essays in Honour of John McCombie* (pp. 209-234). doi:10.1007/978-3-319-69676-8_9

Baddeley, M. (2017). Investment, Unemployment and the Cyber Revolution. In *Economic Policies since the Global Financial Crisis* (pp. 173-220). Springer International Publishing. doi:10.1007/978-3-319-60459-6_5

Baddeley, M. (2016). Behavioural macroeconomics: Time, optimism and animal spirits. In *Routledge Handbook of Behavioral Economics* (pp. 266-279). doi:10.4324/9781315743479

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Baddeley, M. (2015). Behavioral approaches to managing household energy consumption. In *New Perspectives for Environmental Policies Through Behavioral Economics* (pp. 213-235). doi:10.1007/978-3-319-16793-0_9

Baddeley, M. (2015). Economic models in interdisciplinary studies of behaviour change: helpful abstractions or spurious distractions?. In S. Christmas, S. Michie, & R. West (Eds.), *Thinking about behaviour change: an interdisciplinary dialogue*. Silverback Publishing.

Baddeley, M. (2015). Financing Energy Infrastructure. In P. Arestis, & M. Sawyer (Eds.), *Unknown Book* (pp. 111-152). PALGRAVE. Retrieved from http://gateway.webofknowledge.com/

Baddeley, M. (2014). Bubbles or whirlpools? An empirical analysis of the effects of speculation and financial uncertainty on investment. In *Empirical Post Keynesian Economics: Looking at the Real World* (pp. 202-236). doi:10.4324/9781315704845-16

Arestis, P., Baddeley, M., & McCombie, J. S. L. (n.d.). Introduction. Edward Elgar Publishing. doi:10.4337/9781847205216.00007

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Baddeley, M., & McCombie, J. (2001). An Historical Perspective on Speculative Bubbles and Financial Crises: Tulipmania and the South Sea Bubble. In *What Global Economic Crisis?* (pp. 219-243). Palgrave Macmillan UK. doi:10.1057/9780333992746_11

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Sombatruang, N., Kadobayashi, Y., Sasse, M. A., Baddeley, M., & Miyamoto, D. (2018). The continued risks of unsecured public Wi-Fi and why users keep using it: Evidence from Japan. In K. McLaughlin, A. Ghorbani, S. Sezer, R. Lu, L. Chen, R. H. Deng, . . . J. Nurse (Eds.), *2018 16TH ANNUAL CONFERENCE ON PRIVACY, SECURITY AND TRUST (PST)* (pp. 358-+). Belfast, NORTH IRELAND: IEEE. Retrieved from http://gateway.webofknowledge.com/

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Baddeley, M., & Candlish, C. (2019). *Re-thinking Supply Chain Practices: Collaborative Relationships and Working Practices in Anglian Water's @one Alliance*. UK: @one/Anglian Water/UCL.

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Working Papers

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Overview

Dr. Jianlong Zhou is an Associate Professor in the School of Computer Science, Faculty of Engineering and IT, University of Technology Sydney, leading the UTS [Human Centred AI](http://www.hcai-lab.org) research lab. His current work focuses on AI for social good, AI fairness, AI explainability, smart agriculture, visual analytics, behaviour analytics, human-computer interaction, and related applications.

Before joining UTS, Dr. Zhou was a senior research scientist in Data61, CSIRO and NICTA, Australia. He has extensive research experiences on various fields ranging from AI, visual analytics, VR/AR, to human-computer interaction in different universities and research institutes in USA, Germany and Australia. Dr. Zhou is a leading senior researcher in trustworthy and transparent machine learning, and has done pioneering research in the area of linking human and machine learning. He also works with industries in advanced data analytics for transforming data into actionable operations particularly by incorporating human user aspects into machine learning and translate machine learning into impacts in real world applications.

Experience

Academic Appointments

Associate Professsor, Data Science Institute, University of Technology Sydney	2022-present
Senior Lecturer, Engineering and IT, University of Technology Sydney	2019-2022

Education

Degrees

PhD Computer Science, The University of Sydney

Professional Activity

Editorial Roles

Editorial in IEEE Intelligent Systems	2022-2023
Editorial in Human-Centric Intelligent Systems	2022-present
Editorial in Machine Learning & Knowledge Extraction	2021-present
Editorial in Machine Learning & Knowledge Extraction	2021-present
Editorial in Behaviour and Information Technology	2018-present
Editorial in Journal of Visual Languages and Computing	2018-present

Grants

Digital Finance CRC Limited, Real-time compliance verification of digital asset transactions, $60,000	2022-2023
Deep River Group Pty Ltd, Social and Economic Impacts of A Development Project, $115,089	2022
Digital Finance CRC Limited, Trade Surveillance Based on Deep Anomaly Detection, $210,000	2022-2025
Food Agility CRC Limited, Robotics-ready AI in Viticulture, $711,664	2022-2024
Food Agility CRC Limited, Uncertainty Management in Machine Learning and its Applications in Food Data Analytics, $135,000	2021-2024

Food Agility CRC Limited, Predicting kiwifruit yield, $565,427	2020-2022
Vlepis Solutions Pty Ltd, Rapid identification of the real-time health risk for elderly people, $150,000	2020-2021
Reejig Pty Ltd, Non-Biased Talent Shortlisting Algorithm (Milestone 4), $25,051	2020
Reejig Pty Ltd, Non-Biased Talent Shortlisting Algorithm, $95,000	2019-2021
Asian Office of Aerospace R&D, A Longitudinal Study of Trust Calibration Methods with Individual Differences, $433,632	2019-2021
Commonwealth Scientific and Industrial Research Organisation, Smart Infrastructure and Transport Analytics, $931,229	2018-2020

Selected Publications

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Further Publications

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Zhou, J., & Xiao, C. (2007). *Computer Graphics Theory and OpenGL Programming (In Chinese)*. Guangzhou, China: South China University of Technology Press.

Zhou, J. (1999). *Mastering AutoCAD 2000 (In Chinese)*. Chongqing, China: Chongqing University Press.

Chapters

Zhou, J., & Chen, F. (2022). Towards Humanity-in-the-Loop in AI Lifecycle. In *Humanity Driven AI: Productivity, Well-being, Sustainability and Partnership*. Springer. doi:10.1007/978-3-030-72188-6_1

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