Norfolk Island Environmental Assessment

Executive Summary

In 2018, The Norfolk Island Regional Council (NIRC) identified the need to undertake an assessment of Norfolk Island's environmental capacity and provide scientific background on current land use, hydrology, soils, biodiversity and ecosystems to inform the development of a population strategy and ensure that an increase in population on Norfolk Island does not exceed its carrying capacity. The Community Strategic Plan 2016-2026 – *Our Plan for the Future* (NIRC, 2016), and its Delivery Program 2016-2020, mandate the development of a sustainable population policy, acknowledging that population growth needs to be considered within the bounds of environmental sustainability. The Community Strategic Plan also provides some strategic directions for an environmentally sustainable community, which include the following objectives:

- Develop a clean energy future,
- Protect and enhance water quality,
- Reduce, reuse and recover waste and end disposal of waste into the sea,
- Create a food secure community,
- Create a water secure future,
- Retain open spaces and low-density development,
- Protect and preserve environmentally sensitive areas and those of high conservation value, through improved land management and pest control practices,
- Support threatened species and minimise the presence of invasive species,
- Ensure a healthy, diverse marine ecosystem and,
- Protect and preserve vegetation communities and habitat.

In this context, and in accordance with those objectives, NIRC commissioned The Norfolk Island Environmental Assessment, which was conducted in the period ranging from May 2019 to April 2021 by a team of scientific researchers led by Monash University, Monash Sustainable Development Institute, and The University of Newcastle. The research team carried out a desktop review, some consultation with key stakeholders, data collection and analysis, according to the four main streams of the Environmental Assessment:

- Land-use capability, coastal zones and soils, the extent to which existing land use is consistent with environmental sustainability;
- Hydrology, examining surface and groundwater resources, existing use and long-term sustainability;
- Ecosystems and biodiversity; and,
- Systems and technologies that have applicability on Norfolk Island for waste management, energy and food production.

NIRC will include scientific evidence obtained from these assessments in the community engagement program, to develop a sustainable population strategy for Norfolk Island. It will review the Norfolk Island Community Strategic Plan in line with this evidence to bring in a system of planning controls that: a) better reflects ecosystem and population dynamics; and, b) aligns with economic development objectives and community expectations.

BACKGROUND

Norfolk Island is an Australian External Territory situated in the South Pacific Ocean, located at 29°02'S 167°57'E, with an area of 35 km^2, some 1,600 km northeast of Sydney. Norfolk is a volcanic island with a coastline of some 32 kilometres of mainly precipitous cliffs, except for a small section on the south side, and its highest point is at 318 meters above sea level (mAHD). According to the recent census by Australian Bureau of Statistics (ABS), the population was 1748 (ABS, 2016). Norfolk Island's population has seen a steady decrease since 2001 due to migration of 20-34 year olds, thereby creating a predominantly ageing population (Administration of Norfolk Island, 2011a). The Administration also indicated that the Island has a potential to increase its population up to 10,900 people based on achieving the maximum development potential of land, and the likely dwelling occupancy rates (Administration of Norfolk Island, 2011b). However, it also raises questions about sustainability in the event of population growth that could impact land system capability and natural resources, thus necessitating an assessment of the resource variables (such as hydrology, biodiversity and land capability) for shaping future population dynamics and sustainability on Norfolk Island.

Islands are unique in terms of their geography and biological productivity. Biological productivity is determined by the stability of the island ecosystem, which in turn is shaped by factors such as climate and hydrology. Additionally, coastal areas are most at risk of sea level rise, increased sea surface temperature, increased storm intensity and frequency, ocean acidification and changes to rainfall, run-off, wave size and direction and ocean currents (COAG, 2007). This renders island ecosystems vulnerable to climate variability.

Norfolk Island's average annual rainfall is around 1300mm/yr with most rain received in the winter. This has decreased to ~1105 mm/yr over the past 25 years (Petheram et al, 2021). Norfolk Island is of volcanic origin and dominated by a plateau 100-300 mAHD. The plateau is dissected by several river valleys, which, with the exception of Watermill Creek, reach the coast in hanging valleys with waterfalls (Bird, 2010). Throughout the Island, there is an upper water table in porous alluvium and weathered rock aquifers. During periods of drought, these aquifers tend to dry up due to extraction and natural drainage. At the base of the weathered profile, groundwater moves towards the sea through a complex network of fractures. Semi-confined aquifers are estimated to attract 20-30% of the Island's total rainfall. Groundwater recharge is from direct rainfall infiltration and runoff from Mount Pitt and Mount Bates (Abell and Falkland, 1991; Norfolk Island Regional Council, 2018). The Bureau of Meteorology data indicates an overall decline in rainfall on Norfolk Island during the period 1990-2020 (BOM, 2020).

Water is the most critical of all resources on oceanic tropical islands to sustain life. In the case of Norfolk Island, there is concern over whether available freshwater resources can sustain expected population growth. Currently water demand is met through rainwater harvesting, collection from freshwater springs, and extraction of groundwater. Another key concern is water quality, with cases of surface waters being polluted from sewage effluents and nutrients, and groundwater by wastewater and livestock. The majority of the island is serviced by on-site sewage treatment systems, with only ~12% connected to a reticulated sewage system.

Generally, islands have the highest proportion of recorded species extinctions (up to 80%). Currently, the International Union for Conservation of Nature's Red List warns that 45% of endangered species occur on islands. Analysis of biodiversity and land use capability on islands is particularly critical due to limited natural resources and living spaces, interconnected and more complex ecosystems, high vulnerability to natural hazards, and the impacts of climate change on ocean systems (Ahmadi et al., 2017).

In addition to their ecological value, islands' terrestrial and marine ecosystems provide important natural resources necessary for the economies and cultures of island communities. Balancing national priorities with environmental protection poses challenges. These challenges are made more difficult due to isolation and limited human resources, which is very much relevant to Norfolk Island.

CHAPTER 1: CLIMATE, COASTAL DATA, LAND USE CAPABILITY, ECOSYSTEMS & BIODIVERSITY ASSESSMENT

Climate trends

Climate trends for Norfolk Island can be characterised by the warming of the seas, increasing mean annual temperatures, decreasing mean annual rainfall, and increasing mean annual evaporation from Norfolk Island. These trends indicate a shift in climate patterns that are likely to decrease available water, potentially affect biodiversity and land productivity over the next 100 years.

Coastal resilience

The coastline of Norfolk Island is protected under the Australian Marine Park, and every effort should be made to protect sensitive areas and improve coastal resilience. The Norfolk Island Natural Resource Plan (2009) provided a detailed assessment of coastal issues on Norfolk Island, and it recommended that achieving the Resource Condition Targets and Management Action Targets (Table 7-2 in PB, 2009) should be a primary goal.

Soil conservation

The management of Norfolk Island's soils and land use is limited in its scope and impacts – e.g. highly dispersive soils, easily eroded when no vegetation cover, previously cultivated land overgrown with woody weeds. Land and soils need to be managed more effectively.

In the past, the Norfolk Island Administration has commissioned various reports, the aims of which were to provide advice and direction regarding land degradation and conservation strategies. Several prior reports provided a number of recommendations (Stephens and Hutton, 1954; Clive Lucas, Stapleton and Partners Pty Ltd, 1988; Abell & Falkland, 1991; Mosely, 2001). For example, the report prepared for the Norfolk Island Conservation Society by Mosley (2001) recommended a soil and land use study, and the development of policies and long-term plans to manage soil care, land degradation and rehabilitation.

There has been insufficient attention to recommendations made in previous reports. We urge that effective action is taken with regard to assessing/monitoring erosion, nutrients and restoration techniques, the development of a soil conservation policy with appropriate long term planning, protection of the most fertile areas by limiting subdivision, planting of trees, and better control of over grazing.

The stability of soils on Norfolk Island is solely reliant on land use and vegetation cover. Primary management options for Norfolk Island soils in improving soil stability should include:

- Maintaining constant ground cover in all areas;
- Improving cattle management such as temporarily fencing off sensitive areas;
- Management/removal of woody weeds;
- Develop a strategy for land and soil management that focus on land and ecosystems regeneration, soil organic carbon, agrobiodiversity and crop diversification.

Ecosystems and biodiversity

The ecosystems and biodiversity study sought to broadly categorize land use in terms of vegetation (abundance, density) and catchment condition (degrees of disturbance). Vegetation and Catchment condition maps provided in the report were based on satellite imagery and analyses using Support Vector Machine (SVM) approaches. The use of drone surveys improved resolution of images captured and provided additional information using Normalised Distribution Vegetation Index (NDVI) and Digital Terrain Models (DTM) outputs.

Modelling shows that three disturbance classes (Classes 1, 2, and 3) cover 2,192 ha of land area on Norfolk Island, or approximately 64% of land area (excluding major roads and shorelines). The worst condition class (Class 1) includes degraded open grass areas with evidence of sheet and gully erosion which covers ~900 ha (~25% of land area). The report shows that impacts from trampling, grazing, farming and poor vegetation management have a strong correlation with this class.

Probability of occupancy for four threatened bird species have been presented based on catchment and vegetation condition. Probability of occupancy for different catchment and vegetation conditions provides a baseline condition for monitoring changes in bird population, and/or changes in probability of occupancy with respect to planned/future changes in land use. For example, if a species has a high probability of occupancy in a given catchment/vegetation condition (disturbed or undisturbed), then any changes in land use such as clearing is likely to have a negative effect on that population. In contrast, forest restoration, regenerative farming, and weed management will promote a higher catchment/vegetation condition, and likely increase the probability of occupancy for endangered species as new ecosystems evolve. Outputs from this report provide a baseline for environmental impact planning and future comparison.

Existing projects involving plant identification, vegetation community restoration, and weed/pest management, will support gathering and disseminating environmental data to better understand vegetation mapping and management for Norfolk Island (E.g. Mills, 2018; Naomi Christian Consulting, 2020 are developing a transparent, open-access to vegetation mapping for all of Norfolk Island).

The study identified:

- 2,192ha of Norfolk Island (total of 3,460ha) classed as moderate to very poor catchment condition;
- Higher classes of disturbance condition (less disturbed) mostly comprise reserve areas and coastal areas with hardwood forests, and the National Park with some small pockets in the east;
- 52 exotic "weed" species on Norfolk Island;
- Approximately 80% of the endemic flora species are threatened according to the provisions of the Environment Protection and Biodiversity Conservation Act 1999, and the Norfolk Island pine (Araucaria Heterophylla) is on the International Union for Conservation of Nature Red List of Threatened Species.

It recommended:

- Developing a strategy to restore "disturbed" environments of low catchment condition, at a small-scale, and include a range of approaches such as planting projects and drainage line restoration to reduce erosion;
- Connect all biodiversity/ecology programs undertaken on island with the Norfolk Island Flora & Fauna Plan, and provide a knowledge-sharing platform for current flora and fauna experts, National Parks & Marine Parks staff, and other interested individuals;
- Promote community awareness and education, via e.g. developing online tools, citizen science projects. "iNaturalist" as a global flora and fauna app could support citizen science on Norfolk Island.

CHAPTER 2: HYDROLOGICAL ASSESSMENT AND PRELIMINARY WATER BALANCE

Norfolk Island's water security is under threat due to the historical reduction in rainfall and increasing temperatures (since 1970's) (BOM, pers. comm.). The reduction in water availability will have significant implications for the future of Norfolk Island. Water shortages will directly impact upon household supply, food security (from the perspectives of crop irrigation and stock watering), tourism, public health, and commercial businesses. The Emergency Management Norfolk Island Committee (EMNIC) has recently identified several gaps in Emergency Management Response Plans that sit beneath the Norfolk Island Disaster Plan (NORDISPLAN), namely water security and increased risk of unplanned wildfire given a drier, hotter environment.

Major findings from this study confirm that:

- Norfolk Island's water security is under threat due to the historical reduction in rainfall and increasing temperatures;
- Groundwater levels in 2019/20 were at lowest point in recent history and future recharge rates remain uncertain;
- Approximately 131 ML/yr of harvested rainwater and 128 ML/yr of groundwater extracted for Island water demand;
- All wastewater is discharged via septic tanks across the island, or treated through the Water Assurance Scheme before discharged to the ocean;
- Attributed to livestock and non-sewered areas (septic tanks), surface water quality in major creeks often exceed ANZECC guidelines after heavy rain, sometimes causing closure of Emily Bay (as a human health hazard);
- Poor monitoring and metering of water use across the island;
- Up to 65% of buildings do not have optimised roof/tank volume for increasing rainwater yields;
- Initiate water-metering projects to determine demand and diurnal water use patterns for a range of sites (hospital, school, residential, commercial, tourist accommodations and industrial sites). The use of water meters has proven useful for leak detection in water systems and the use of "smartmeters" can incorporate a citizen science approach to Norfolk Island water management;
- Continued monitoring of surface water discharge throughout the island using stations installed by CSIRO;
- Monitor of groundwater levels and rainwater tank levels at appropriate sites, and;
- Update Development Application (DA) standards for new dwellings (in progress).

Norfolk Island Regional Council (NIRC) has made progress towards the upgrade of the Norfolk Island Sewerage Treatment Plant by commissioning the Balmoral Report (2019), which also canvassed feedback from the community, and provided several options available to NIRC. The community and Emergency Management Norfolk Island Committee (EMNIC) strongly supported *"Option 1 - Membrane Aerated Biofilm Reactor with water recycled to agriculture and community standpipe. Reticulated pressure system for priority areas."* An estimated 55 ML/y of recycled Class A water would initially be available, which would be used to provide irrigation and stock watering, reducing the demand on rainwater and groundwater. The proposal for the Wastewater Treatment Plant (WWTP) upgrade was developed in consultation with Norfolk Island Regional Council and the community in response to the business needs, and assessment of appropriate treatment technologies for the replacement of Norfolk Island's wastewater treatment plant. The total cost for Option 1 was ~$18 million.

In this study, an "available water" assessment identified all alternate water options. Figure 1 highlights the main sources of water used, proposed, or available for Norfolk Island in 2019/20. Figure 2 highlights how available water could be better utilised, whilst reducing the need for desalination or increasing groundwater extraction rates. The significant differences between water availability now (Figure 1), and what could be utilised (Figure 2) are based on:

- Recycled water used for ~43% of the Island's demand ("fit for purpose" users) and is climate independent, resulting in an additional 103 ML/yr for Island water demand.
- Rainwater harvesting improved by a conservative estimate of 15% by optimising roof area/tank volume on existing dwellings/accommodations.
- Decreased dependency on groundwater extraction (lowers extraction by 55 ML/yr, effectively reducing extraction to pre-1990's levels) (lubbe side is).
- Desalination and deep groundwater extraction pre-feasibility options only provide 30.8 ML/yr and would be almost ineffective in a "dry" period similar to that experienced by Norfolk Island in 2019/20.

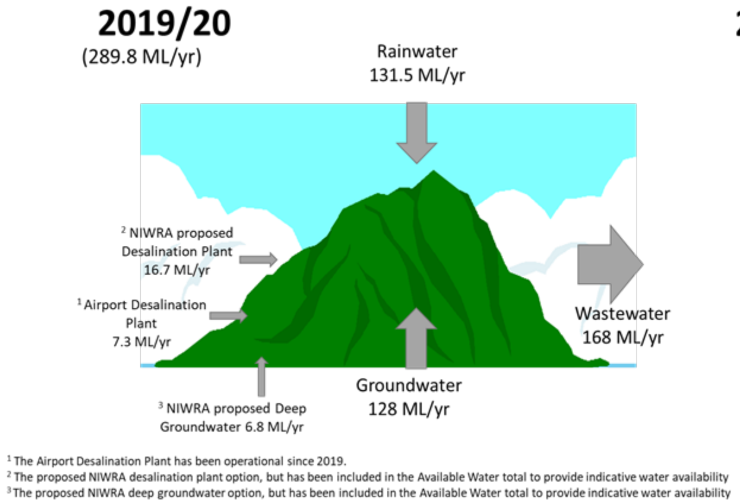

Figure 1: Available water on Norfolk Island during 2019/2020

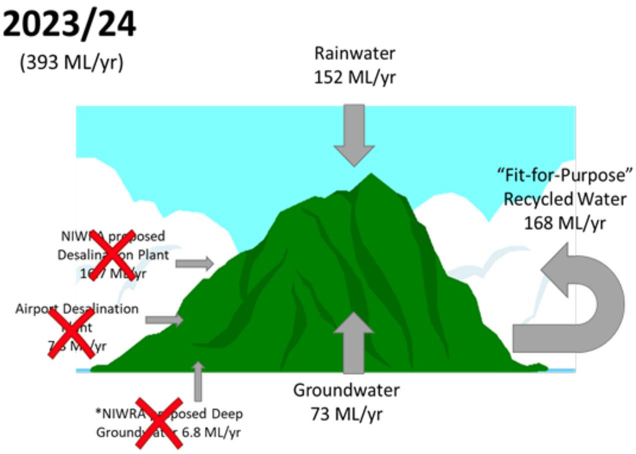

Figure 2: Available water on Norfolk Island after the WWTP upgrade and Reuse Option 1 in the Balmoral Report

The fact is that Norfolk Island is not short of water, the Island only lacks the infrastructure to provide a sustainable approach to utilising all available sources and increasing water security into the future (refer Figure 2). The cost of a new Norfolk Island Sewerage Treatment Plant alone is ~$9 million. However, to not invest the full amount of $18 million for the additional new connections, reticulated water to "fit-for-purpose users" (commercial growers, services/industry, and livestock, reflecting ~43% of the Island's water use), and community stand-pipe; would be significant opportunities missed. For example, ocean discharge would continue to enter the Marine Park at considerable environmental costs and economic losses through fines, septic tanks will still pollute surface and groundwater, and the loss of 103 ML/yr of available water (~38% of existing total water demand). By investing the full $18 million, these significant opportunities can be realised.

The increasing risk of fire, especially within the eucalypt plantations of the Norfolk Island National Park (NINP) has been flagged with EMNIC and NINP as a real and emerging threat. It is recognized the WWTP upgrade and reuse (Option 1 in Balmoral Report) would provide a reliable supply of water that may be utilised for firefighting purposes, which currently do not exist. There has never been a more compelling argument for water security, improved food production, and emergency management on Norfolk Island. The full WWTP upgrade, connection of additional dwelling/accommodations to the Water Assurance Scheme, a reticulated network to "fit-for-purpose" users, and stand-pipe for other users; all point to a sustainable water and food future for Norfolk Island.

CHAPTER 3: NORFOLK ISLAND'S WASTE MANAGEMENT SYSTEM

Norfolk Island Regional Council (NIRC) is uniquely challenged in developing a modern waste management system protective of the marine park in which they exist and equivalent to mainland Australian Councils. NIRC lacks the resource base that mainland Australian Councils have and has waste management costs that are magnitudes higher due to a current reliance on exporting wastes back to Australia. This comes at great cost through reliable air-freight or infrequent shipping often limited to breakbulk operations.

Port Macquarie Council for example has total waste management revenue of $20.5 million per annum from a population of 85,000 from a revenue base (2019) of $213 million (48% from rates), which includes $31.6 million in grants from the NSW and Australian Governments1 . Waste management costs for Port Macquarie-Hastings Council therefore consumes 9.6% of its total budget while total per capita waste management costs are an economical $241 per annum due to modest disposal costs.

Norfolk Island reported collecting total waste management revenue of $793,492 from a population of 1748 from a revenue base (2019) of $41.70 million (7.8% from rates), which includes $20.4 million in grants from the Australian Government. Waste management costs for Norfolk Island Regional Council is equivalent to 2.3% of its total budget with grants, or 4.5% without, while total per capita waste management costs for NIRC was $454 per annum, approximately double the Port Macquarie per capita costs due to high export and disposal costs (comparable to the $500 charged per person on Lord Howe Island).

Unique to remote locations the economics of waste management in Norfolk Island are extreme and closer to the situation in Antarctica than a mainland council in Australia. For comparison, the costs of disposing of a cubic metre (to landfill) for 1 tonne of mixed household waste to landfill in Port Macquarie 3 is approximately $240, while for Norfolk Island disposal of the same waste to landfill costs approximately 10 times this cost. For example, sea freight and disposal costs $1,169, and air-freight and disposal costs $2,288 based on costs incurred by NIRC in 2020/2021.

This quantity of exported waste is also likely to increase both as NIRC reduces the amounts of waste being disposed of at headstone and with increased consumption if regular shipping is introduced through construction of a temporary groyne at Cascades Pier which eliminates break bulk cargoes and permits full shipping containers to be unloaded.

Conversely, there is also a prospect of lowering shipping costs from the $6,500 charged by Boral for a 20 FCL, to be reduced to approaching costs around $2,500 to$3,500. This is similar to that experienced by similar locations in the Pacific (Tuvalu, Kiribati, Niue, and Nauru) through negotiating a regular back loading rate which would significantly reduce export and disposal costs by sea freight though still remaining at estimated costs of $708 for residual waste and $344.06 for recyclables per tonne.

However, the clear gap in available funding versus costs in pursuing higher levels of waste management to protect Norfolk Island's unique environment is not easily answered. The suitability of thermal treatment systems such as incineration, pyrolysis or gasification on paper are an appealing proposition. However, based on international, regional and Australian experience these are still speculative propositions for Norfolk Island. Uncertainty about the viability of thermal treatment systems for Norfolk Island based on high costs and risks were raised in two assessments already conducted by Norfolk Island Administration in 2009 and 2015. In contradiction to Circular Economy principles, these systems would be significant emitters of greenhouse gases and a major source of air pollution and ash.

A reduction in expensive waste exports may be achieved through greater emphasis of Circular Economy principles, through fast tracking and better resourcing of programmes, equipment and human resourcing, to ensure waste such as glass and cardboard (which together make up 53% of all commercial and household municipal wastes) are processed and utilised on Norfolk Island as soon as possible. Though cardboard utilisation as 'renewable' material as part of the biomass load in the energy sector is a possibility either as cogeneration with timber trash and woody wastes such as occurs in Fiji at the sugar and timber mills or as part of biogas generation.

Partnering with plastic packaging companies is an option to convert residual waste bales, which currently contain 60% to 70% plastic, from a quarantine waste to plastic bales through concentrating the plastics and addressing contamination. For example, food and hygiene products could be diverted to the Hot-Rot system, through a NIRC program subsidising bio-based nappies and feminine hygiene products.

Clean plastic bales could potentially be used in new Circular Economy applications now being developed. Through leveraging packaging brand audits conducted under this project and linking with new initiatives, such as the ANZPAC Plastic Pact and the Commonwealth's new projects working in the same space, this could be achieved.

Further engagement with the private sector is needed to move toward packaging free and low packaging products. Following the example of the Prinke store and commitments made by the private sector in Australia, with the aim of reducing the flow of waste materials into Norfolk Island that add to the waste management problem.

The Waste Management Centre and its staff should be recognised for the great strides in improved waste management that have occurred since 2015. However, its services are not fully utilised by the entire population as shown in the survey results and the persistence of damaging practices of waste burning, burial and dumping (via Headstone).

Many individuals choose to use the Waste Management Centre to dispose of only certain waste streams that they cannot easily burn on their properties such as glass. Others opt to boycott the Waste Management Centre entirely due to the required fees and misinformation about what is done with their waste once deposited at the centre.

This should be addressed through properly formulated Community-Based Social Marketing which has been successfully used in identifying barriers and benefits and developing targeted projects to change normative behaviours which would be needed to gain full partnership from the community.

Nonetheless, whether residents utilise the Waste Management Centre or dispose of their waste by other means, the sheer volume of waste on the island remains a key challenge. It is therefore critical that Norfolk Island moves towards a system that focuses on reduction and reuse, and that the accessibility and processes of the current Waste Management Centre are improved.

CHAPTER 4: NORFOLK ISLAND'S ENERGY SYSTEM

Chapter 4 provides a detailed overview of the energy system on Norfolk Island, addresses the shortfalls and current issues on the energy system and how can they be improved, referring to some relevant case studies of other islands and remote communities. Finally, it makes some recommendations for improving efficiency and the sustainability of the energy system on Norfolk Island.

The study has revealed the following issues associated with electrical energy generation, management and use:

- Norfolk Island has high diesel usage for electricity production, high energy costs and high overall greenhouse gas emissions;
- The power plant is old, lacking automation, and a lack of data on both the plant production and power grid;
- The power grid suffers from localised grid voltage issues because of unplanned high penetration of rooftop Solar PV (1.4MW of solar). This causes localised outages and tripping of Rooftop solar PV inverters;
- Most rooftop Solar PV inverters are nearing end of life and have a limited management ability to assist with grid stabilisation;
- There has been a moratorium in place since 2013 on the installation of Solar PV due to the high penetration of rooftop Solar PV. A high feed in tariff for rooftop Solar PV has resulted in an inequity between homes and businesses that have Solar PV and those that do not;
- Together with a mix of old disk type and bidirectional digital meters, there is no time of use tariffs, resulting in non-Solar PV users subsidising Solar PV users use of diesel generated electricity at night. At the time of writing the report a load bank was used to burn off power generated by rooftop Solar PV that cannot be utilised through the day rather than being stored for later use. The load bank itself caused outages to the grid in previous years. In addition, one diesel generator is running continually at minimum 30 per cent capacity for spinning reserve and other ancillary services. The commissioned TESLA Battery Storage System has provided electricity storage, smoothing of the Island 1.4MW distributed solar systems, and absorbs energy that would usually be diverted to the Power Station Load Bank.

Norfolk Island has abundant wind, solar, and wave resources. Solar and wind energy are mature forms of energy generation that have low running costs. Data from previous studies has shown that both solar and wind are viable forms of renewable energy to help satisfy energy demand on the island. Wave energy is an emerging technology as an alternative renewable energy source, which, in the longer term, could supply a sizeable part of the island's energy needs. While solar and wind are inherently variable in supply, with appropriate firming capacity from energy storage or dispatchable electricity generation, solar and wind energy could displace and potentially eliminate diesel generation. This could take the form of a hybrid system entailing wind, solar, battery storage, and diesel generation.

Battery storage can provide an effective form of energy storage, providing firming capacity for variable renewable energies such as wind and solar and can also be used to stabilize the grid and take that burden away from diesel generation that traditionally provided ancillary services on remote islands.

Energy efficiency can produce significant fuel and monetary savings for Norfolk Island through reduced power demand. Payback periods for energy efficiency are generally much shorter than renewable energy. Therefore, prior to investing in further energy generation it is essential that energy efficiency measures are undertaken first prior to the installation of renewable energy to minimize capital costs.

Prior to embarking in further renewable energy installations, several changes should be implemented. The electricity grid needs to be stabilised and this would include several changes:

- the replacement of old Rooftop solar PV inverters with new smart inverters that can assist with grid stabilisation;
- the implementation of a micro-grid control system, and;
- the implementation of a demand management system.

This should be undertaken in conjunction with the migration of ancillary services from the diesel generators to the centralised Battery Storage. These technologies will also assist in grid stabilisation. The power plant should be automated, together with improvements in data logging of both plant and grid generation and consumption. The diesel generation could also be reconfigured to be in standby mode (diesel off mode).

Once these measures are in place, tariff reform would be required to reduce the inequity between the Rooftop Solar PV haves and have-nots and reduce electricity charges across the island. This should be undertaken in conjunction with the removal of the Rooftop Solar PV moratorium.

Several renewable energy pilot projects could be considered with the objectives to identify the most effective ways to decrease costs and increasing resilience on the Island. These could include:

- Rooftop Solar PV and Home Battery bulk buys,
- Solar Farm/Community Owned Solar Farm,
- Solar Gardens,
- Grid/Community Battery Storage,
- Wave Energy,
- Electric Vehicle Strategy, and,
- Induction Cooking replacing LPG gas.

CHAPTER 5: NORFOLK ISLAND'S FOOD SYSTEM

This study sought to investigate the characteristics of Norfolk Island's food system, its organisation, capacity and constraints, to better assess the opportunities and challenges to build a sustainable and resilient food system for Norfolk Island. The context for this study was to inform the implementation of the Norfolk Island Community Strategic Plan 2016-2026 and make recommendations for the realisation of a 'Food Secure Community'.

Norfolk Island has seen a progressive shift from a strong reliance on local food supplies to food sourced from an increasingly globalised food industry network. This shift has brought substantial benefits in the form of competitive pricing and access to a wider variety of food types. Yet some aspects of Norfolk Island's food system have become heavily reliant on external supplies, that is for a range of consumable goods as well as farm inputs such as fertilisers, pesticides and stock feed. This reliance on importation creates vulnerability of both residents and businesses affected by freight delays and shortages of some products.

There is presently a strong interest in local food, as well as an increasing number of initiatives amongst community members that are/ or intending to take part in producing food. All interviewees reported a strong demand from both tourists and residents for better access to local food products, and many stated that they perceive significant untapped market potential. All the food producers interviewed expressed interest for expanding production, diversifying and improving their offerings, and taking advantage of new concepts, tools for land regeneration and sustainable farming. Similarly, aspiring food producers cited numerous opportunities for contributing to producing and/or adding value to food locally. Yet, Norfolk Island's agri-food businesses face a unique set of impediments, including higher energy costs, higher input costs, expensive freight and irregular freight schedules, frequent droughts and water unavailability.

This context demands attention and the development of a considered approach to simultaneously ensure long-term food security for Norfolk Island and leverage the economic, social and environmental potential of an underdeveloped economic sector, the agri-food sector.

The Norfolk Island Community Strategic Plan 2016-2026 determines to '*protect and enhance {Norfolk Island} unique culture, heritage, traditions and environment for the Norfolk Island People'.* It outlines the objectives to create a food secure community, as well as to safeguard environmental sustainability, reduce waste, and promote cultural diversity, social engagement, health and wellbeing, tourism and economic diversification.

Norfolk Island has a unique opportunity to strengthen its local food system to ensure food security for its residents, while placing food at the core of a place-based sustainable development strategy that would benefit the Island's economy, its tourism sector and the health and wellbeing of its residents.

A strategic approach to a food secure community

Currently food security issues are addressed incrementally, in a siloed-approach. Responsibility for food policy is highly dispersed, food-related matters are scattered across various departments and agencies.

The implementation of the Norfolk Island Community Strategic Plan 2016-2026 warrants a strategic approach to building a more resilient and sustainable food system in Norfolk Island. That is a comprehensive and holistic approach to address food security and other related development objectives in a synchronized manner.

Effectively addressing the determinants of food security requires taking a multi-sector approach by operationalizing the linkages between agriculture, food security, nutrition, the environment, culture and heritage and the local economy. It necessitates a fit-for-purpose governance framework, inclusive and participatory mechanisms, community ownership of a vision and a policy agenda. Interventions do not happen if there is no shared vision for what is needed and why.

Government's involvement may be appropriate in supporting the development of a policy framework to provide support for the implementation of the community's vision and guide decisions to achieve rational outcomes.

The report highlighted some priority actions, and recommended a strategic framework to provide the foundations for a more resilient and sustainable food system, placing food production at the heart of a comprehensive sustainable development strategy.

Key recommendations

Governance

- Mobilise key stakeholders within the community to drive a strategic approach to food security and sustainable development (e.g., setting- up a multi-stakeholder working group to lead the process).
- Consider the development of a policy framework [*Norfolk Island Food Strategy]* to improve coordination and synchronized action between key stakeholders and drive institutional support and investment in infrastructure and resources needed for sustaining a community food system.
- Address jurisdictional restrictions and other eligibility criteria, which make residents and businesses of Norfolk Island ineligible for some grants, subsidies or finance available in other Australian jurisdictions.

Agri-environmental innovation (Pilot Projects)

- Investigate setting up a '*Regenerative Farm Hub*' applying best practices in regenerative farming that focus on resource efficiency, land and ecosystems regeneration, soil organic carbon, agrobiodiversity and crop diversification.
- Investigate the setting up of hydroponic systems and the use of local nutrient sources.
- Investigate options (business models, finance, and participation) for infrastructure supporting local food preservation/transformation, distribution (and exports) (e.g., a Co-Op, or a community-owned facility).
- Investigate options to encourage and facilitate the cultivation of local grains (for animal feed and flours) that can enhance soil quality, biodiversity and agrobiodiversity on Norfolk Island.
- Investigate ways to support the (re)establishment of a dairy industry, including improving herd genetics, and mitigating lack of feed, water scarcity in order to increase productivity.

Facilitate knowledge building and sharing

- Allocate resources for the creation of a community learning space [*Food Knowledge Hub*] to facilitate sharing knowledge, build capacity in sustainable food production, and build community awareness around food, agrobiodiversity, nutrition and health, and food production/preserving.
- Examine the potential for developing a farm to school program at the Norfolk Island Central School (incl. providing local organic food meals at the canteen, garden-based learning and practicing).
- Investigate how to promote agri-ecotourism development, appropriate capacity building programs on agri-ecotourism for local community and food producers.

Water Security

- Investigate ways to mitigate the effects of climate change, drought, and seasonal water shortages on food producers, such as alternative sources of water for irrigation.

CHAPTER 6: THOUGHTS AND REMARKS FOR BUILDING A RESILIENT AND SUSTAINABLE FUTURE FOR NORFOLK ISLAND

Most of the challenges that Norfolk Island is facing – land and soil degradation, biodiversity loss, water scarcity, wastewater management, food shortages- are presently addressed in siloes, managed by various separate entities at the federal, state and regional levels. Exemplars of cross-sectoral innovation from Europe, North America and Asia show the feasibility, and benefits, of integrated approaches to address social, economic and environmental sustainability issues. Models, conceptual tools and approaches now exist to facilitate the transition to more sustainable, inclusive and ecological resilient societies.

The future of Norfolk Island needs to be considered from a strategic, whole-system perspective to drive an island-wide transition towards sustainable development. Many of the challenges Norfolk Island faces can be approached in a systemic, coordinated way, such as discussed in Chapter 5. Placing food at the core of a place-based sustainable development strategy would benefit the Island's economy, its tourism sector, the health and wellbeing of its residents and environmental health.

Norfolk Island needs an enabling environment to foster better coordination between all stakeholders, including the Norfolk Island community, and promote a multi-stakeholder/ multi-sector approach to enhance strategic and operational capacities and synchronize actions towards a comprehensive policy approach to sustainability and resilience on Norfolk Island.

Community empowerment and leadership have to be central to the approach. Effective public participation, associating the community to future research design, innovation and policy formulation, can be an important factor in enhancing community trust and ownership of the future.

From vulnerability to an exemplar of resilience and sustainability

We suggest an approach through which the Norfolk Island community is given the tools and structures to effectively participate in, and be at centre of, a new governance approach to envisioning and building its own future. Leveraging best practice and effective techniques for community engagement, the approach seeks to foster meaningful public participation in research, innovation and decision-making processes, to empower the community to define its own development trajectory, moving from its current vulnerability to become resilient and sustainable (Figure 1).

Figure 1: A Community working towards resilience and sustainability

A Norfolk Island Sustainability Lab

The concept, scope and aims of a 'Norfolk Island Sustainability Lab' will have to be discussed with, and determined by, the Norfolk Island community. In our vision, the lab would act as a research and innovation hub on Norfolk Island, assisting dissemination of research outputs, acting as a knowledge repository of past reports/strategies, and enabling the community to play a central role in future research, innovation and policy/ strategy formulation.

In our view, the lab would:

- Constitute a platform for the Norfolk Island community to be engaged in co-designing and co-implementing projects of value to the Island and participate in decision-making processes more effectively;
- Provide the tools, materials and a network of global experts to support education and training in a broad range of areas of relevance and necessity for long term sustainability and resilience of Norfolk Island – biodiversity conservation, land stewardship, regenerative farming and sustainable food production, eco-entrepreneurship, etc;
- Facilitate the development of new projects taking a systemic, participatory approach, and connecting needs, expertise and funding;
- Apply best practice and develop innovative methods, tools and approaches to better understand land use dynamics and develop strategies to sustainably manage Norfolk Island's resources.

The development of the Norfolk Island Sustainability Lab will rely on the willingness and dedication of the Norfolk Island community, which would have to play a central role in its instigation, management and delivery.

KEY FINDINGS AND RECOMMENDATIONS

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<td>Chapter 1: CLIMATE, COASTAL DATA & LAND USE CAPABILITY ASSESSMENT (SOILS), ECOSYSTEMS & BIODIVERSITY</td>
<td>Summary/Findings

Decreasing rainfall, increasing evaporation, and increasing temperatures characterise the future climate of Norfolk Island.
Rainfall not uniformly distributed over Norfolk Island.
Increasing sea levels.
Decline in reef integrity.
Highly dispersive clay soils (in absence of vegetation cover).
Only 10ha of cultivated land exists in 2020, down from ~460ha in the 1830’s.
Woody weeds dominant on previously cultivated land left unused.
2,192ha of Norfolk Island (total of 3,460ha) classed as moderate to very poor catchment condition.
Higher classes of disturbance condition (less disturbed) mostly comprise reserve areas and coastal areas with hardwood forests, and the National Park with some small pockets in the east. This area of 633ha of vegetation provides the most significant area of habitat on Norfolk Island.
The relatively high correlation of lower biodiversity with disturbed lands is a common issue, also resulting in land degradation in sensitive areas.
There are 52 exotic “weed” species on Norfolk Island.
Approximately 80% of the endemic flora species on Norfolk Island are threatened under the provisions of the EPBC Act, and the Norfolk Island pine (Araucaria heterophylla) is on the International Union for Conservation of Nature Red List of Threatened Species.

Recommendations

Improve reef integrity – studies investigating the potential of “re-seeding” existing coral reef systems using a range of artificial reef-based systems.
Marine surveys – temporal and spatial in various areas within the Norfolk Island Marine Park. Topics may include monitoring reef restoration efficacy, shark movements/numbers and/or studies on other species of interest.
Coast Watch initiatives involving litter clean-up days and other community activities that promote reef improvement.
Effective implementation of the Norfolk Island Coastal Management Plan (Chapter 7, Table 7-2 in particular).
Livestock management projects – these may include investigating the use of E-Shepherd collars (these act as “virtual fencing” and significantly reduce the cost of fencing and cattle grids).
Undertake pest and weed eradication projects.
Utilise LANDCARE initiatives involving weed removal days and other community activities that promote sustainable living.
Use of solar pumps to offset livestock watering points in the landscape (reduces soil erosion).
Develop a strategy/ action plan to improve land cultivation /productivity, applying best practices in regenerative farming and integrated landscape management that focus on resource efficiency, land and ecosystems regeneration, soil organic carbon, agrobiodiversity and crop diversification.
Develop a strategy to restore “disturbed” environments of low catchment condition, at a small-scale, at first, and include a range of approaches such as planting projects and drainage line restoration to reduce erosion. Satellite imagery or drone images can been used to monitor changes/improvements over time.

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	• Connect all biodiversity/ecology programs undertaken on island with the Norfolk Island Flora & Fauna Plan, and provide a knowledge-sharing platform for current flora and fauna experts, National Parks & Marine Parks staff, and other interested individuals. • Promote community awareness and education, via e.g. developing online tools, citizen science projects, and 4G apps. For example, "iNaturalist" as a global flora and fauna app could support citizen science on Norfolk Island.
Chapter 2: HYDROLOGICAL ASSESSMENT AND PRELIMINARY WATER BALANCE	**Summary/Findings** • Norfolk Island's water security is under threat due to the reduction in rainfall and increasing temperatures. • Groundwater levels in 2019/20 at lowest point in recent history and recharge rates remain uncertain. • Approximately 131 ML/yr of harvested rainwater and 128 ML/yr of groundwater extracted for Island water demand. • All wastewater discharged via septic tanks across the Island, or treated through the Water Assurance Scheme before discharged to the ocean. • Attributed to livestock and non-sewered areas (septic tanks), surface water quality in major creeks often exceed ANZECC guidelines after heavy rain, sometimes causing closure of Emily Bay (as a human health hazard). • Poor monitoring and metering of water use across Norfolk Island. • Up to 65% of buildings do not have optimised roof/tank volume for increasing rainwater yields. **Recommendations** • Investigate ways to mitigate the effects of climate change, drought, and seasonal water shortages, such as alternative sources of water for irrigation. Option 1 in the Balmoral Report provides a climate dependent source of recycled wastewater into the future. • Alleviate pressure on groundwater extraction by utilising wastewater discharged to the ocean, thus also eliminating nutrient loads on the Marine Park. • Investigate approaches to decreasing runoff, such as leaky weirs, and other retention/detention devices in the landscape. • Digitise location of existing septic tanks and improve operational processes, such as initiating a septic tank inspection program to reduce poorly performing systems contributing to surface and groundwater quality issues. • Incrementally over time, connect dwellings to the Water Assurance Scheme, further securing "fit-for-purpose" water into the future. • Optimise roof area/tanks volume on up to 65% of dwellings to improve rainwater harvesting yields. • Initiate water-metering projects to determine demand and diurnal water use patterns for a range of sites (hospital, school, residential, commercial, tourist accommodations and industrial sites). The use of water meters has proven useful for leak detection in water systems and the use of "smartmeters" can incorporate a citizen science approach to Norfolk Island water management. • Continued monitoring of surface water discharge throughout the island using stations installed by CSIRO. • Monitor of groundwater levels and rainwater tank levels at appropriate sites. • Update Development Application (DA) standards for new dwellings (in progress).

Chapter 3: NORFOLK ISLAND'S WASTE MANAGEMENT SYSTEM	**Summary/Findings** • Waste management costs significantly high due to a reliance on exporting wastes back to Australia. • Waste management costs for NIRC is equivalent to 2.3% of its total budget with grants, or 4.5% without, total per capita waste management costs is $454 per annum. • Quantity of exported waste likely to increase both as NIRC reduces the amounts of waste being disposed of at Headstone and with increased consumption if regular shipping is introduced. • Clear gap in available funding versus costs in pursuing higher levels of waste management to protect Norfolk Island's unique environment. • Suitability of thermal treatment systems such as incineration, pyrolysis or gasification not conclusive (high costs, risks, source of air pollution and ash. **Recommendations** • Develop a Circular Economy strategy for better resourcing of programmes, equipment and human resourcing, to ensure waste such as glass and cardboard (which together make up 53% of all commercial and household municipal wastes) are processed and utilised on Norfolk Island. • Engage in partnership with plastic packaging companies as an option to convert residual waste bales, which currently contain 60% to 70% plastic, from a quarantine waste to plastic bales through concentrating the plastics and addressing contamination. • Implement a NIRC program subsidising bio-based nappies and feminine hygiene products so food and hygiene products could be diverted to the Hot-Rot system. • Engage further with the private sector to move toward packaging free and low packaging products, following the example of the Prinke store on Norfolk Island. • Formulate a Community-Based Social Marketing strategy to develop targeted projects to change normative behaviours with regard waste. • Develop some guidelines – and implement - a system that focuses on reduction and reuse.
Chapter 4: NORFOLK ISLAND'S ENERGY SYSTEM	**Summary/Findings** • Norfolk Island has abundant solar, wind and wave energy resources. • Norfolk Island has high diesel usage for electricity production, high-energy costs and generates high overall greenhouse gas emissions. • The Island power plant is old, lacking automation, and a lack of data on both the plant production and power grid. • The power grid suffers from localised grid voltage issues because of unplanned high penetration of rooftop Solar PV (1.4MW of solar). This causes localised outages and tripping of Rooftop solar PV inverters. • Most rooftop Solar PV inverters are nearing end of life and have a limited management ability to assist with grid stabilisation. • A high feed-in tariff for rooftop Solar PV has resulted in an inequity between homes and businesses that have Solar PV and those that do not. • An initial centralised battery storage system has been commissioned smoothing of the Island 1.4MW distributed solar systems and to absorb energy that would otherwise be diverted to the Power Station Load Bank.

	Recommendations • Prior to undertaking further renewable energy installations several changes should be considered to stabilize the electricity grid, including the replacement of old rooftop solar PV inverters with new smart inverters that can assist with grid stabilisation, the implementation of a micro-grid control system, and the implementation of a demand management system. This should be done in conjunction with the migration of ancillary services from the diesel generators to the centralised Battery Storage. The power plant should be automated, together with improvements in data logging of both plant and grid generation and consumption. The diesel generation would also be reconfigured to be in standby mode (diesel off mode). • Consider tariff reform to reduce the inequity between the Rooftop Solar PV haves and have-nots and to reduce electricity charges across the island in conjunction with the removal of the Rooftop Solar PV moratorium. • Consider the deployment of additional battery storage to provide firming capacity for variable renewable energies such as wind and solar, to stabilize the grid and take that burden away from diesel generation that traditionally provided ancillary services on remote islands. • Consider a hybrid system entailing wind, solar, battery storage, and diesel generation, and increasing capacity of energy storage or dispatchable electricity generation, so that solar and wind energy would displace and potentially eliminate diesel generation. • Consider several renewable energy pilot projects, such as Rooftop Solar PV and Home Battery bulk buys, Solar Farm/Community Owned Solar Farm, Solar Garden, further Grid/Community Battery Storage, Wind Farm, Wave Energy, Electric Vehicle strategy, and Induction Cooking replacing LPG gas.
Chapter 5: NORFOLK ISLAND'S FOOD SYSTEM	**Summary/Findings** • Progressive shift from a strong reliance on local food supplies to food sourced from an increasingly globalised food industry network. • Norfolk Island's food system is heavily reliant on external supplies, for a range of consumable goods (fresh and processed food), as well as farm inputs such as fertilisers, herbicides, pesticides, and stock feed. • Reliance on importation means vulnerability of both residents and businesses affected by freight delays and shortages of some inputs. • Strong demand within the Norfolk Island community for better access to local food produce. • Acknowledgement of a significant untapped market potential to grow more food, diversify crop and food produce, and process food on island. • Norfolk Island's agri-food businesses face numerous impediments, such as high energy costs, water scarcity and limited access to finance and grant support. **Recommendations** • Develop a strategic approach to food security, sustainability and resilience to drive an island-wide transition towards increased availability, accessibility and affordability of local foods to support healthy-eating practices, sustainable economic development and enhanced landscape functions. • Mobilise key stakeholders within the community to drive a strategic approach to food security (e.g. setting- up a multi-stakeholder working group). • Consider the development of a policy framework, *Norfolk Island Food Strategy* to improve coordination and synchronized action between key stakeholders

	and drive institutional support and investment in the infrastructure and resources needed for sustaining a community food system. • Address jurisdictional restrictions and other eligibility criteria which make residents and businesses of Norfolk Island ineligible for a range of schemes, grants, subsidies and finance available in other Australian jurisdictions. • Investigate setting up a '*Regenerative Farm Hub*' applying best practices in regenerative farming and integrated landscape management that focus on resource efficiency, land and ecosystems regeneration, soil organic carbon, agrobiodiversity and crop diversification. • Investigate the setting up of hydroponic systems and the use of local nutrient sources. • Investigate options (business models, finance, and participation) for the development of infrastructure supporting local food preservation, distribution and retail (e.g., a Co-Op, a community-owned facility). • Investigate options to encourage and facilitate the cultivation of local grains (for animal feed and flours) that can enhance soil quality, biodiversity and agrobiodiversity on Norfolk Island. • Investigate ways to support the re-establishment of a dairy industry, including improving herd genetics and mitigating lack of feed to increase productivity. • Allocate resources for the creation of a community learning space' 'Food Knowledge Hub' to facilitate knowledge sharing, build capacity in sustainable food production, and build community awareness around food, agrobiodiversity, nutrition and health, and food production/preserving. • Examine the potential for developing a farm to school program at the Norfolk Island Central School (incl. providing local organic food meals at the canteen, garden-based learning and practicing). • Investigate how to promote agri-ecotourism development, appropriate capacity building programs on agri-ecotourism for local community and food producers. • Investigate ways to mitigate the effects of climate change, drought, and seasonal water shortages on food producers, such as alternative sources of water for irrigation.