The Future of Agriculture in Nillumbik

Draft V4

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Executive Summary

Nillumbik Shire Council respectfully acknowledges the Wurundjeri Woi-wurrung people as the Traditional Owners of the Country on which Nillumbik is located, and we value the significance of the Wurundjeri people's history as essential to the unique character of the shire.

The Future of Agriculture in Nillumbik Project is a climate change resilience project that aims to inform government, the local agricultural sector and the broader community of the possible impacts and opportunities for food and fibre production as the climate changes in the study area. The information has been developed with the intention of increasing the adaptability and sustainability of agricultural production and provide options for the regeneration of the farming landscape.

The traditional custodians of the land are the Wurundjeri Woi-wurrung people. Nillumbik Shire has a strong agricultural history as well as a being known as the conservation Green wedge. Globally, agriculture has many challenges to address including climate change mitigation and adaptation, soil degradation, food waste, an aging farming population, loss of agricultural land to urbanisation and food security for a growing population. To address the global issues, local action is imperative.

Looking at the climate projections for the broader Melbourne metropolitan region (including the north), mean temperatures are expected to increase from 13.6 °C to 15.4 °C by 2050 under RCP4.5 (not shown) and to 15.8 °C under RCP8.5. By 2050, rainfall is expected to decrease slightly in the north but more so in Melbourne's outer east (Figure 10). It is useful to consider these possible climatic changes in the full peri-urban and state-wide context. At the regional Victoria level, increases in temperature and decreases in rainfall put pressure on existing agriculture systems north of the Great Dividing Range by decreasing crop yield and suitable land (Figure 11). On the other hand, with increasing population in metropolitan Melbourne and less severe climatic changes, agriculture may have a competitive advantage (in terms of the biophysical environment and proximity to markets) on the urban fringe.

The modelling and associated mapping shows that overall, the picture is positive for agriculture in Nillumbik. Suitability for livestock and fodder growing (based on pasture models), berries, citrus, brassica (vegetables) and agroforestry. These maps have been produced to offer insight into the agricultural potential of the Nillumbik landscape. They showcase nine products and their suitability for production across the shire. These nine products were selected in consultation with the local community and internal Council stakeholders. The modelling uses an expert-systems approach that incorporates the knowledge and views of local farmers and other land managers. That expertise, along with the knowledge and experience of the project team, informed the selection of the nine commodities that were modelled. The strong community survey response, the SWOT analysis and key findings from other keystone projects (Foodprint Melbourne and the Farm to Plate Peri-Urban Planning Scheme Audit) are also indicative of the potential for a positive future for agriculture in Nillumbik

Access to culturally appropriate, nutritious food is key to a thriving community. The sustainable, local production of this food is essential for a thriving landscape. There cannot be one without the other. Nillumbik Shire Council is in a unique position to be a leading contributor in addressing these issues. Already well established as the 'conservation' green wedge of Melbourne, the Council can build on these credentials, landscape assets and strong community ethos to develop an active, regenerative agricultural movement in the shire that contributes to climate resilience, local employment, economic development, localised food security and enhanced biodiversity and connectivity on private land. Innovative and regenerative agricultural practices, such as permaculture, agroecology, holistic management and biointensive techniques, coupled with scale appropriate market access models, including Community Supported Agriculture and farm gates, offer great opportunities for the shire. Through the use of best practice sustainable and regenerative agricultural techniques, the working role and the preservation role within the landscape can not only coexist, but one benefit the other.

Introduction

The Future of Agriculture in Nillumbik Project is a climate change resilience project that aims to inform government, the local agricultural sector and the broader community of the possible impacts and opportunities for food and fibre production as the climate changes in the study area. The information has been developed with the intention of increasing the adaptability and sustainability of agricultural production and provide options for the regeneration of the farming landscape.

The project team has worked with the Nillumbik Shire Council's Economic Development team to liaise with the local community. This consultation has advised on suitable product opportunities for mapping, as well as focus areas for future actions to enhance the economic, environmental, social and cultural sustainability of the future of agriculture in Nillumbik.

Background and Context

Nillumbik Shire Council is located to the northeast of Melbourne's CBD and covers an area of 43,201 Ha, of which 39 km2 is classified as urban land area, and 393 km2 is classified as non-urban land area. The Shire borders the City of Whittlesea to the west, Murrindindi Shire to the north, Yarra Ranges Shire on the eastern boundary, and the City of Manningham and City of Banyule to the south (Figure 1). Although adjacent to urban expansion areas with rapidly growing populations, such as the City of Whittlesea, Nillumbik's population is relatively stable at 65,219 (as of 2020). This population is concentrated in the south of the Shire, with the rural north being less densely populated. The shire's population has a high socio-economic status, ranked as the most advantaged community in Victoria (Figure 5). Major activity centres in the Shire include Eltham and Diamond Creek, with the Neighbourhood Activity Centre of Hurstbridge together with the rural townships of Research, Panton Hill and St Andrews.

Nillumbik is one of the twelve Green Wedge zones that surround Greater Melbourne (Figure 2). The Nillumbik Green Wedge covers approximately 91% of the Shire (39,600 hectares) (Figure 3). Residents living in this area numbered more than twelve thousand (12,639) in 2017. Land use activities in the Green Wedge include agriculture, conservation, tourism and rural living.

The region has a strong agricultural history, including livestock and fodder production, dairy, viticulture, orchard production, poultry, market gardening and timber industries. The area was also known for gold mining. The traditional custodians are the Wurundjeri Woi-wurrung people. The name Nillumbik is a derivation of the traditional name which roughly translates to “shallow earth”. The geology of the area is primarily Silurian. The Plenty River forms the border between City of Whittlesea and Nillumbik Shire, with the Yarra River marking the boundary between Nillumbik and Manningham. Both these rivers are noted for the agricultural value of their alluvial soils, as are tributaries of the Yarra River, Arthur Creek and Diamond Creek. Other waterways in the area include Watsons Creek and Running Creek (Figure 4). Notable local assets include the Kinglake National Park and the Sugar Loaf Reservoir. The Shire sits in the Highlands – Southern Fall Bioregion and the Port Phillip and Westernport Catchment.

The Shire is well connected logistically with excellent freeway and arterial road access. Proximity to regional agricultural infrastructure including the Victorian Livestock Exchange and the Yea Saleyards (both under 100 kms from the shire) represents a strategic advantage. The Melbourne Wholesale Fruit and Vegetable Markets are located in Epping just 30 kms from Nillumbik, as is the strong northern Melbourne food manufacturing sector, supported by the Melbourne’s North Food Group. Melbourne Airport is also within 35 kms of the shire. Melbourne Polytechnic has one campus within the shire boundaries and others close by. La Trobe University and RMIT University are also close by in neighbouring municipalities. Therefore, strong agricultural training opportunities are available.

Nillumbik has two local farmers markets – Hurstbridge and Eltham - Eltham being a weekly Victorian Farmers’ Market Association (VFMA) accredited market. There are a number of strong community groups supporting local agriculture and food systems, including the Nillumbik Landcare Network and Local Food Connect.

Figure 1 Municipalities surrounding Nillumbik Shire Council (Source: Planning Victoria)

Figure 2 Green Wedge Zones surrounding Melbourne (Source: Planning Victoria)

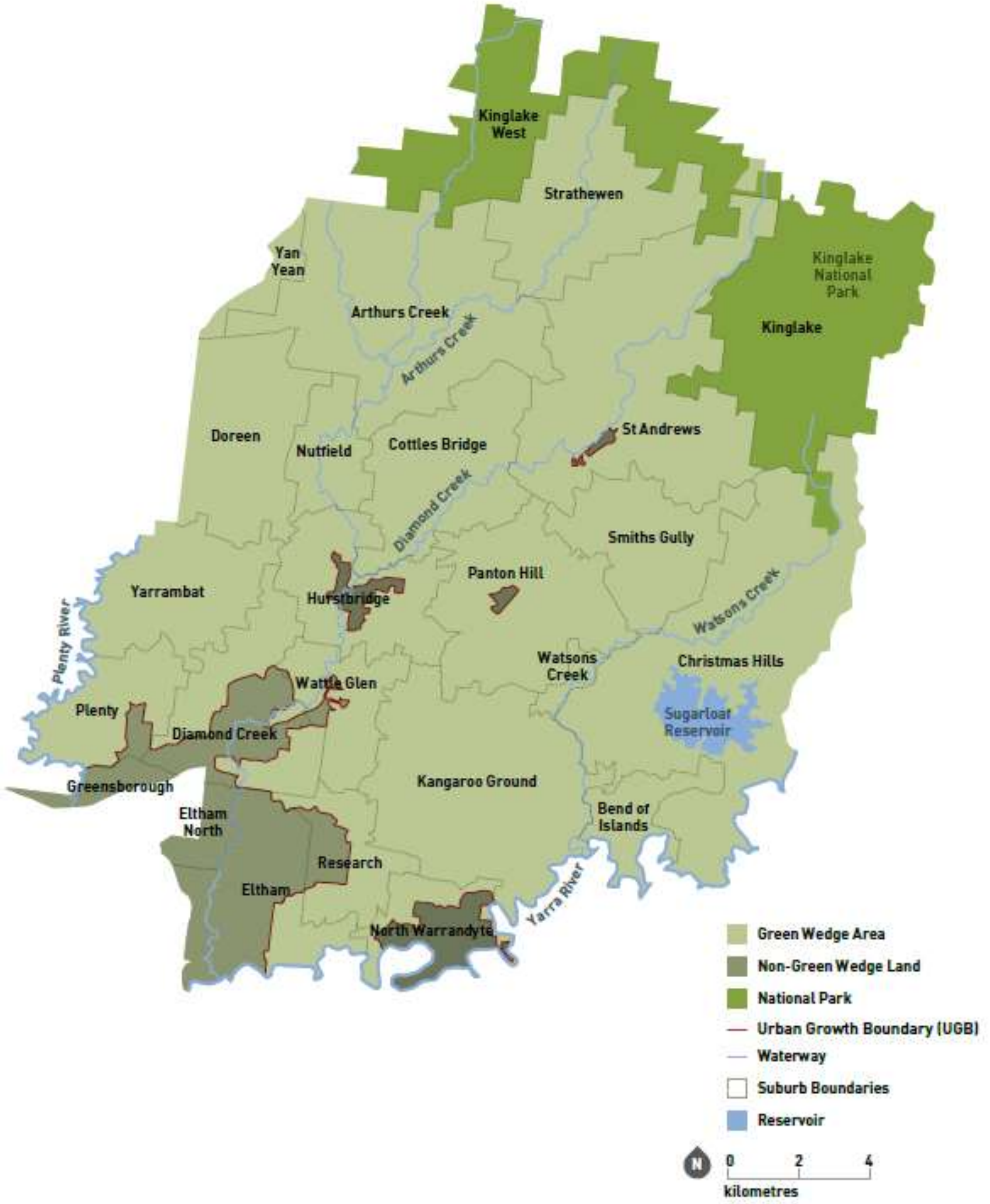

Figure 3 Green Wedge of Nillumbik Shire

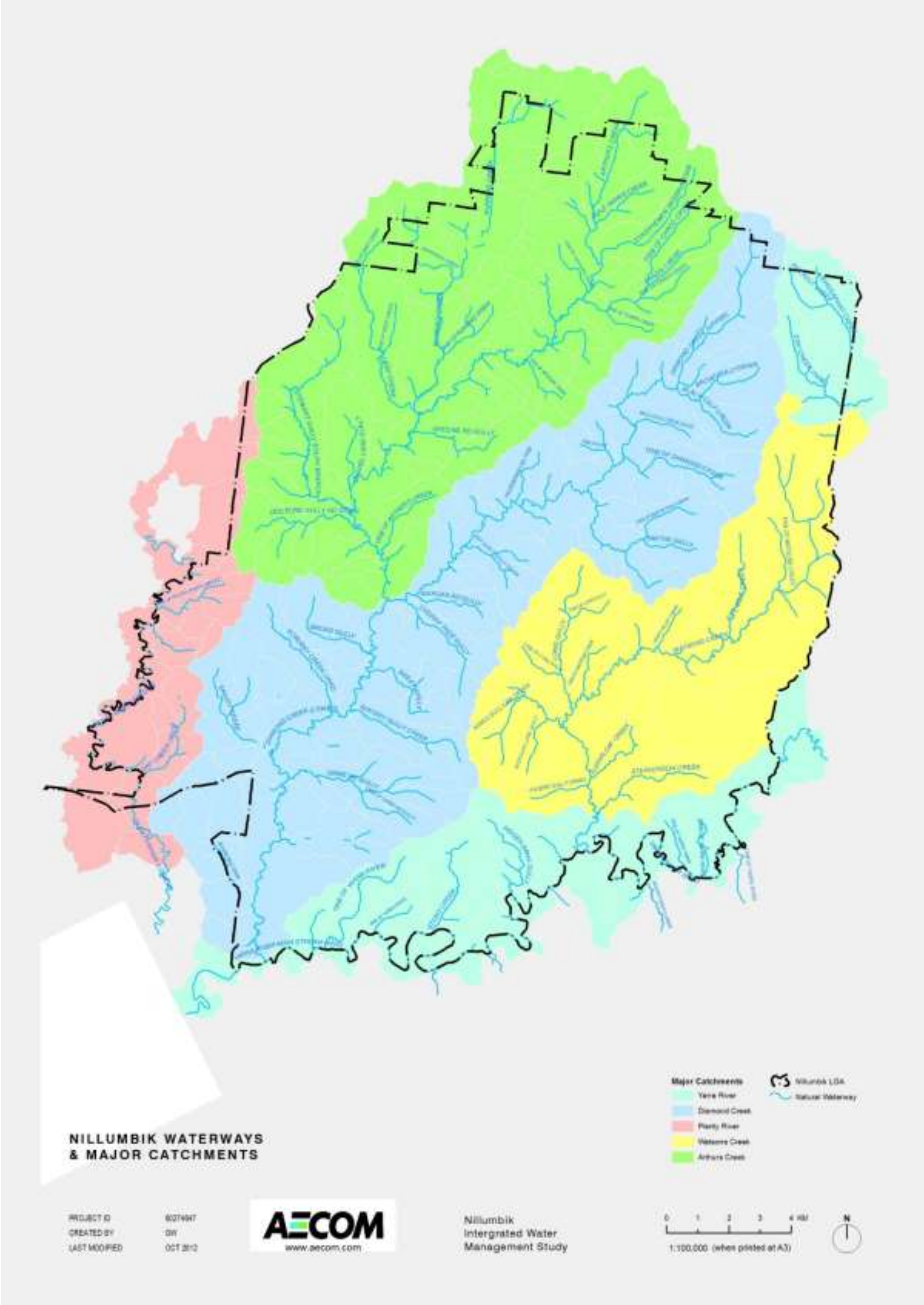

Figure 4 Main Water Catchments and Waterways of Nillumbik Shire

Figure 5 Key socio-economic indicators for Nillumbik Shire

Local Strategic Plan Context

This project aligns with the implementation of the *Nillumbik Green Wedge Management Plan*:

- Objective 4.3: Encourage sustainable and regenerative agriculture; and
- Objective 4.4: Recognise the contribution of hobby or small-scale farming in the green wedge with supportive policy in place.

This project directly supports the achievement of the Council Plan 2021-2025 strategy Business and tourism

- We support businesses, industries and events, and encourage investment within Nillumbik.

This Council Plan action feeds directly into the Nillumbik Economic Development Strategy 2020-2030:

- Objective 3 Facilitate economically and environmentally sustainable use of land within the Shire's Green Wedge.

The Problem

Agriculture, forestry and land clearing accounts for 22% of the world's greenhouse gas emissions. If we include fertiliser, transport, processing, and sales, this increases the contribution to 29% (IPCC, 2019). Australian agriculture contributes 14.9% of the total national carbon emissions (80.1 Mt CO_2-e), of which Victorian agriculture contributes 21% (or 16.8 Mt CO_2-e) (Australian Government, 2020). The majority of agriculture's contribution in the form of methane and nitrous oxide (Figure 6, NGGI, 2021). Key sources of these emissions are enteric fermentation (mostly from ruminants), land clearing, savanna burning, fertiliser use and manure management (Longmire, 2014). If we are to address climate change, we must consider the emissions of our food system and farming methodologies.

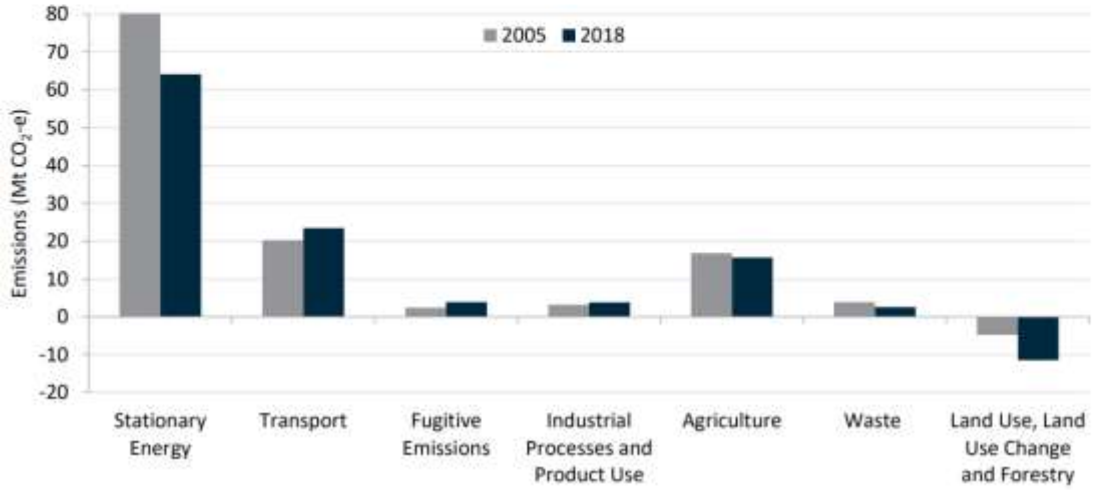

Figure 6 Victoria's annual emissions by sector 2018 (Aus Gov, 2020)

Soil degradation is a broadly acknowledged issue internationally. The impacts are varied, from environmental, economic and social perspectives: reduced agricultural productivity, biodiversity loss, sedimentation and eutrophication of streams and water sources, food insecurity, land abandonment, slowing or stalling of economic development in impacted regions and urban migration. It is a broad, complex and wicked problem in the truest sense. Human-induced soil degradation has affected 24% of the inhabited land area globally: 12% in North America, 18% in South America, 19% in Oceania, 26% in Europe, 27% in Africa and Central America, and 31% in Asia." (Figure 7, Oldeman et. al. 1991, Oldeman, 1992).

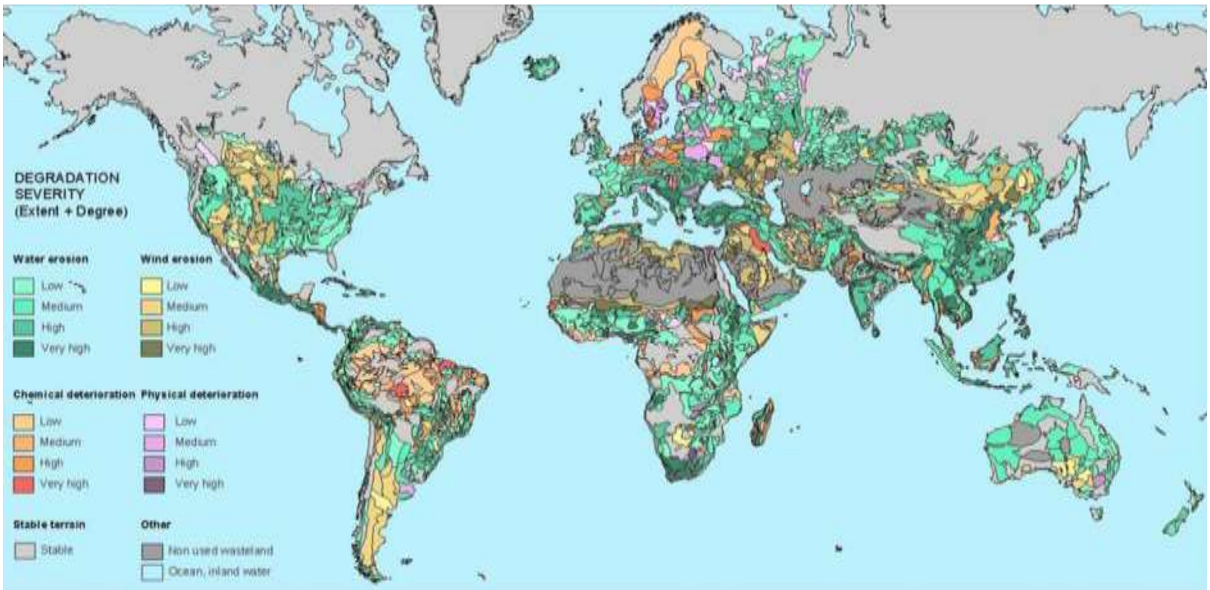

Figure 7 Global Assessment of Human-induced Soil Degradation (GLASOD)

In 1988, the United Nations Environment Program (UNEP) funded the Global Assessment of Human Induced Soil Degradation project. This work was completed in 1991 – 30 years ago. The causative factors of soil degradation as determined in this report include deforestation, overgrazing and conventional agricultural practice.

Climate change and soil degradation are both exacerbated by and directly impact upon agriculture and food security. If we are to ensure ongoing food security for the community as well as protect biodiversity and ecological service such as clean air and water, we have a responsibility to build adaptation and resilience systems through the adoption of best practice sustainable and regenerative agriculture principles.

These are substantial global issues that are played out at a local level and require local action. As the modelling demonstrates, there is both threats and opportunities in the changes growing conditions created by climate change. In addition, the pressures of expanding urbanisation and the associated loss of agricultural land around Melbourne is an ongoing concern given the need to balance affordable housing and a growing population. The Foodprint Melbourne project (see next section) has shown us that 41% of the city's food requirements are supplied by agriculture in peri-urban zones. Without intervention, this will drop to 18% by 2050, putting our food security at risk (Carey et al. 2015) (Figure 8).

Although population growth is not directly impacting on Nillumbik itself, there is the opportunity to farmers in Nillumbik to be a part of the food security solution and assist in addressing climate change through shortened supply chains, soil conserving and carbon sequestering regenerative agriculture practices, whilst supporting sustainable farming businesses keeping the landscape and community connected. The importance of local food security has been highlighted by the recent supply chain impacts of the COVID-19 pandemic and the 2020 Black Summer bushfires.

Other considerations that are also challenging agriculture and food security include the aging farming population and the impact that has on productive and sustainable land management practices, as well as the waste created by the current industrial, centralised food system paradigm. There is ample opportunity for local government to both lead and advocate for positive change in these areas.

Access to culturally appropriate, nutritious food is key to a thriving community. The sustainable, local production of this food is essential for a thriving landscape. There cannot be one without the other. Nillumbik Shire Council is in a unique position to be a leading contributor to addressing these issues. Already well established as the 'conservation' green wedge of Melbourne, the Council can build on these landscape assets and community ethos to develop an active, regenerative agricultural movement in the shire that contributes to climate resilience, local employment, economic development, localised food security and enhanced biodiversity on private land. Through the use of best practice sustainable and regenerative agricultural techniques, the working role and the preservation role within the landscape can not only coexist, but one benefit the other.

Foodprint Melbourne

Foodprint Melbourne is a University of Melbourne research project that investigates ways of strengthening the resilience of Melbourne's food system to increase equitable access to fresh, healthy foods and promote sustainable production and consumption for current and future generations.

The extensive work conducted by Foodprint Melbourne project has shown the potential and possibilities to improve our local food systems to address the challenges of climate change, population growth and the impacts of emergencies, such as bushfires, floods and pandemics through innovative and regenerative farming approaches that foster circular systems reusing waste and capitalise on our natural assets, while protecting biodiversity and ecosystem services, such as clean air and water, and healthy, carbon rich soils (Figures 19 and 20). The Foodprint Melbourne project offers an extensive range of resources to inform Council and the community. They can be found at www.fvas.unimelb.edu.au/research/projects/foodprint-melbourne.

Figure 8 Food security of Melbourne

Figure 9 A vision for a resilient city foodbowl for Melbourne

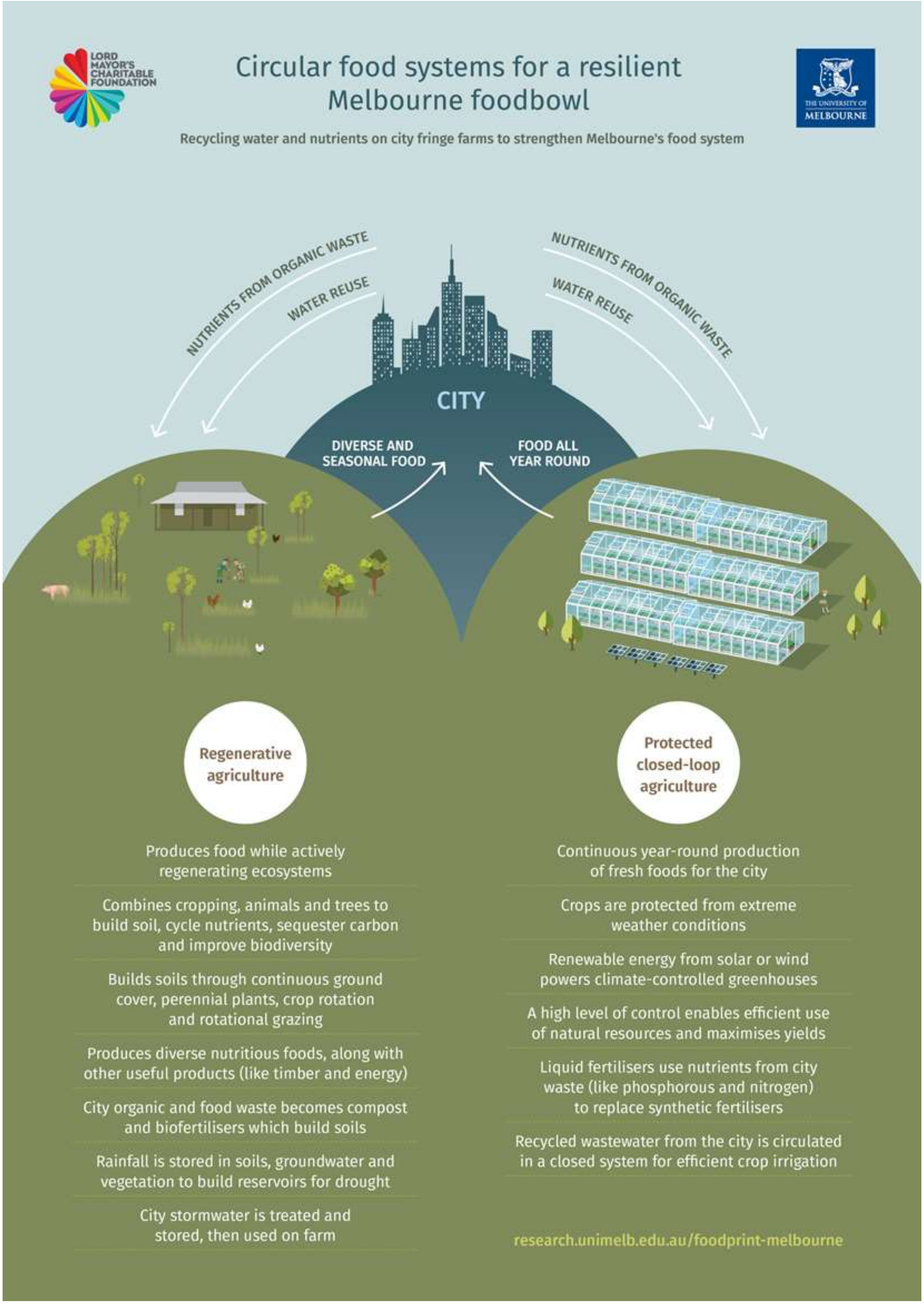

Figure 10 Circular food systems for a resilient Melbourne foodbowl

Climate projections for Melbourne and the Nillumbik Shire

Future climate projections were developed using the CSIRO ACCESS 1.0 Global Climate Change Model (GCM). This was run through the emissions scenarios or *Representative Concentration Pathways* (RCP) 8.5 for the years 2030 and 2050. RCP8.5 is a scenario in which global temperatures reach, on average, temperatures that are 4^0C warmer than pre-industrial averages by 2100 and represents a worst-case climate scenario. The Interim Emission Reduction Targets for Victoria Issues paper notes that 'over recent decades, global greenhouse gas emissions have been growing at a rate similar to RCP8.5 (IEPIT, 2017). The RCP8.5 scenario assumes a rising greenhouse gas concentration over time, representative of a scenario leading to high greenhouse gas concentration levels by 2100. It is the highest representative concentration pathway as described by the Intergovernmental Panel on Climate Change. The RCP8.5 scenario was chosen as it is reflective of the global situation currently, as also confirmed by the most recent Intergovernmental Panel on Climate Change (IPCC) summary report on the impacts of global warming of 1.5^0C above pre-industrial levels and related global greenhouse gas emission pathways (IPCC, 2018) and the recent IPCC update. Clearly, it is hoped that national and international efforts to curb greenhouse gas emissions ramp up urgently to increase the chances of limiting global warming to more moderate levels. However, the historical climate and the RCP8.8 scenario projections used in this study provide the full envelope of possibilities, from worst case through to status quo.

Figure 9 shows the mean temperature for Melbourne's Green Wedge and Peri-Urban Areas (averaged annually over the 12 months). The left panel depicts the SILO baseline historical mean average from 1960 to 1990. The panels to the right show the RCP 8.5 projection annual mean, averaged monthly for 2030 and 2050.

Figure 10 shows the average total annual precipitation for Melbourne's Green Wedge and Peri-Urban Areas. The left panel depicts the SILO baseline historical average total from 1960 to 1990. The panels to the right show the RCP 8.5 projection precipitation, averaged annually for 2030 and 2050.

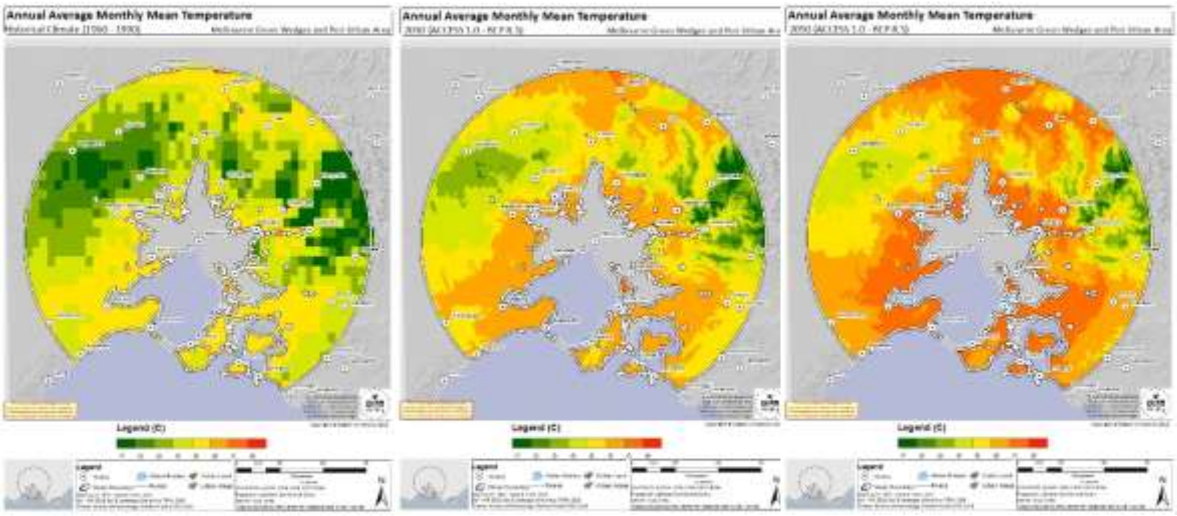

Figure 11 Average annual monthly mean temperature for Melbourne's Green Wedges

In this study, the atmospheric content of the GCM model for RCP8.5 was used to generate monthly data, which was inserted into crop models to compare possible land suitability against historical averages for the same monthly timeframes.

The variables analysed for the purposes of crop modelling were temperature (mean, minimum and maximum) and rainfall. Monthly means across the full Melbourne metropolitan region are presented in this report to show the likely evolution of climate parameters over time.

Looking at the projection at the broader Melbourne metropolitan level, mean temperatures are expected to increase from 13.6 °C to 15.4 °C by 2050 under RCP4.5 (not shown) and to 15.8 °C under RCP8.5. By 2050, rainfall is expected to decrease in Melbourne's Outer East and increase in other areas such as Melbourne's South East (Figure 10).

It is useful to consider these possible climatic changes in the full peri-urban and state-wide context. At the regional Victoria level, increases in temperature and decreases in rainfall put pressure on existing agriculture systems north of the Great Dividing Range by decreasing crop yield and suitable land (Figure 11). On the other hand, with increasing population in metropolitan Melbourne and less severe climatic changes, agriculture may have a competitive advantage (in terms of the biophysical environment and proximity to markets) on the urban fringe.

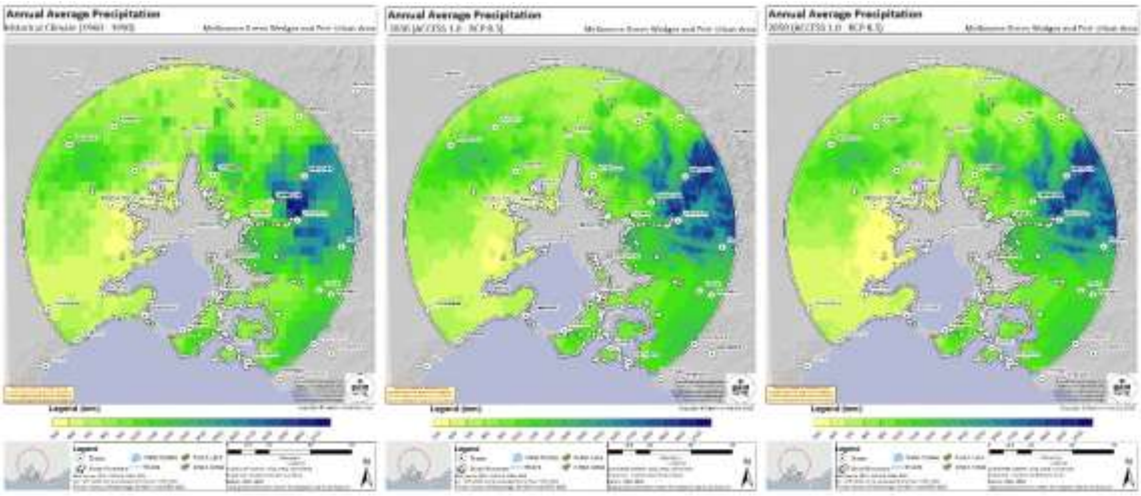

Figure 12 Average annual rainfall for Melbourne's Green Wedges

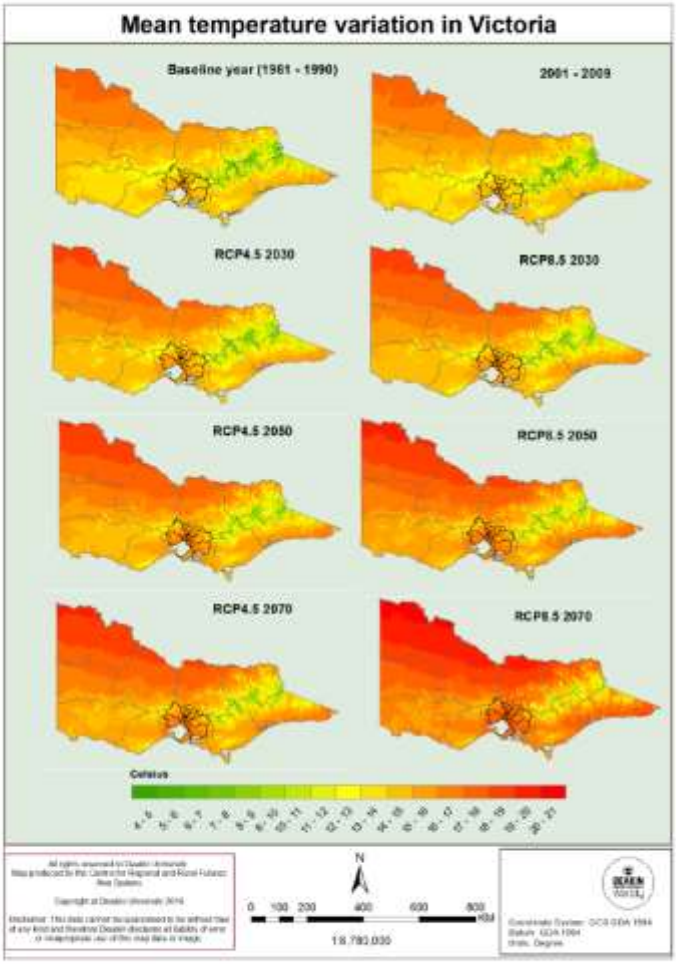

Figure 13 Mean temperature variation in Victoria

Community response

An extensive community consultation process, coordinated by the Nillumbik Economic Development team, was conducted to assist in informing this report. The intent behind community consultation was to a) give local farmers, land managers and other members of the community an opportunity to inform the modelling process, given their own unique expertise and local knowledge and b) provide an avenue for general input on issues around peri-urban agriculture and climate change and c) provide insights into local drivers of agricultural development and land-use change. At the inception of this project, it was hoped to engage with the community on a face-to-face basis, however, due to COVID-19, this consultation was undertaken virtually.

The virtual consultation consisted of four open zoom meetings that were broadly advertised and offered a range of times for attendance, including an evening session (8pm) to encourage participation and improve accessibility. Few community members took the opportunity to attend these sessions.

A fifth session was conducted with the Nillumbik Landcare Network. This was a particularly productive discussion with strong support from the group for the project. Some of the key takeaways from this consultation included:

- The importance and potential of sustainable intensification to balance biodiversity outcomes and local food and fibre production;
- Fostering the emerging entrepreneurial approach to small scale farming within the shire, with direct marketing of produce to the community, diversity of produce and production systems, adoption of regenerative approaches (such as permaculture and holistic grazing management) and connecting community to their farming landscapes through a vibrant local food system;
- Facilitation of leasing land to young farmers as a way to activate the landscape, bring new entrants into the industry and create productive succession for older farmers who are looking towards retirement;
- The potential of ecomarkets beyond Net Gain 2002 to support farming diversification, biodiversity on private land and soil conservation for carbon sequestration;
- The acknowledgement that land fragmentation has occurred throughout the Shire and that, given current market conditions and land prices, re-aggregation is unlikely. No further subdivision should occur in the Green Wedge;
- The rare opportunity offered for appropriate zoning and aggregation of Green Wedge land with the sale of Melbourne Water land in Christmas Hills;
- The potential of perennial farming systems for soil carbon sequestration and the exciting role of indigenous produce to support this outcome, whilst reconnecting with and learning from our First Nations people land management systems;
- The need for education programs and peer to peer networks to support a new regenerative approach to farming in the local landscape for strong biodiversity and local food system outcomes.

The other key element of the consultation was a postal survey that could either be completed online or via hard copy returned to Council. The survey response was excellent, with over 700 responses to the 4500 surveys mailed out to landowners and residents on properties classified as rural properties, identified by the Nillumbik Rate department according to Planning Zones – Rural Conservation Zone (RCZ), Green Wedge Zone (GWZ), as well as some Low Density Residential Zone (LDRZ). This represented a contribution to the project outcomes by close to 20% of landholders, with a broad geographic distribution across the Shire's Green Wedge (Figure 12).

Location	Number of survey responses
Kangaroo Ground	55
St Andrews	53
Panton Hill	50
Arthurs Creek	43
Hurstbridge	42
Diamond Creek	32
Yarrambat	30
Plenty	30
Eltham	29
Smiths Gully	24
Cottles Bridge	23
Wattle Glen	21
Research	19
Christmas Hills	18
Doreen	13
North Warrandyte	11
Nutfield	8
Bend of Islands	8
Eltham North	8
Strathewen	7
Yan Yean	2
Greensborough	1

Figure 14 Survey response distribution

There were 155 respondents that operated agricultural businesses, with a further 69 intending to start agricultural businesses in the future.

The dominant land use identified by the survey was livestock, followed by horticulture, conservation and recreation respectively (Figure 13).

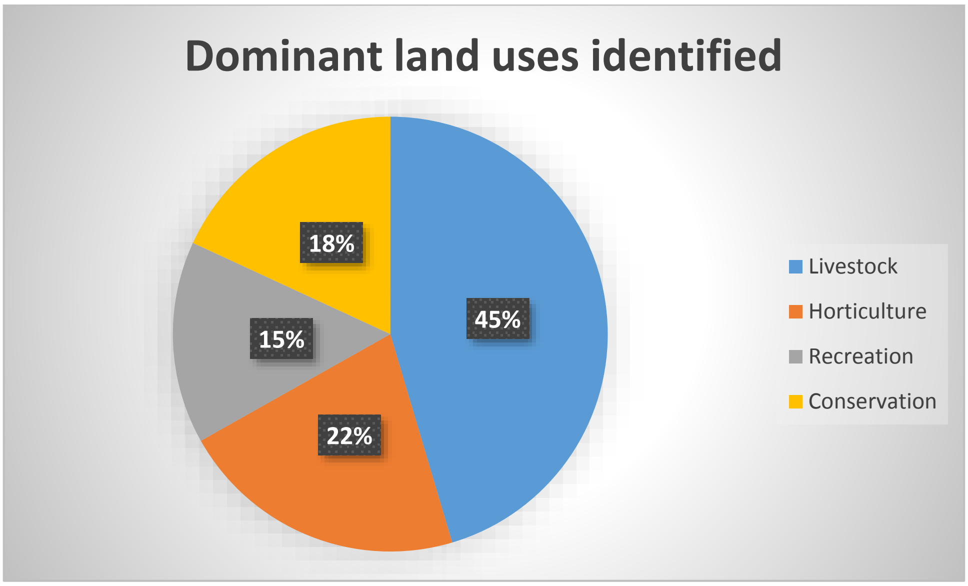

Figure 15 Dominant land uses identified

The livestock land use detail shows cattle being dominant with various equine based activities also very strong. Poultry and beekeeping were also notable land uses (Figure 14).

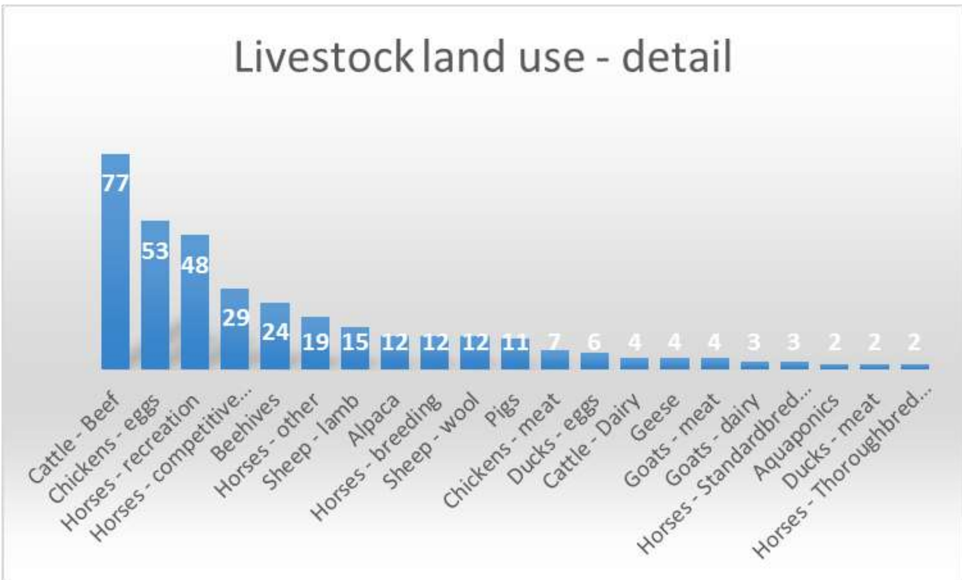

Figure 16 Livestock land use - detail

Horticultural land uses emphasized fruit orchards, fodder production, viticulture and vegetable growing, with herbs and olives also showing strong numbers (Figure 15).

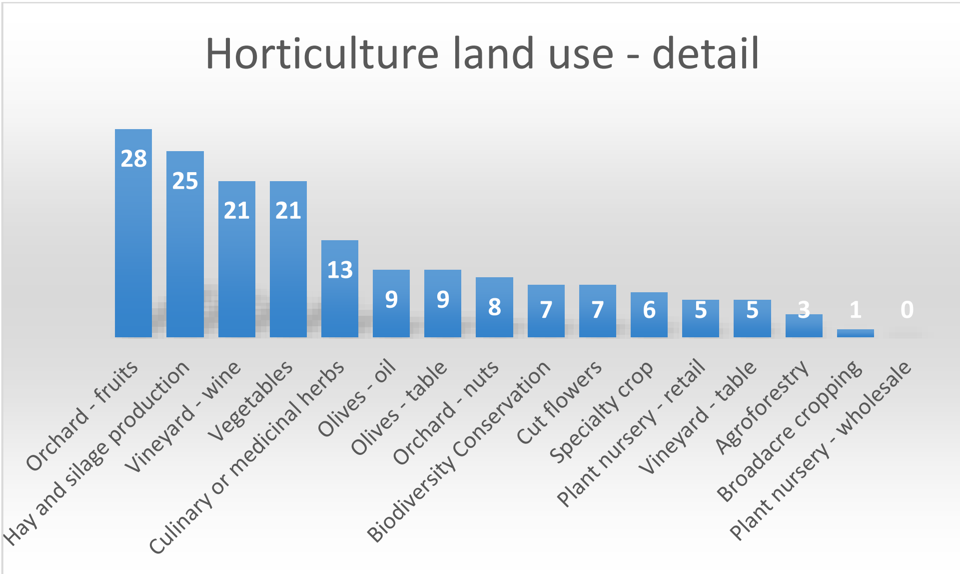

Figure 17 Horticulture land use detail

Ninety eight (98) survey responses identified an intention to increase or diversify their agricultural operations in the future, while 105 did not. Sixty three (63) were unsure. Key influences on this decision were the following:

- Climatic impacts (eg increased temperatures, decreased rainfall);

- Bushfires;
- Age of landholder / farmer;
- Market access;
- Impact of pest plants and animals, including blackberry, deer and rabbits;
- Impact of kangaroos;
- Small block size;
- Lack of support from Council:
    - Over regulation and changeability of that regulation;
    - Lack of understanding of agricultural realities;
    - Restrictive nature of council planning on agriculture;
    - High rates;
- Water access;
- COVID-19;
- Access to financial resources;
- Return on investment;
- Land stewardship;
- Land for wildlife and pollinators;
- Potential for regenerative agriculture;
- Land suitability;
- Time resources;
- High livestock prices.

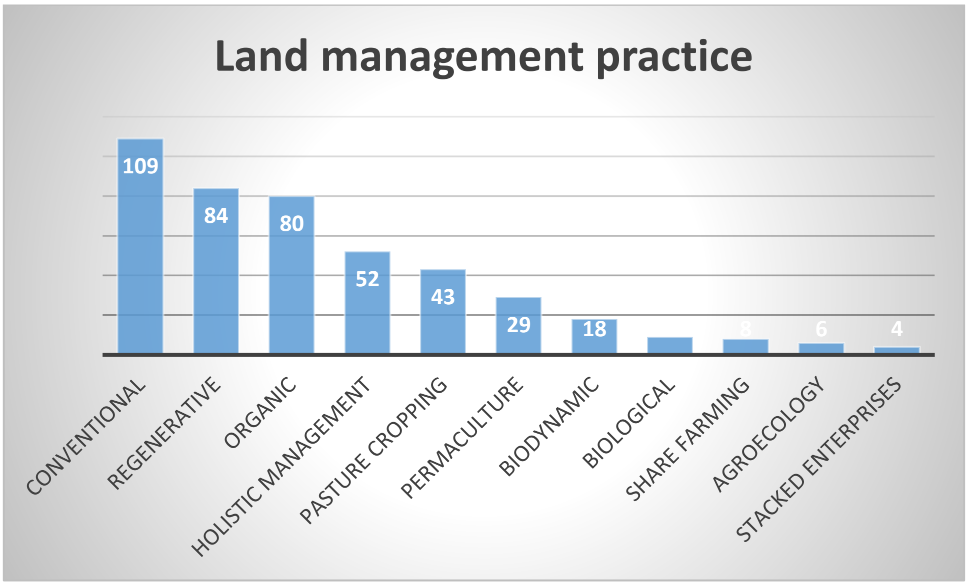

Figure 18 Land management practices

While conventional land management was dominant in this survey question, regenerative, organic and holistic management were close behind (Figure 16).

Figure 19 Is climate change a concern to your agricultural business?

Climate change was embraced as a concern by the majority of the survey participants (Figure 17). Discussion of this question was quite varied with some responses identifying gradually earlier harvest times for horticultural crops and variations in flowering times for beekeeping food resources. Shortened growing seasons for pastures and lack of water access was also mentioned, as was strong concern about increasing bushfire risk. Increasing pest plant and animal impacts were also mentioned, including the southerly movement of fruit fly into the area. On the other hand, there were a number of respondents who could not identify any discernable impact from climate change on their property or surrounding area to date.

Product	Rank
Wine grapes	228
Apples	227
Citrus	177
Raspberries	139
Agroforestry	110
Cherry	87
Protea	82
Phalaris	65
Brassicas	60

Figure 20 Preferred products for land suitability mapping

The top four products for mapping based on the survey responses are wine grapes, apples, citrus and raspberries (Figure 18). Other products that featured strongly in the comments beyond those listed included olives, indigenous perennials such as murnong and native grass species, as well as hemp and medicinal cannabis.

The Maps

These maps have been produced to offer insight into the agricultural potential of the Nillumbik landscape. They showcase nine products and their suitability for production across the shire. These nine products were selected in consultation with the local community and internal Council stakeholders. Those selected were:

- Perennial ryegrass
- Raspberries
- Pome fruit (apple)
- Phalaris
- Wine grape
- Cut flowers (generic protea)
- Citrus
- Brassica
- Agroforestry (combined blue gum and pine)

The map to the left shows the current suitability given the historical climate data from between 1960 and 1990. The map on the right displays the projected suitability for each product in 2050 under an ACCESS 1.0 – RCP 8.5 model – a worst case climate change scenario. Areas that are green indicate a highly suitable match between the biophysical environment (soil, topography and climate) and the crop. As the colour transitions to lighter greens and yellows, the suitability declines. Pink and purple designate temporarily not suitable and permanently not suitable respectively. More information about these climate parameters, as well as the overall approach to map development are provided in the Methodology section on page 41 of this report. The maps and crop suitability are then analysed in the Discussion on page 42.

It should be noted that the maps are not intended to be advice on the suitability of specific farms or paddocks, but are to be interpreted as an indication of suitability at a landscape level. It is recommended that any farmer or business person undertake their own due diligence in terms of soil testing, water access, processing, market access and other important considerations to business success before making investment or business decisions.

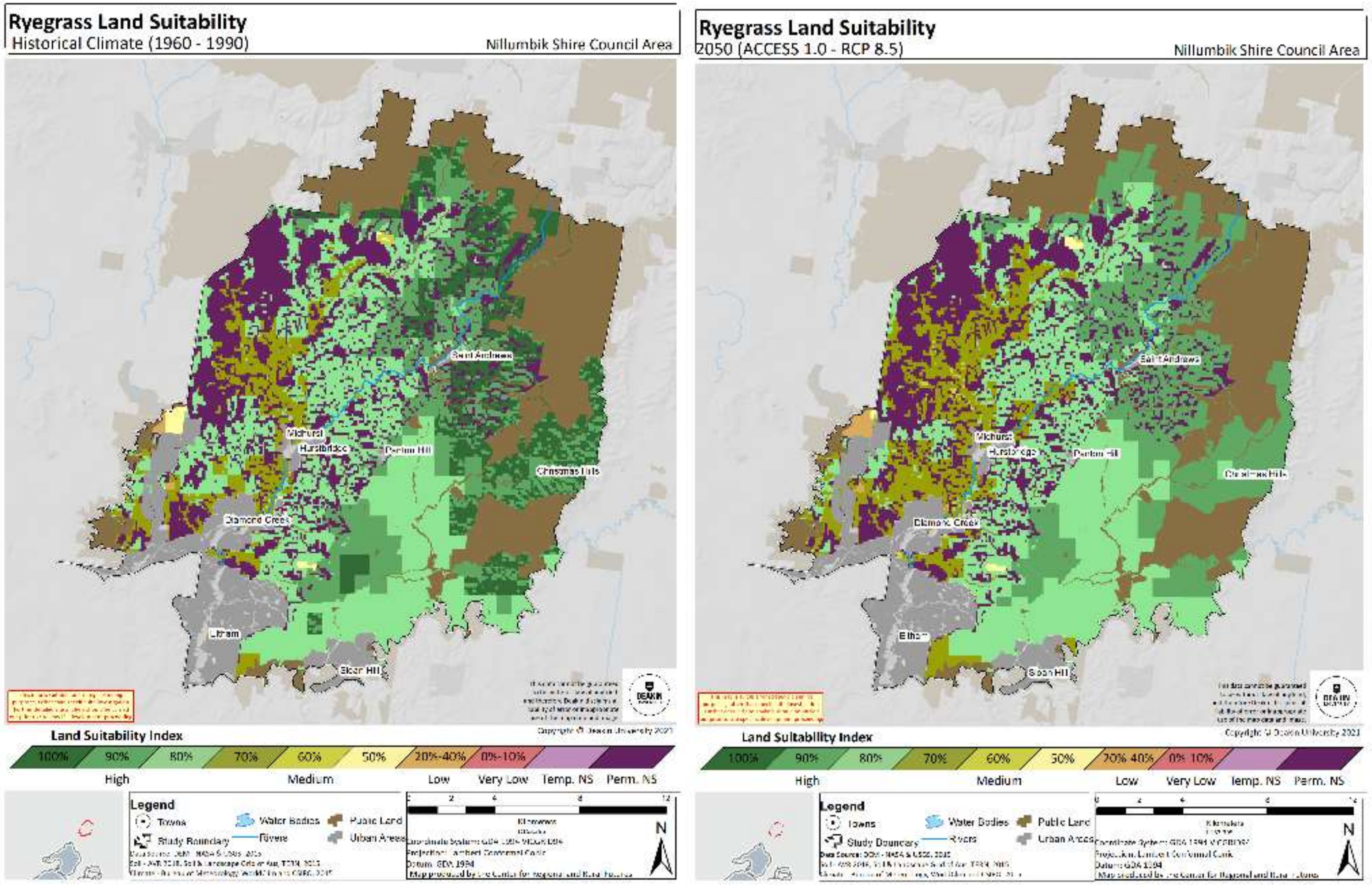

Figure 21 Perennial Ryegrass

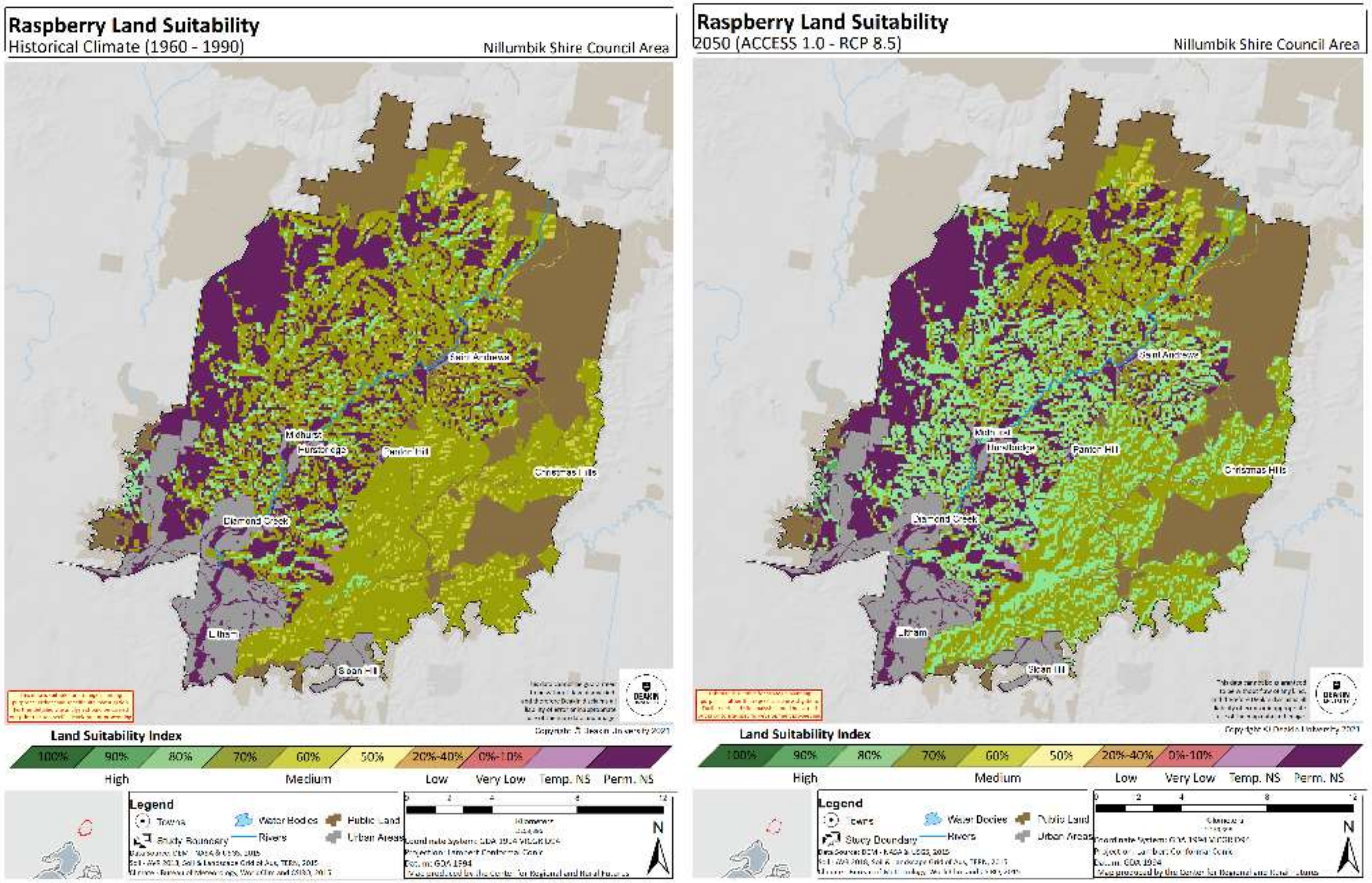

Figure 22 Raspberries

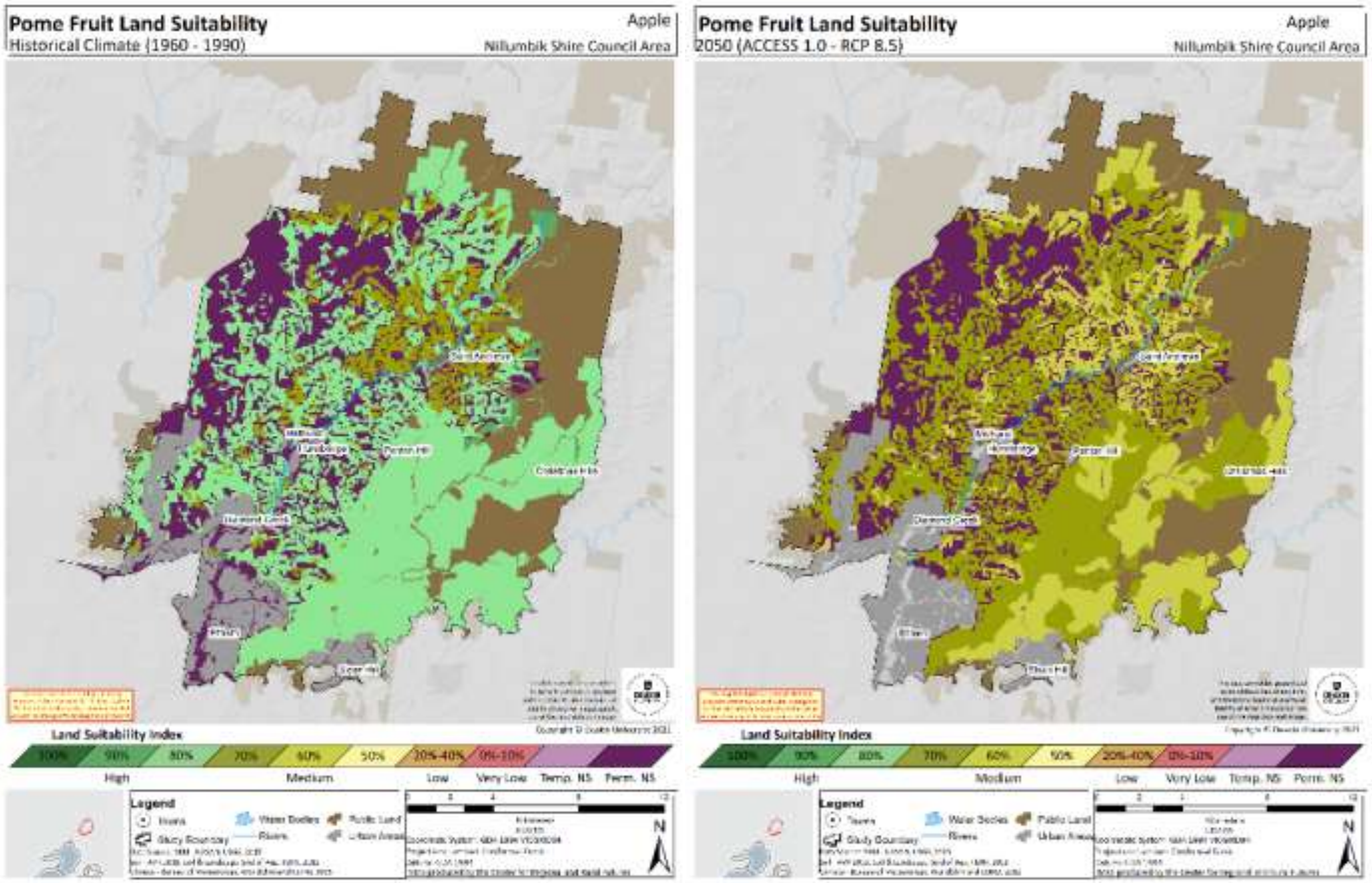

Figure 23 Pome - Apple

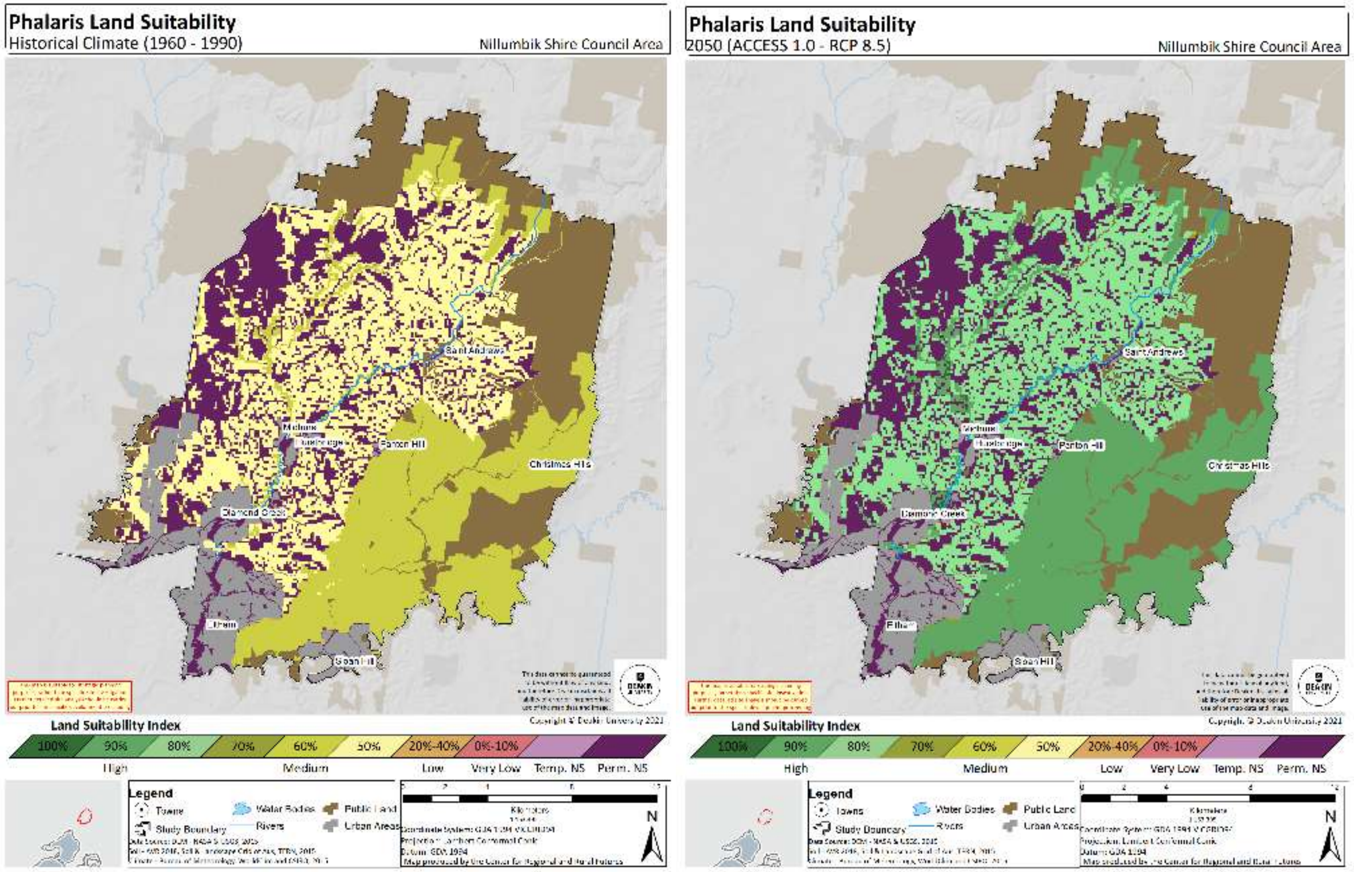

Figure 24 Phalaris

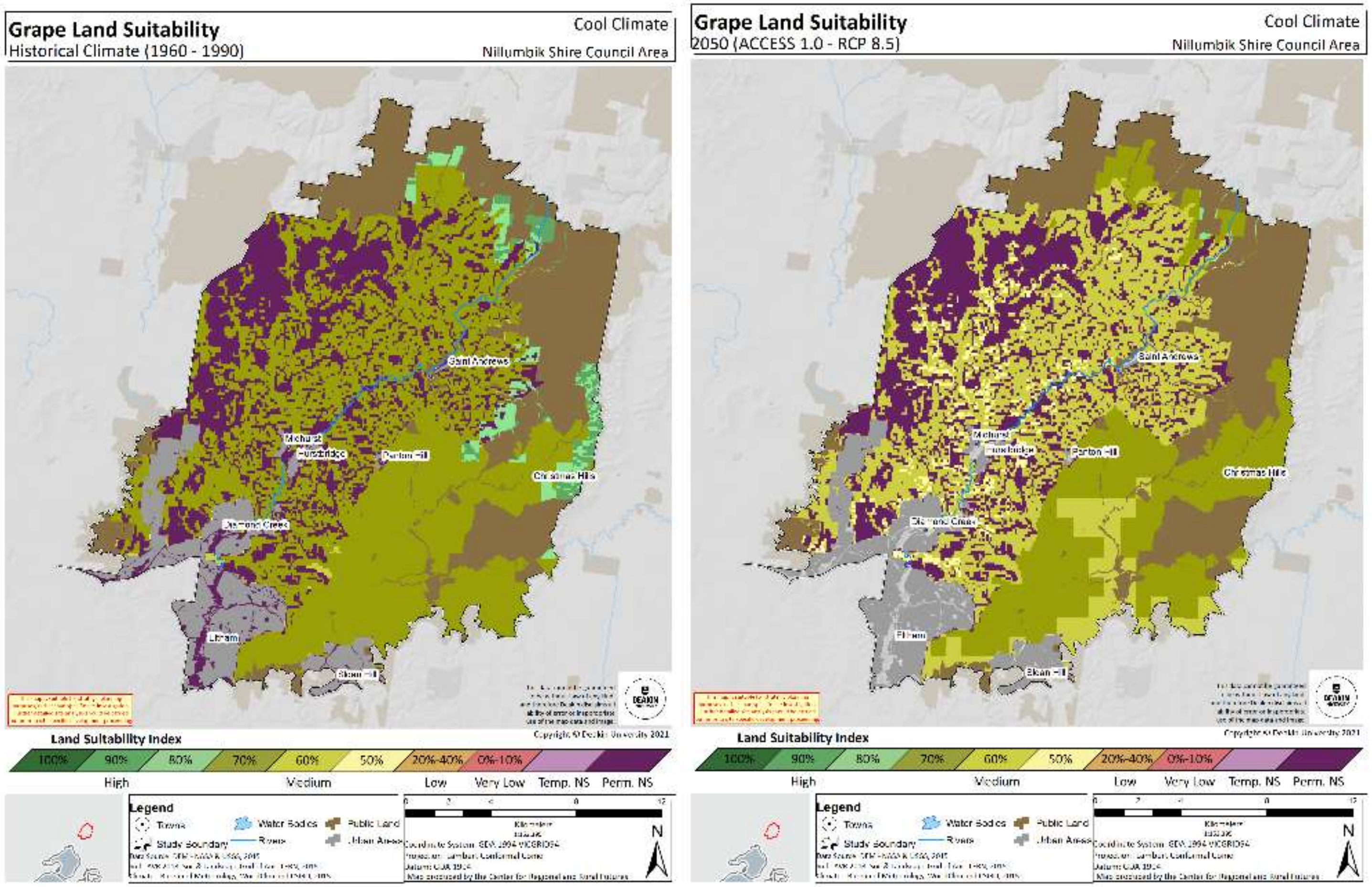

Figure 25 Grapes

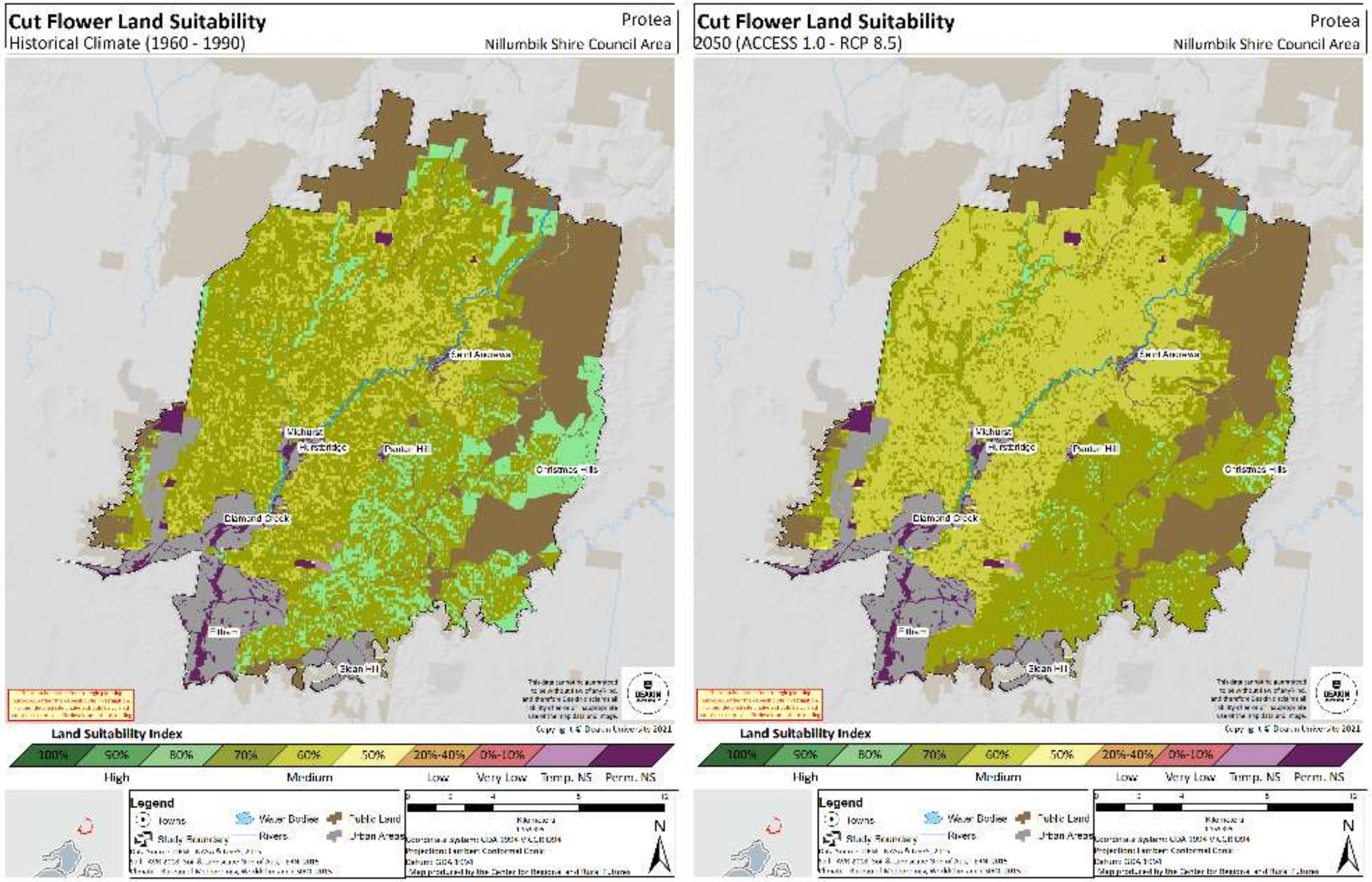

Figure 26 Cut flowers – generic model based on protea

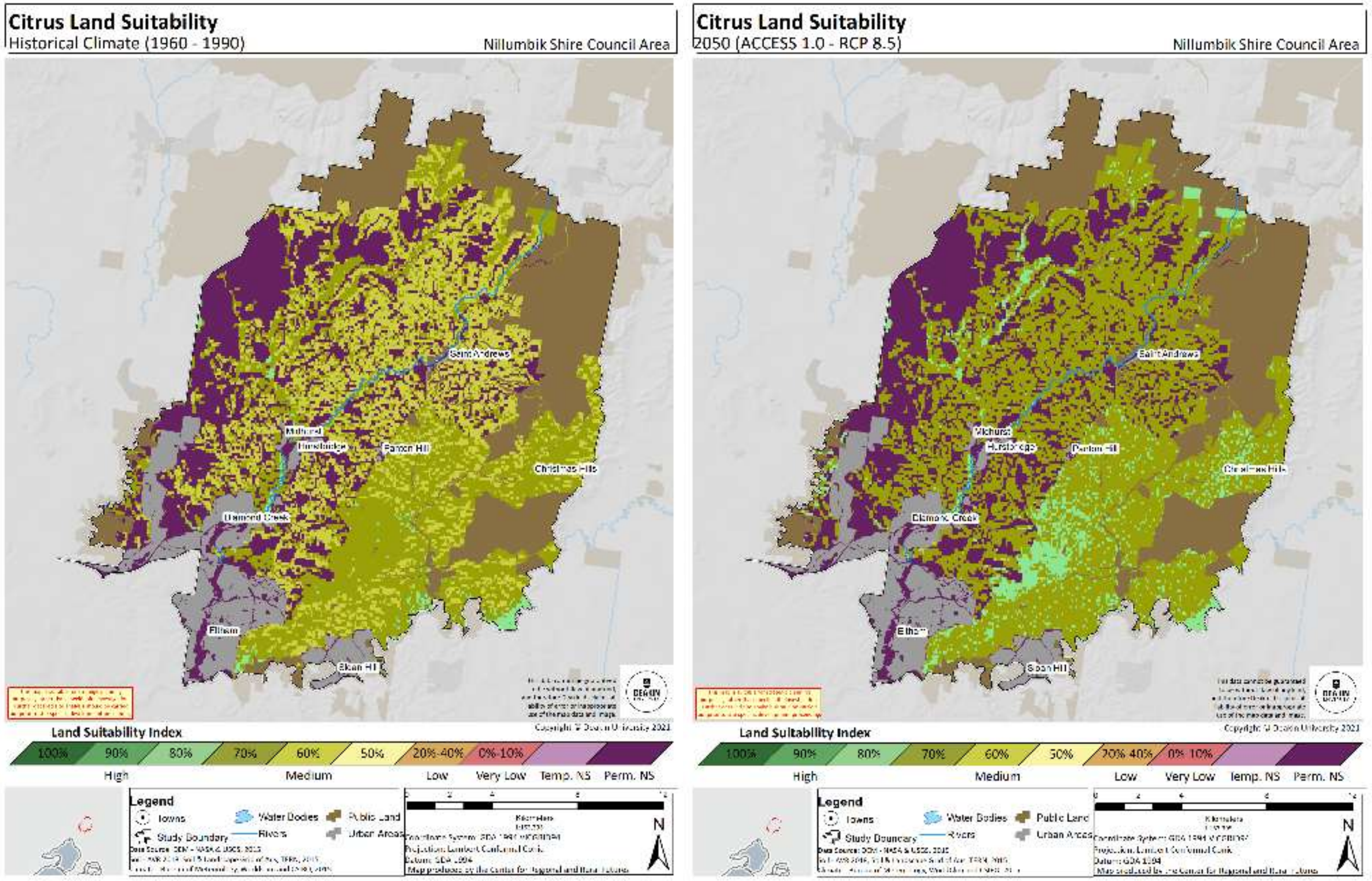

Figure 27 Citrus

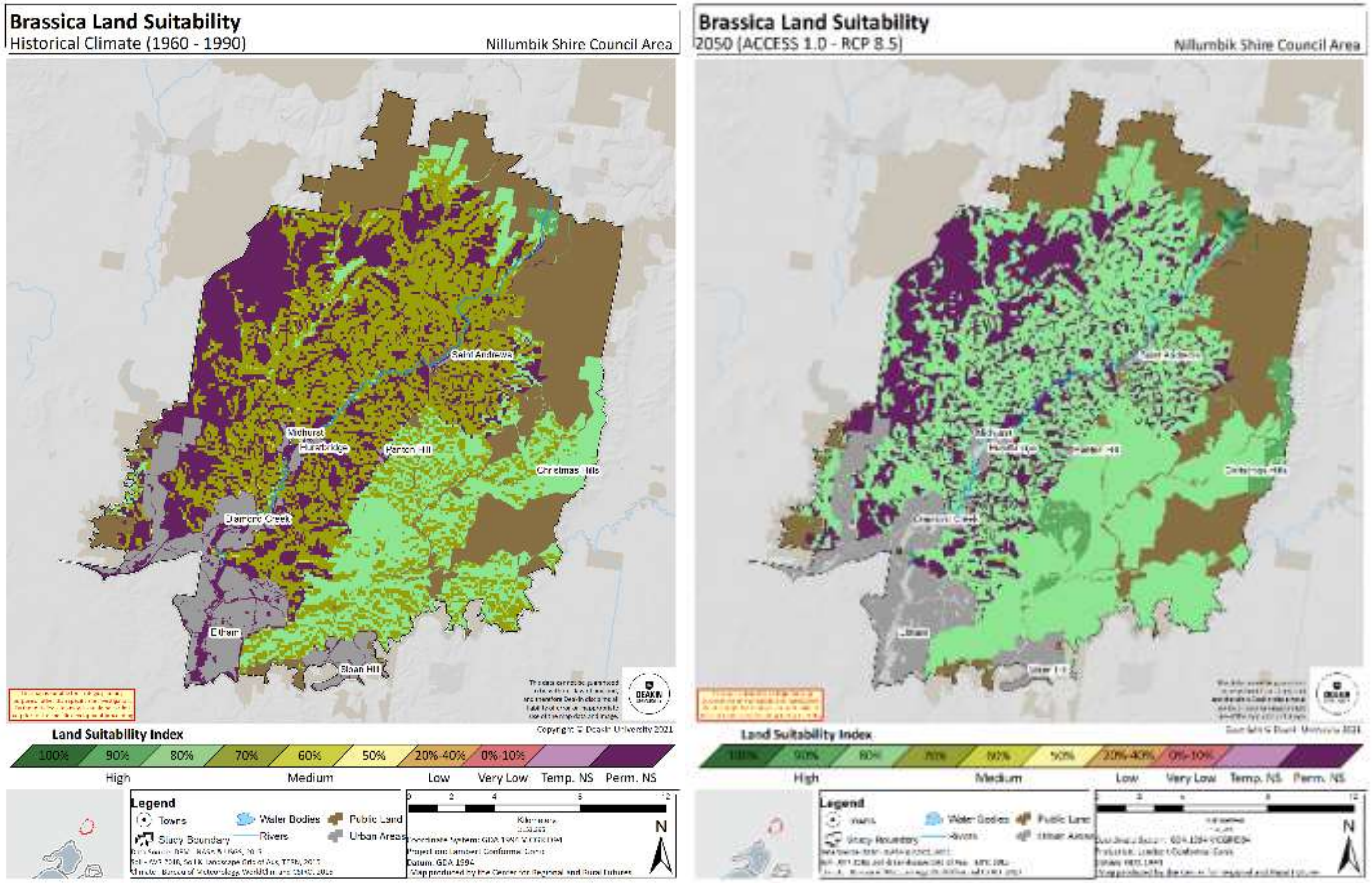

Figure 28 Brassica

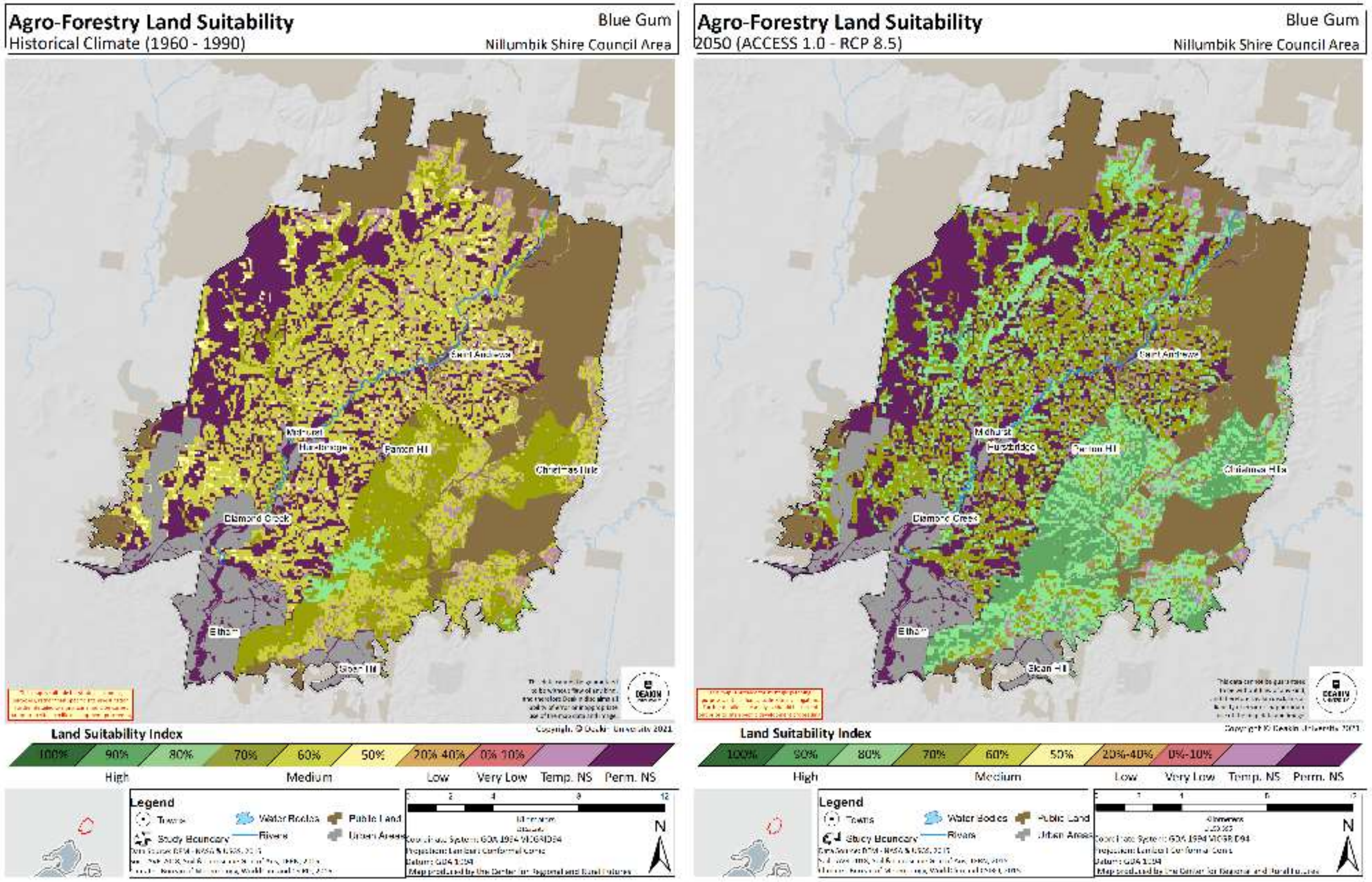

Figure 29 Agroforestry – combined Blue Gum and Pine model

Methodology

In order to understand how projected climatic changes impact on agricultural production in the Nillumbik region, we used an internationally accepted expert-system modelling approach that has been deployed by Deakin University across Victoria, NSW and many other parts of the world. In short, a Multi Criteria Analysis (MCA) was applied with an Analytical Hierarchy Process (AHP) in a Geographic Information Systems (GIS), to spatially represent the biophysical suitability of land for a particular crop. The approach has been published (Sposito et al 2013) and applied extensively, especially across Victoria (for example, Faggian et al 2016). An important point to note is that the underpinning AHP and land suitability models allow for experts' participation in the decision-making process. Compared to empirical models, an expert systems model such as those used in this project explicitly incorporates the 'subjective' knowledge of experts who understand the system of concern. This is an essential step in regional and local suitability analysis because often regional empirical data is lacking in detail or resolution and therefore expert based knowledge can fill the gaps. The key to using expert knowledge as a data input is to ensure that a consensus position is achieved from all contributors on the weighting of each criteria. Due to COVID-19 and time restricitions, this project did not incorporate an expert interview step to inform the models. Instead, only heavily validated (and peer-reviewed) models were used to assess crop climate impacts in Nillumbik, following customisation for the local Nillumbik context by the project team.

It should be noted that the models look specifically at 'biophysical' suitability. That is, they consider only soil, climate and topography and deliberately omit human-influenced parameters such as farmer management practices. This is to enable a more objective comparison of one geographical area versus another, where only the *intrinsic* biophysical features of the study region inform the model outputs. This eliminates spurious results that reflect bad practices or are the result of farming systems establishing and developing over time in areas not particularly suited to such a crop (which has occurred in some areas because of past settlement patterns). For the same reason, irrigated crops are assumed to have some portion of their water requirements met as a parameterised setting within the model. That is, we assume that some water is supplied by irrigation, regardless of its availability, and then suitability is defined as plant water requirements move up or down around that water threshold. In this situation, we can assess whether geographical areas have the potential to support irrigated crops if water infrastructure was introduced in the future, or if irrigation water supply levels were to change.

Suitability modelling Framework and interpretation

Given the number of 'land capability' and 'land suitability' methods in use around the world, a brief summary of their evolution over time has been provided in Appendix One. This is intended as a basis for Council staff to better contextualise the genesis of land suitability information and therefore better understand how it can be interpreted and used for local planning and economic development purposes. It is important to note that 'land capability' and 'land suitability' are distinct. Land capability relies predominantly on soil information but is incapable of dealing with climate variability or climate change in assessing prime agricultural land. Land suitability incorporates climate and temporal components, which allows assessment of prime agricultural land over time and as climate changes. It is therefore a superior approach for the sort of analysis required in the project.

The model outputs are presented as maps that represent land suitability for a given crop spatially. Areas that are green indicate a highly suitable match between the biophysical environment (soil, topography and climate) and the crop. As the colour transitions to lighter greens and yellows, the suitability declines. Pink and purple designate temporarily not suitable and permanently not suitable respectively. This relates to a fundamental biophysical barrier, such as rock (in the case of permanently not suitable) or soil pH (in the case of temporarily unsuitable). Greyed areas are for those for which no soil data exists, such as built-up areas or national / state parks. For each crop, suitability is presented relative to the historical climate (here, a climate average period of thirty years from 1960-1990) and relative to a worst case 2050 projected climate scenario for the Nillumbik region.

Discussion

The modelling and associated mapping shows that overall, the picture is positive for agriculture in Nillumbik. Suitability for livestock and fodder growing (based on pasture models), berries, citrus, brassica (vegetables) and agroforestry.

It should be noted that the mapping is indicative of suitability at a landscape level only. Any farm or business decisions need to be assessed on a site by site basis.

Perennial ryegrass and phalaris (Figures 18 and 21) were modelled to capture the highly popular, core livestock and fodder production sectors in the shire, both of which were represented strongly in the survey. The maps indicate little change over time for ryegrass, with a substantial improvement for phalaris. Both these species are highly productive, improved pasture varieties. Being perennials, they are suited to permanent pastures and, if carefully managed through planned grazing strategies, can offer excellent soil carbon sequestration potential, as well as protecting soil health and preventing erosion with permanent ground cover, particularly on steep and sloping country. Although the model has captured individual species, these grasses lend themselves to incorporation into diverse pasture swathes, complementing nitrogen fixing clovers especially well. Pasture polycultures foster greater productivity, soil coverage, nutrient cycling and climate adaptability and resilience.

Perennial pastures can be used as a base for traditional livestock industries, such as cattle and sheep. They can also be used for horses, the keeping of which were also strongly represented as a land use in the shire. Care needs to be taken with some horses as improved pastures can lead to health issues such as laminitis. Native pastures such as Weeping Grass (*Microlaena stipoides*) and Kangaroo Grass (*Themeda triandra*) commonly found in the area offer great perennial alternatives suitable for 'good doers' while breeding stock and horses in heavy work can utilize these improved pasture species with less health risks. A strong, well-managed perennial pasture base can also lend itself to a variety of innovative, small scale livestock enterprises, such as pastured poultry for eggs or meat, goats for dairy or meat and pastured pigs, to name only a few.

It should be noted that phalaris can become a competitive weed when in native bushland areas and increase fire risk. Phalaris is already common in the region, so a new weed issue would not be introduced through its use. Phalaris should be kept to well-managed pastures where possible and controlled outside of this production environment.

The fruits modelled for this project include bramble fruits (specifically raspberries, Figure 19), pome fruit (apples and pears, Figure 20), and citrus (Figure 24). There is currently successful commercial pome fruit production in the shire. This is reflected in the models, showing current growing conditions to be favourable for apples and other pome fruit. However, the mapping does show that suitability will be decline into the future. It is worth remembering that the models only consider biophysical factors – pome fruit growers are adapting to climate change through the introduction of new varieties, improved water management and modifications to the orchard microclimate via the use of nets and misting technology. As such, a decline in suitability is not necessarily indicative of an inevitable decline in the pome fruit industry. Instead, it should be considered forewarning of the possible need to develop and implement adaptation plans, or as a prompt for further site-specific investigations.

In contrast, the suitability of raspberries improves with the impact of climate change, as does citrus. Both models show the pattern of suitability being variable across the shire, therefore, like all the models, due diligence is required at a site level to assess the suitability of any property for production of any crop.

Raspberries have the potential to offer an excellent crop for direct sale given their perishability and short shelf life – Nillumbik's close proximity to a ready market is a clear market advantage. Citrus do have a longer shelf life but would also offer an excellent direct marketing opportunity. Both products offer excellent scope for processing and value added products.

The viticulture model is based on a generic cool climate white variety (Figure 22) and indicates a decline in suitability over time. It would be useful to develop more specific cool and warm climate grape varietal models to interrogate this further. Nillumbik Shire is adjacent to the formidable powerhouse of the Yarra Valley viticulture industry. There are a number of small, successful vineyards within Nillumbik capitalising on this proximity and producing some notable wines. As per the pome fruit example, land suitability analysis does not account for site specific management and adaptation. It does indicate that this choice may be more difficult and require additional labour and inputs, therefore another choice may be more sustainable, successful and suitable for the landscape. There are multiple considerations when assessing the potential for success of any farming business. These can only be assessed by the individual or group proposing the farming business and land suitability is only one piece of the puzzle.

The cut flower model is generic based on the cultural requirements of protea (Figure 23). This model is also quite variable across the shire and deteriorates in the future. Although this does not necessarily bode well for the future of cut flower production in the Shire, it should be noted that there are a large variety of cut flowers, particularly natives that may be more suitable than the model used in this study. Due diligence should be demonstrated by any business considering cut flowers, which variety is best suited to a particular site , market access and other considerations influencing this potential business.

The brassica model (Figure 25) is generic for vegetable brassicas (broccoli, cauliflower, cabbage etc.) The mapping indicates some areas of the shire with 80% suitability currently, with this improving into the future. Although not a traditional vegetable growing region, there are a number of small scale, biointensive and organic producers already doing well with diverse vegetable production systems in Nillumbik. This small scale, organic production of vegetables lends itself very well to localized direct marketing through Community Supported Agriculture programs, sale at farmers markets or wholesale markets. Specialty crops can also be targeted to the northern Melbourne food manufacturing sector. Local vegetable production is key to local food security and nutritional food access. This is a very positive model for the future agricultural potential of the region. It should be noted that the model assumes access to irrigation water.

The final model is that considering agroforestry (Figure 26) based on a combination model of blue gum and pine. This model shows considerable improvement into the future. This is a positive outcome from a number of aspects. Agroforestry can provide much needed renewable resources in timber production on less viable farmland. By accessing timber resources via agroforestry, old growth forests can be left to be the important biodiversity assets and carbon sinks we need to mitigate a climate change future. High grade timber production is also directed towards the production of products such as house framing and furniture, which can also act as carbon sinks.

Agroforestry can also offer farmers a way to diversify their farming incomes. Integrated farm forestry offers farmers huge potential to increase biodiversity assets on farm, increase stock shelter and, as a result, improve livestock growth rates, as well as offering the potential for a financial return on high value timber if trees are managed appropriately. The work of Rowan Reid and Bambra Agroforestry Farm is a great example of this potential.

In conclusion, the mapping indicates that, although Nillumbik shire does have some challenges in terms of topography, soils and water access, the suitability of the land is good for agriculture now and into the future, and shows potential for the development of a highly productive and successful agricultural future. This statement and associated underpinning analysis is made in consideration of those parts of the municipality that are already agricultural - it does not suggest or imply the need for impinging on land with current (or future) environmental, conservation or biodiversity value.

Caveats

Despite the extensive validation of the models that have been used in this project, it should always be remembered that any model is only a model. Models are mathematical representations of our current understanding of a situation where actual data is limited (as is the case when looking into the future of agriculture under climate change scenarios). Land suitability modelling, as implemented here, is intended to inform regional-level decision-making rather than farm-level decision-making. As such, farmers and other public participants should be made aware of the limitations in the resultant information:

1. The methodology has been formulated for application at regional and local levels. In particular, LSA maps are developed and presented at a regional level with a spatial resolution of up to 5 square km, which is the resolution of the downscaled climate change projections. *Therefore, LSA maps should not be used to infer (current and future) conditions at a site level (e.g. at farm level).*

2. LSA maps depicting future conditions substantially depend on the input climate change projection data, which are inherently uncertain. A multiplicity of futures is possible depending on major (global) decisions over time and how the climate system will respond to them. *Therefore, future LSA maps depict a likely future and, by no means, the only future.*

3. The modelling approach does not account for some important components of crop production; for instance, the effect that changing climatic conditions may have on bees and pollination, or on crop disease status.

4. Each crop's biophysical requirements for climate, soil and landscape were identified by a review of the scientific literature and their value ranges were validated using expert opinion and regional expertise. The final weightings and rankings are consensus values and may differ from the views of, or values provided by, individual experts.

5. The study did not examine different varieties within a particular agricultural commodity. Considerable variation can occur between varieties within a species with respect to their biophysical requirements.

6. It is difficult to account for the contribution that a farmers skill level and expertise can make to the suitability of a specific commodity at a particular geographical location. It is hence entirely possible for a particular grower to achieve good yields at a location that has been modelled as having a low biophysical suitability and, conversely for a grower to achieve poor yields at a location that is ranked with a high biophysical suitability. It should also be noted that the models do not take into account other factors that may impact on suitability and yield, such as extreme weather events or socio-economic considerations.

7. The report has looked at a selection of agricultural commodities across the Nillumbik area. The reader should therefore be aware that the designation of an area in the region as less suitable today or in future climates only applies to the particular crops modelled in this report, and that those same areas may become more suitable for other crops. *Additional modelling will be required to examine other agricultural commodities in order to have a more comprehensive understanding of the agricultural potential, now and in the future.*

8. The models were deployed across the whole Nillumbik landscape to explore future agricultural opportunities in a scenario-driven approach where climate was the primary variable. This is not, however, intended to imply that agriculture can or should be implemented in any given location. Clearly, environmental and other local considerations are important drivers of current and future land-use decision making.

The Potential

SWOT Analysis

This SWOT analysis has been compiled based on the community consultation and survey responses, discussion with internal stakeholders in Nillumbik Shire Council, as well as reviewed relevant literature.

Strengths	**Weakness**
• Existing strong agricultural business base and associated service businesses; • Proximity to Melbourne for market access, processing, education, agritourism, waste streams and other inputs, as well as human resources; • Logistic and regional asset connectivity; • Reduced climatic impact compared to northern food bowl regions; • Strong existing biodiversity resources and resulting ecosystem services for agriculture, as well as potential sources of indigenous species and systems for food and fibre production innovation; • Clean, green image underpinning ethical farming enterprises such as organics and regenerative agriculture; • Strong local knowledge of innovative farming models, such as permaculture, agroecology, biointensive, organics and biodynamics. • Strong local farmers markets in Eltham and Hurstbridge; • Community value of the green wedge landscape; • New landholders bringing diverse skill sets and innovation to the shire's agricultural enterprises; • Strong social-economic status to support smaller, environmentally conscious, local food and fibre production businesses; • *Fragmented landscape.	• Highly variable soils; • Steep topography; • Aging farming population; • High land prices for young farmer entry; • Water access; • Pest plant and animal impacts, including deer, rabbits, fruit fly and blackberry; • High kangaroo population; • *Fragmented landscape.
Opportunities	**Threats**
• Activation of small acreage, diverse farms with regenerative farming practices to foster soil health, biodiversity and carbon sequestration while supplying the local food system;	• Poor land management such as overgrazing, native vegetation removal and soil erosion;

• Peer to peer education and support networks; • Supporting established local farmers with skills in innovative food systems, such as permaculture, organics, biointensive and stacked enterprises to share their knowledge with aspiring landholders and farmers; • Entrepreneurial and innovation programs; • Fostering multi-functional, sustainable intensification and regenerative agriculture opportunities; • Support for supplementary rural business activities, such as farm gate sales, farm stays and other low environmental and amenity impact enterprises that are consistent with green wedge values • Agritourism; • Urban farming; • Facilitation of circular approaches to foster waste reuse to reduce reliance on synthetic inputs; • Advocacy for ecomarkets and enhancement of biodiversity assets on private land integrating with agriculture; • Scale appropriate market access opportunities, such as cooperatives, food hubs, aggregators and distributors; • Local decentralized processing, such as mobile abattoir infrastructure for on-farm slaughter; • Young farmer support programs such as incubators, lease land access and business education programs; • Support complementary activities such as farm gate sales, events, education, and accommodation to allow agricultural enterprises to diversify income sources. • Specialty protected cropping opportunities such as greenhouses, hydro- and aquaponics and vertical farming; • Council planning and regulatory frameworks that support and encourage diverse, innovative farming enterprises based on ecologically sound, regenerative land management principles; • Allow landholders a right to farm in the Rural Conservation Zone on pre-existing cleared agricultural land with decision	• Land use planning and other regulation that does not protect farm land and the right to farm; • The misconception that strong biodiversity and agriculture are not able to co-exist; • Disconnection between the Council and the local agricultural community.

guidelines to avoid damage to surrounding properties or environment.	

***Note:** A particular explanatory note about the fragmented landscape being positioned as both a strength and a weakness in this SWOT analysis: Scale has been seen as an agricultural competitive advantage for many years, primarily due to the Green Revolution where agrochemicals, synthetic fertilisers, machinery and plant breeding coalesced to create the current industrial farming paradigm and the large scale monocultures that are characteristic of this. Recent research and much traditional wisdom has highlighted the vulnerability of these systems, and the previously mentioned negative environmental and climate impacts they create. Diversity in the landscape is more sustainable. Small scale farming operations that are diverse, foster this new regenerative paradigm not only within the farming unit, but across the landscape. They do this by embracing the following attributes:

- more labour involvement rather than machinery;
- complimentary mosaics of production and biodiversity;
- variety in both production methods and the products available to the community; and
- a richness in the landscape that capitalizes on networks, relationships and synergies rather than scale.

Related initiatives that could inform local advocacy

Planning and decision-making with respect to agriculture in peri-urban areas are issues that many researchers and planners are grappling to understand. For the most part, local councils have limited opportunities to shape policy in this area, but they can, and do, have a strong advocacy role to play to ensure peri-urban agriculture remains a viable land-use. The following sections outlines a recent initiative that could be drawn upon by Nillumbik to inform their own actions and advocacy for local agriculture that has been driven and funded by a Nillumbik resident and philanthropic trust.

Farm to Plate Peri-urban Planning Scheme Audit

Plan-it Rural completed the Farm to Plate Peri-urban Planning Scheme Audit in 2020. Seven benchmarking principles were adapted from the Vermont Farm to Plate framework and used to audit 26 Victorian peri-urban and green wedge planning schemes. The benchmarking principles support the following food system elements:

- Food production
- Food Processing and Manufacturing
- Aggregation, Distribution and Storage (wholesale distribution)
- Nutrient Management.

Benchmarking principles for the implementation of a local sustainable food system

Food Production:

1. Does the planning scheme support "accepted agricultural practices" by exempting them from the requirement to obtain a planning permit (note: other regulation/s may apply).
2. Does the planning scheme support "accepted farm structures" by exempting them from the requirement to obtain a planning permit (note: other regulation/s may apply).
3. Does the planning scheme facilitate:
    - Expansion of the array of food produced – to satisfy demand for local food and expand access to local food for the community;
    - Resilience against climate change, peak oil and other threats;
    - New sources of revenue on-farm? Does the planning scheme support non-exempt agricultural uses – farm-based businesses, agritourism, direct sales – by taking a generally flexible and scale-sensitive approach?

      (Sustaining Agriculture Local Regulatory Context, pp. 2–3)

Food Processing and Manufacturing:

4. Does the planning scheme respond to the scale of an operation and developmental needs for food processing? (F2P 3.4 Food Processing and Manufacturing, accessed 23 March 2019)
5. Does the planning scheme provide for the on-farm sale of prepared food, if components of that food are produced or processed on the farm? (Sustaining Agriculture Local Regulatory Context, pp. 1–2, accessed 23 March 2019)

Aggregation, Distribution and Storage (wholesale distribution):

6. Does the planning scheme facilitate:

    - Producers self-distributing their products, especially when they have small- and medium-sized farms;
    - Producers' access to all types of local and regional supermarkets, restaurants and institutions – where most food is purchased – which is a necessary precursor to significantly expanding the consumption of locally grown products (F2P Aggregation Distribution and Storage, accessed 23 March 2019);
    - "Secondary integrated agricultural activities" on farms – such as the sale of non-farm products (where these are ancillary to the marketing of an on-farm product), and the hosting of educational and cultural events related to farming (p. 9 Sustaining Agriculture Local Regulatory Context, accessed 23 March 2019).
    - Personal relationships among producers and consumers whose collective desire is to eat food that is healthy, fresh, tastes good, and to support those who produce it (F2P Goal 24, accessed 23 March 2019). Also: https://www.vtfarmtoplate.com/features/food-connects-food-hub-bridge-from-farm-to-market#.XlIFJigza00

Nutrient Management:

7. Various planning tools (e.g. erosion management overlays, land management plans, nutrient management plans) play an important role in assisting to prevent nutrient loss from the landscape. Council can play an important role in landscape-level nutrient management and soil conservation by highlighting the issue and the mitigating function of pertinent policies:

    - The prevention of nutrient losses in the environment, moving away from waste management to nutrient management?
    - The production and use of compost as a valuable component of sustainable farming operations?
    - Sustainable agriculture practices – for example, environmental stewardship that supports soil health and biodiversity conservation/enhancement, prevents manure and fertiliser runoff, reduces soil erosion and prevents livestock access to waterways. This may be achieved with buffers and setbacks that relate to the scale of the use/development.

The recommendations for Nillumbik from the audit are outlined below.

Locally relevant documents:

Investigate the incorporation into the scheme of elements from the *Nillumbik Shire Green Wedge Management Plan 2019* (not implemented in the planning scheme) which provides relevant content for climate change resilience (page 21), and local food production. There is a specific objective to encourage sustainable and regenerative agriculture (O4.3) and to encourage sustainable, diversified, and productive agriculture, access to markets, and the right to farm (O4.2). Actions do not specifically recommend changes to planning policy, but include:

A4.3 To inform future policy development, conduct research into the types of agriculture that are likely to be successful in the green wedge and compatible with its environmental and lifestyle values.

A4.7 Consider options (that comply with the planning scheme) to promote the diversification of agricultural enterprises to ensure multiple income sources. This could include support for complementary activities such as farm gate sales, events, education, and on-farm accommodation.

A4.10 Advocate to the Victorian Government that it alters planning and other controls to:

- allow landholders a right to farm in the Rural Conservation Zone on pre-existing cleared agricultural land with decision guidelines to avoid damage to surrounding properties or environment
- support supplementary rural business activities, such as farm gate sales, farm stays and other low environmental amenity impact enterprises, that are consistent with green wedge values
- to support small-scale and productive hobby farming.

The economy section of the document provides the following content:

There is an opportunity to more productively utilise land in Nillumbik's green wedge to supply Melbourne's growing demand for food. With the establishment of stronger local supply chains, use of technology and motivated landowners, growing produce for Melbourne will ensure farming in the green wedge is protected and enhanced.

One of the barriers to food production is being able to move product to market efficiently. The small-scale production that can occur in Nillumbik is not of a scale that suits the large wholesale market or supermarkets. However, strengthening the supply chain between Nillumbik food producers and food retailers could provide new opportunities for food production.

The close proximity of the Melbourne Market in Epping presents opportunities for our current and future producers, particularly given the growing importance placed on fresh and sustainable production.

(Nillumbik GWMP 2019, p. 29.)

The document also provides support for local food access for the community and the encouragement of local farmers markets and activities that encourage "food exchanges" (Nillumbik GWMP 2019, p. 30.)

Specific actions from the GWMP are deferred to annual implementation plans, which are not searchable on the website. As such, it is difficult to gauge whether the above actions have a high priority for Council.

In terms of recommendations for the planning scheme, there is little existing policy that lends itself to the incorporation of this content – a new Green Wedge Policy is required to give full justice to the opportunities from the GWMP.

One policy in the Municipal Strategic Statement provides a limited opportunity for modified text to reflect the content available:

Clause 21.05-2 (Objective 1 – Rural land use) [Note: Scheme has since been updated]:

The objective for this clause is "To retain existing agricultural land for soil based agricultural production and promote sustainable agricultural activities." Strategies to achieve this objective could be augmented as follows (existing content black text/proposed content blue text):

- *Support the continuance and diversification of agriculture which demonstrates sustainable land management practices, including regenerative and agroecological farm practices.*
- *Facilitate opportunities for diversification in agricultural activities, which could include advocacy, education programs or economic development initiatives that promote diversification of income agribusiness streams (within the bounds of pertinent green wedge restrictions).*

Objectives and action plan

The following objectives and actions have been developed based on the results of the community consultation, survey results, the land suitability analysis, the SWOT analysis and associated literature. They are to suggest directions for achieving a viable and vibrant 'future agriculture' in Nillumbik over the next 10 years. Clearly all suggestions come with the caveat that they must satisfy pertinent policy and regulatory frameworks. For those suggestions considered worthy of action, it is recommended that action delivery is reviewed and reported on to Council every two years and a full review of this document and the agriculture program is conducted in 2031.

1. ***Protect, promote and support sustainable, regenerative agriculture and local food systems in the Shire for greater climate resilience and adaptation in the broader community;***
2. ***Investigate and advocate for policy that promotes diverse, innovative farming systems that foster ecological responsible economic development, local employment, circular resource use and local food systems and security;***
3. ***Support the creation of a vibrant, connected local agricultural community through peer to peer networks, targeted education programs, market access innovation and active, open communication between Council and the agricultural community***

Objectives	Actions
1. Protect, promote and support sustainable, regenerative agriculture and local food systems in the Shire for greater climate resilience and adaptation in the broader community;	• Employ a dedicated Sustainable Agriculture Development officer within the Economic Development team, with close ties to the Environmental Programs team to drive the Agriculture and Food Systems project, including extension activities, workshop programs, demonstration sites and other associated initiatives in line with this report's recommendations;

	• Develop demonstration sites on public and private land for best practice regenerative farming practice; • Consider Right to Farm protections for existing and emerging farm projects; • Investigate the potential of urban farming in activity centres to support greater food security and climate resilience; • Extend the Open Farm Day program; • Extend the current Land Management Incentive program with a commercial farming component targeting the development of innovative, environmentally responsible farming systems.
2. Investigate, advocate and create policy for diverse, innovative farming systems that foster ecological responsible economic development, local employment, circular resource use and local food systems and security;	• Inventory current waste resources generated in the shire with potential for use in agriculture, such as green waste, organics and waste water; • Advocate for greater ecomarket opportunities to support the retention and enhancement of biodiversity assets and soil carbon sequestration on private land; • Consider collaborative integrated pest management programs to manage pest plant and animals in the shire in a coordinated and targeted approach. Consider harvesting as a part of management, as well as biological solutions before chemical management; • Advocate for and support supplementary rural business activities, such as farm gate sales, farm stays and other low environmental amenity impact enterprises, that are consistent with green wedge values; • Develop a program to facilitate the leasing land to young farmers as a way to activate the landscape, bring new entrants into the industry and create productive succession for older farmers who are looking towards retirement; • Development of cultural advice notes for crops modelled in this document; • A secondary investigation to build on this study and delve further into selected

	models, such as multiple grape variety models, new climate adaptive varieties for pome fruit and varieties of citrus to find those best adapted to future agricultural use.
3. Support the creation of a vibrant, connected local agricultural community through peer to peer networks, targeted education programs, market access innovation and active, open communication between Council and the agricultural community;	• Establish an agricultural advisory group to improve communication between Council and the local farming community; • Review the Council planning and regulatory frameworks for barriers and opportunities to innovative localized agriculture and food systems; • Investigate opportunities for scale appropriate market access models, such as food hubs, community supported agriculture, distribution networks, aggregators, farm gates, cooperatives etc. • Deliver targeted integrated land management education programs for various sectors of the agricultural community, such as equine, viticulture, olives, cattle etc. • Work with the 'Keep Yarra Ranges Fruit Fly Free' market access group to assist in developing regional fruit fly management programs; • Establish an annual celebratory dinner for the local farming community showcasing local produce; • Establish peer to peer training programs capitalizing on local and regional farming knowledge and innovative practices, such as permaculture, agroecology, biointensive vegetable production, integrated pest management, stacked enterprises and others important regenerative elements and models.

Conclusion

Access to culturally appropriate, nutritious food is key to a thriving community. The sustainable, local production of this food is essential for a thriving landscape. There cannot be one without the other. Nillumbik Shire Council is in a unique position to be a leading contributor in addressing these issues. Already well established as the 'conservation' green wedge of Melbourne, the Council can build on these credentials, landscape assets and strong community ethos to develop an active, regenerative agricultural movement in the shire that contributes to climate resilience, local employment, economic development, localised food security and enhanced biodiversity and connectivity on private land. Through the use of best practice sustainable and regenerative agricultural techniques, the working role and the preservation role within the landscape can not only coexist, but one benefit the other.

Appendix One

Historical evolution of Land Suitability Analysis techniques

The earliest work on land suitability for planning, in the late nineteenth and early twentieth centuries, involved hand-drawn sieve mapping overlays. This combined soil and vegetation information with topography to infer relationships with other land-uses, and underpinned important town-planning activities such as the establishment of new circulation routes (Steinitz et al, 1974). This method was used through to the 1930s and 40s and formed the basis for the New York Regional Planning study (see Adams 1934), amongst others.

In the 1950's, the hand-drawn sieve mapping overlay method was subjected to academic discussion and development. An updated approach was presented in the textbook "*Town and Country Planning*" (Architectural Press, 1950), which contained an article by Jacqueline Tyrwhitt who is considered one of the founders of modern urban design. The article presented an advance on the overlay method that used four maps (relief, hydrology, rock types and soil drainage), drawn on transparent paper and combined into one 'land characteristics' map to inform planning. This approach was widely accepted and used extensively during the post-war, large-scale planning and development of Britain and North America (Lyle & Stutz, 1983).

Development of the method continued through the 60's and 70's, with the most noteworthy being the seminal work of Ian McHarg who incorporated the ecological inventory process (McHarg, 1969). McHarg introduced mapped information of the human-made influences on the landscape as well as the natural attributes of an area – these were overlaid to identify areas intrinsically suitable for broad land-use planning categories like conservation, recreation and urbanisation. On the basis of McHarg's work, many postgraduate students with an interest in planning flocked to study under him at Pennsylvania State University. As such, a significant body of applied research ensued on suitability analysis through the 1970s and 80s. During this phase, the number and type of maps being included in suitability studies increased, which made the analyses much more complex. This coincided with the rise of computers and therefore computer-assisted suitability analysis was developed.

The application of computer technology to suitability analysis was driven primarily by researchers from Harvard University (e.g. MacDougall, 1975; Sheehan, 1979; Berry, 1983) and generated the well-known SYNAP (syngraphic mapping system) and MAP (mapping analysis program) planning software packages. The University of Massachusetts was also active during this period and developed the METLAND suitability tool (Metropolitan Landscape Planning Model) (Fabos et al 1978). These computer-assisted suitability analyses formed the basis for the development of *Geographic Information Systems* (GIS), which is now an integral planning tool.

As suitability analyses become more complex, problems with the traditional Boolean land unit classification system became apparent. For example, Boolean land classifications assign precise definitions to a land unit and homogeneous land units with values that fall outside the definition are not included in the class. By contrast, fuzzy set theory dictates that the inclusion of a land unit within a particular class is a matter of 'degree of belonging' rather than strict classification according to precise definition. This is particularly evident when considering a soil's capacity to support agriculture and the influence that human-intervention (ie. farmer management practices) can have on said capacity. The integration of fuzzy set theory within suitability analysis and more broadly in GIS therefore became prominent through the 1980s and 1990s (see for example Banai, 1993; Burrough et al 1992; Goodchild et al 1993).

Similarly, it soon became necessary to find less restrictive methods to incorporate decision-makers' preferences within land-suitability analysis. The most well-researched approach was the integration of the multicriteria decision-making (MCDM) or multicriteria evalution (MCE) methods. For example, Pereira and Duckstein (1993) developed a method to evaluate alternative land-use decision options based on their closeness (distance) to the ideal point that served as a frame of reference. Banai (1993) then offered the integration of the *Analytic Hierarchy Process* (AHP) within a GIS environment as a means to rank options from among pairwise comparisons of many options. The AHP was initially developed by Saaty in the 1970s (Saaty 1980) and has since been used extensively around the world in planning and suitability analysis (for example, Nieman & Meshako 1983; McDonald & Brown 1984; Banai-Kashani, 1989; Banai 1993, Malczewski 1996; Miller et al 1998).

Today, the 'suitability' methodology is used to assist decision-making not only in land-use planning but a broad range of areas, from cancer research (Cheever et al, 2009) through to project management (Al-Harbi, 2001). An example of a recent local implementation for land-use planning, which is very similar to that being outlined in this report, is the work of the CSIRO (together with the CRC for Irrigation Futures and UNESCO) to determine the suitability of irrigated areas of the Murray Darling Basin. In that case, the suitability analysis was developed as a tool to inform investment decisions; such as upgrades to existing irrigation schemes, the establishment of new schemes or the retirement of others (Chen et al 2010).

Our methodology of biophysical *Land Suitability Analysis* (LSA) is based on the universally-recognised approach of Ian McHarg (1992), as developed in his seminal book *Design with Nature*, and draws on elements of the Dutch Suitability Analysis system. It includes the consideration of soils, but also includes other factors that are critical to plant production such as climate and water availability as well as a specific treatment of the temporal component (climate change over time) to bring the results in line with medium- to long-term planning horizons. In short, an analytical hierarchy process is established that ranks and weights all major biophysical factors that are important to crop growth in space and time. Suitability is related to yield, where highly suitable land is considered able to support a crop that a farmer would consider high-yielding. The input data (climatic parameters, soil data and information, topographical information) originate from curated sources but how those factors are ranked and weighted relative to each other is driven by local knowledge (farmers).

For the purposes of this study, the United Nations Food and Agricultural Organisation (FAO) suitability framework was adopted in modified fashion. The FAO have an established framework structure for the assessment of suitability for any type of land use and cover (FAO, 1976). This structure is hierarchical in design and comprises of Orders, Classes, Subclasses and Units. Suitability Orders indicate if a unit of land is Suitable (S) or Not Suitable (NS). Suitability Classes are used to reflect degrees of suitability, with three base classes defined; High, Moderate and Low Suitability.

The outputs of the models are therefore represented as maps with suitability classes represented in different colours. Dark green represents areas where the model predicts high yields could be achieved (high suitability), and as the suitability decreases, so too does yield and this is represented by lighter shades of green and eventually yellows. Areas of public land (such as national and state parks) are excluded, as are built-up urban areas.

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