NSW GOVERNMENT Office of Environment & Heritage

Integrated Regional Vulnerability Assessment: North Coast of New South Wales

Volume 1: Assessment report

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Glossary

Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC 2013).
Adaptive capacity	The emergent property of a system to adjust its characteristics or behaviour to better cope with existing climate variability or future climate conditions. Adaptive capacity is expressed as actions that lead to adaptation that serve to enhance a system's coping capacity and increase its coping range, thereby reducing its vulnerability to climate hazards. Adaptive capacity also refers to the set of resources available for adaptation, and the ability of a system to deploy resources effectively in pursuit of adaptation (UNDP 2005).
Climate	Average weather (or, more specifically, the mean and variability of variables such as temperature, precipitation and winds) over a time period ranging from months to thousands of years to millions of years.
Climate change	A statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC 2013).
Impacts (climate)	Consequences of climate change on natural and human systems.
Infrastructure backlog	The work required to ensure an asset is able to continue to provide the same level of service that has not been carried out at a particular reporting date (usually the end of the financial year).
Integration	The process by which separately produced components or assessments are combined, and incongruities in their interactions are considered and addressed.
Maladaptation	Any changes in natural or human systems that inadvertently increase vulnerability to climate variables; an adaptation that does not succeed in reducing vulnerability, but increases it instead.
Mitigation (emissions)	A human intervention to reduce the sources or enhance the sinks of greenhouse gases.
Mitigation (natural disasters)	Measures to contain or reduce the severity of human and material damage caused by extreme weather events and natural hazards.
Region	The planning regions of NSW as depicted in NSW2021 – A plan to make NSW Number 1.
Resilience	Amount of change a system can undergo without changing state.
Sector	A part or division, as of the economy (e.g. the manufacturing sector, the services sector) or the environment (e.g. water resources, forestry).
Sensitivity	The degree to which a system is sensitive to variability or change.
System	A population or ecosystem; or a grouping of natural resources, species, infrastructure or other assets.
Vulnerability	Sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC 2013). Vulnerability is a function of the character, magnitude and rate of climate change, and variation to which a system is exposed, its sensitivity and its adaptive capacity.
Weather	Atmospheric conditions at a particular time, such as hours or days, as defined by variables such as temperature, precipitation and winds.
Weather extremes	Weather phenomena that are at the extremes of the historical distribution, especially severe or unseasonal weather.

Preface

A key target of the NSW Government's 10 year plan, NSW 2021, was to minimise impacts of climate change in local communities. Climate affects multiple systems and so risks from climate change require a systemic, coordinated response. This requires the input, agreement and collaboration of multiple stakeholders.

An Integrated Regional Vulnerability Assessment (IRVA) is a process developed by the Office of Environment and Heritage to engage regional stakeholders, gain a holistic view and plan collaborative responses to the emerging risks from a changing climate. It produces a qualitative assessment of the influence of climate impacts on services and infrastructure for which state and local governments have a primary responsibility – such as public health, land-use planning, infrastructure and emergency services – and identifies factors that affect the vulnerability of those services. Using a participatory learning approach, an IRVA helps to develop relationships and networks within sectors and creates a sound knowledge and skill base from which regional managers and decision-makers can adapt government services, aware that action by one sector may have consequences in another.

Being a cross-agency initiative, this innovative and rigorous intervention helps a region to:

- assess the situation, by
    - identifying local climate change vulnerabilities in vital sectors, and understanding how these vulnerabilities influence other sectors
    - developing a comprehensive understanding of the region's vulnerability through the interaction of each sector's vulnerability
    - gauging a region's existing capacity to adapt to climate change
- mobilise industries and communities, by
    - increasing stakeholder understanding of climate change issues and potential impacts – in the process boosting their capacity to respond appropriately
    - embedding the importance of acting collectively – raising awareness that action by one sector may have adverse consequences in another
    - developing relationships among and within sectors to support collaborative action
- start planning a workable adaptation strategy, by
    - identifying potential responses for reducing vulnerability in a systemic way
    - creating a sound information base from which to prepare practical adaptation plans, in response to local priorities, using a region's existing management and planning structures.

This report outlines the outcomes of the IRVA process undertaken in the North Coast region of NSW. It describes the key areas of vulnerability to climate change identified by regional participants.

The North Coast IRVA builds on the IRVAs of the South East, Riverina Murray and Metropolitan Sydney, and furthers the framework from which other regions can begin the vital work required to prepare NSW for the impacts of climate change. This process has highlighted the depth and breadth of regional knowledge held by local officers, decision-makers and community leaders. The IRVA process provides a system for accessing that wealth of information, and capturing it in a way that provides a basis for effective and collaborative regional planning for a changing climate.

1. How the IRVA overcomes the challenges of planning for climate change

1.1 Why do we need an Integrated Regional Vulnerability Assessment?

The NSW Government has committed to assisting local communities to minimise the impacts of climate change and build resilience to future extreme climatic events and hazards (NSW Government 2011). For the North Coast region, climate projections indicate both hotter temperatures and an increase in rainfall seasonality (more in summer, less in winter), with consequent impacts upon natural systems and the way communities and economies operate (OEH 2014)[1]. Thus it is imperative that we begin to consider how our systems can adapt to continue to function effectively and efficiently under these future conditions.

The Integrated Regional Vulnerability Assessment (IRVA) contributes to this commitment through a cross-agency initiative, which allows regional communities the opportunity to gain a holistic view of the emerging risks from a changing climate and plan a collaborative response.

By assessing regional vulnerabilities and undertaking adaptation planning, priority areas can be identified and effective action implemented through coordinated and cooperative networks across groups and sectors. Such action will increase the resilience of the community, environments and economy of the North Coast to ensure that impacts are minimised and to capitalise on opportunities.

1.2 What is an IRVA?

The IRVA process produces a qualitative assessment of the influence of climate impacts on a dynamic system (Jacobs et al. 2014). Through research and stakeholder workshops, an IRVA creates a sound knowledge and skill base from which regional managers and decision-makers can develop adaptation responses for government services in the region.

The concept of vulnerability is key to the IRVA process. Vulnerability can be thought of as a system's exposure to climate change impacts, sensitivity to those impacts and the capacity to adapt (IPCC 2007). Regional vulnerability occurs in the context of demographic and economic influences (external drivers) that influence the adaptive capacity and sensitivity of multiple sectors, as shown in Figure 1.

In undertaking an IRVA, participants consider the likely impacts of climate change within key regional sectors and how this may influence other sectors in the region. In addition, each sector's capacity to adapt is discussed. In identifying sectoral and regional impacts and issues of adaptive capacity, the gaps, or vulnerabilities can be identified, from which adaptation options to increase the region's resilience can begin to be developed.

Use of this approach acknowledges the uncertainty in the impacts of climate change and still allows identification of key vulnerabilities from which a regional adaptation strategy can be built. Most importantly, the IRVA uses a participatory approach that builds networks, empowers stakeholders to act on the results and promotes regional ownership (OEH 2013).

[1] The analysis was completed prior to the release of updated projections in December 2014. However, the nature of changes projected under both sets of information is similar and when considered in the context of the approach of this assessment will not change the outcomes or vulnerability narrative.

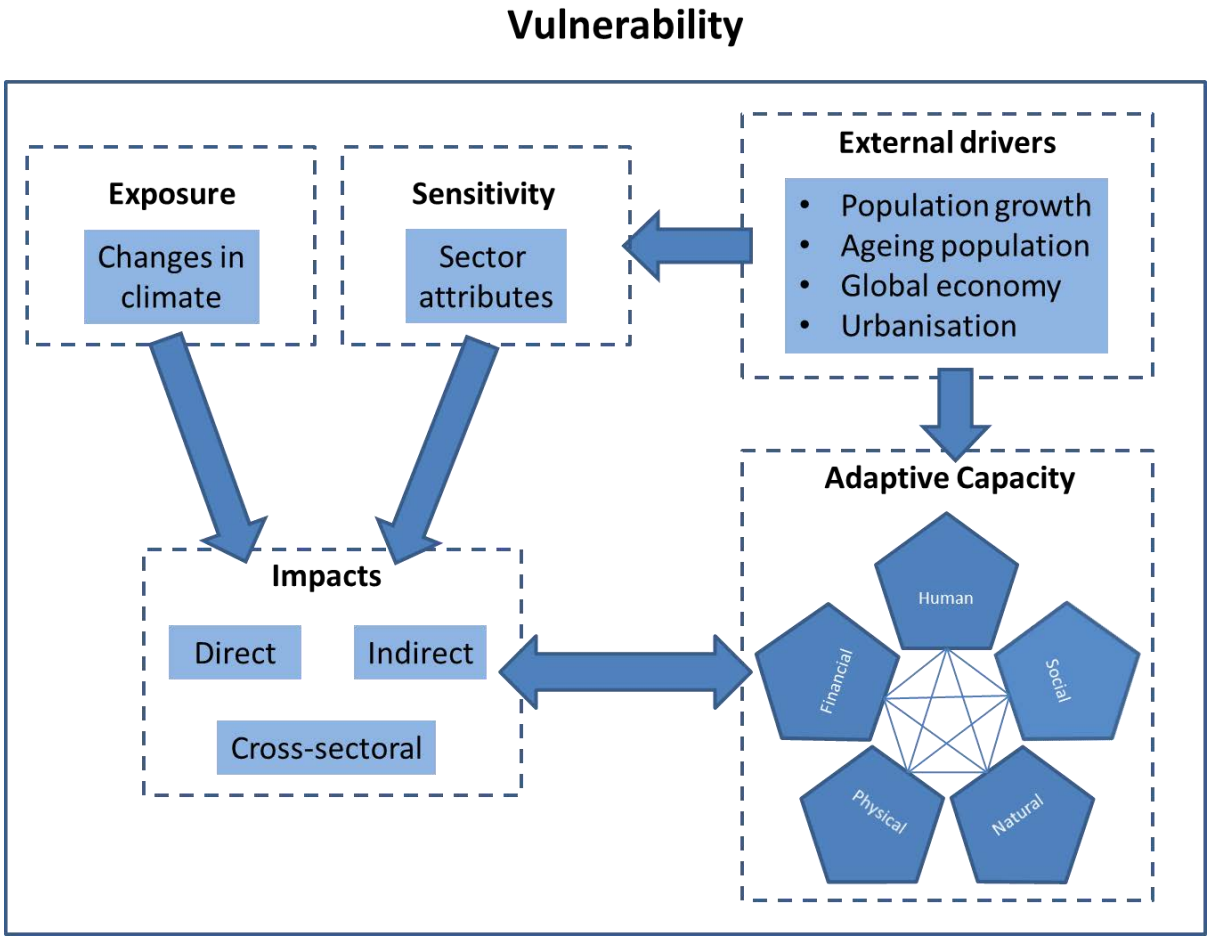


Figure 1: Vulnerability model – integration of impacts and adaptive capacity for multiple sectors (adapted from Allen Consulting 2005)

2. The North Coast region of NSW

This section provides an overview of the regional context. A more detailed summary of the regional context considered during the workshops is provided in Appendix B.

For the purposes of the North Coast IRVA the region is defined as the local government areas of Ballina, Bellingen, Byron, Clarence Valley, Coffs Harbour, Greater Taree, Kyogle, Kempsey, Lismore, Nambucca, Port Macquarie–Hastings, Richmond Valley and Tweed Heads.

The North Coast region stretches from the Queensland border in the north, to Taree in the south and from the coastal plains in the east to the Great Dividing Range in the west. The region covers an area of approximately 35,790 square kilometres (Figure 2) and has a population of approximately 543,450 people that are primarily located in the major regional centres of Tweed Heads, Lismore, Ballina, Grafton, Coffs Harbour, Port Macquarie and Taree.

The region has two Regional Organisations of Councils (ROCs). The Northern Rivers Regional Organisation of Councils (NOROC) consists of seven local councils and two water county councils[2], and the Mid North Coast Regional Organisation of Councils (MIDROC) comprises eight local councils. MIDROC incorporates two local government areas that fall outside of the North Coast IRVA area, Gloucester and Great Lakes.

The North Coast comprises a number of prominent landscapes that help to define the region. These landscapes include the escarpment and hinterland that contain World Heritage rainforests, the major river systems and associated alluvial floodplains, and the estuaries, lakes and beaches of the extensive coastal plains.

These landscapes are integral to the prosperity of the region and underpin tourism and agriculture, two of the region's key economic drivers. In particular the coastal landscapes have long been the main attraction for tourists and are now in high demand for settlement.

The population has grown by 4.1% over the period 2006–11 and is projected to grow a further 15% by 2031. The North Coast population is also ageing, with people over the age of 65 representing 21% of the population and forecast to grow to 30% by 2031 (DPE 2014).

The region has a diverse economy with Health Care and Social Assistance, Retail Trade, Education and Training, Accommodation and Food Services, and Manufacturing each employing more than 10,000 people. However, the number of people employed in many industries declined over the 2006–11 period including Agriculture, Manufacturing and Retail, while Health Care and Social Assistance, and Education and Training, experienced growth. Tourism also plays an important role in the region with 12 million visitors spending approximately $3.76 billion annually (TRA 2013).

[2] Water county councils are organisations established under the *Local Government Act 1993* for the purpose of providing drinking water to the area they cover.



Figure 2: The North Coast region of NSW

3. The North Coast IRVA

The North Coast IRVA sought to identify the regional vulnerability as a basis for developing approaches and actions that will build community resilience to a changing climate. The project aimed to:

- establish an understanding of climate change impacts within key regional sectors and how these impacts may interact between sectors
- determine what sectoral stakeholders currently know, and plan to do, about climate change
- identify the main sources of each sector's, and the region's, vulnerability
- assess barriers to adaptation in these key regional sectors and the adaptive capacity of the region as a whole
- identify opportunities to reduce vulnerability and enhance regional resilience
- continue to refine the IRVA methodology to be applied in other NSW regions.

3.1 The IRVA process

The process involved the following stages (see also Figure 3):

1. establishing project governance
2. collecting and synthesising regional climate change and socioeconomic information
3. assessing sectoral impacts and adaptive capacity via sectoral workshops
4. analysing and integrating sectoral workshop outcomes to enable identification of regional vulnerability through an integration workshop
5. synthesis of workshop outcomes with existing research into the social, economic and environmental impacts of climate change, to develop the North Coast vulnerability assessment report.

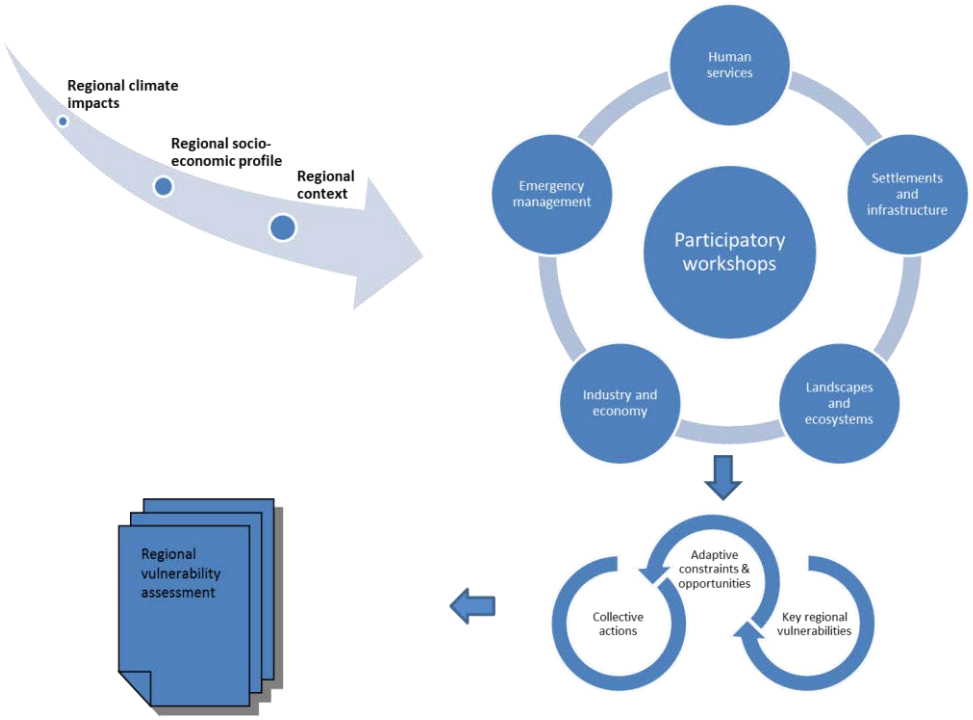


Figure 3: Overview of the North Coast IRVA process

For the North Coast IRVA a steering committee was established comprising regional representatives from a number of key government agencies to advise on and oversee the project (Appendix A).

The steering committee agreed that the North Coast IRVA would consider five sectors, which are outlined in Table 1.

Table 1: Workshop sectors for North Coast IRVA

Sector	Coverage
Industry and economy	Primary industries, processing and manufacturing industries and tourism
Landscapes and ecosystems	Natural resource management, biodiversity conservation, natural and cultural heritage
Settlements and infrastructure	Transport, energy, communications, buildings and settlements, retail, water infrastructure
Emergency management	Preparation, response and recovery to fire, flood, storm, drought and other emergencies
Human services	Employment, health, aged care, disability services, community services, education

To inform the assessment, regionally-specific climate change information developed for the NSW Climate Impact Profile (DECCW 2010a) and Impacts of Climate Change on Natural Hazards Profiles (DECCW 2010b) was collated (Appendix C). Information on regional socioeconomic and environmental trends was collated from socioeconomic research and demographic data (ABS 2011b; DPE 2014) to provide a snapshot of the current socioeconomic and environmental conditions in the region (Appendix B). This background information and the professional knowledge and experience of the participants provided the basis for analysis in the workshops.

Six sector workshops were held, including two with the settlements and infrastructure sector (one for the Northern Rivers and another for the Mid North Coast) to capture potential differences between the Northern Rivers and the Mid North Coast. Workshop participants were invited from NSW Government agencies, state-owned corporations, local governments and organisations involved in delivery of government services to the North Coast region. Close to 40 organisations were represented throughout the North Coast IRVA process (Appendix A) with multiple functional areas from some organisations participating.

The workshops were based on a participatory approach. In groups of 5–10, participants were asked to collectively construct influence diagrams to show climate change impact pathways and relationships with other sectors.

Mapping the influences of climate change impacts to each sector provided the context in which adaptive capacity could be discussed using the 'five capitals' framework of sustainable development. The five capitals addressed were human, social, natural, physical and financial. A broad definition of each capital is presented in Table 2.

Table 2: Broad definitions of the five capitals used in the sustainable development framework (adapted from Ellis 2000)

Capital	Definition
Human	The skills, health (including mental health) and education that contributes to the productivity of labour and capacity to manage resources
Social	The family and community support available, and the networks through which ideas and opportunities are accessed
Natural	The productivity of land, and actions to sustain productivity, as well as the water and biological resources from which livelihoods are derived
Physical	The infrastructure that contributes to livelihoods
Financial	The level, variability and diversity of sources of income, and access to other financial resources such as credit and savings

For each capital, indicators of adaptive capacity were identified by asking the participants the following questions:

'Given what we know are the likely effects of climate change in this region, for your sector:

1. What must change to service the community and why?
2. What is needed to enable change?
3. Where is change needed most/least?
4. Who can make change happen?

This discussion provided clear indications of adaptive capacity within each sector, identifying both enabling and constraining factors that influence overall adaptive capacity, and also the level at which these operate: local, regional, and/or state/national.

Following the workshops the impact diagrams and adaptive capacity discussions were analysed by OEH project staff in conjunction with existing and projected regional dynamics. This process identified:

- sectoral vulnerabilities, and
- cross-cutting issues and common themes of key regional vulnerability.

In a single integration workshop approximately 30 participants 'ground-truthed' the outcomes of the sector workshops and then prioritised the identified vulnerabilities within their sectors. Following this they prioritised these issues across sectors, to identify cross-sectoral or cross-cutting impacts, which provided the foundation for participants to think about integrated regional vulnerability.

Participants were then allocated to cross-sectoral groups to discuss the identified themes of regional vulnerability. These vulnerability descriptors were refined and potential adaptation responses were identified and discussed. Each group then reported to the broader workshop in a plenary session.

Outcomes of this workshop were then analysed to produce this final report on regional vulnerability.

A full explanation of the IRVA approach and process is available in the *Guide to Integrated Regional Vulnerability Assessment for Climate Change* (OEH 2013). Outputs of the sectoral workshops are provided in the sector summaries (Volume 2).

4. Overview of climate change impacts on the North Coast

The projected changes in climate and their associated impacts on land, settlements and ecosystems were an important input for this vulnerability assessment. A detailed summary of the changes and their associated impacts considered during the workshops is provided in Appendix C. Below is an overview of the projected changes in climate released by the NSW Government in December 2014.[3]

Based on long-term (1910–2011) observations, temperatures have been increasing in the North Coast region since about 1970, with higher temperatures experienced in recent decades. The North Coast region is projected to continue to warm in the near future (2020–39) and far future (2060–79), compared to recent years (1990–2009). The warming is projected to be on average about 0.7°C in the near future, increasing to about 2°C in the far future. The number of high temperature days is projected to increase, while a reduction is anticipated in instances of potential frost risk. The warming trend projected for the region is large compared to the natural variability in temperature and is of a similar order to the rate of warming projected for other regions of NSW.

The North Coast currently experiences considerable rainfall variability across seasons and from year-to-year and this variability is also reflected in the projections. Seasonal rainfall projections for the near future and far future span both drying and wetting scenarios. The range of projected changes for the near future are: summer –17% to +14%, autumn –9% to +37%, winter –40% to +30% and spring –18% to +25%. In the far future the range of projected changes are: summer –10% to +39%, autumn –8% to +39%, winter –35% to +38% and spring –18% to +49%.

For the North Coast region the majority of models agree that autumn and spring rainfall will increase in the near future (7 out of 12 models) and far future (9 out of 12). For the North Coast region the majority of models agree that winter rainfall will decrease in the near future (8 out of 12) and far future (7 out of 12). A decrease in summer rainfall is projected by 7 out of 12 models in the near future, while 9 out of 12 models project that summer rainfall will increase in the far future.

Sea level is projected to continue rising, posing a major risk to property and infrastructure. Developments closest to the shore and on sand spits are most at risk. Increases in heavy rainfall events are expected to increase the likelihood of flooding along urban streams. Towns on coastal plains and near estuaries are likely to suffer additional risk of flooding.

The projected rise in sea level is expected to have a substantial impact on estuarine and foreshore ecosystems, while sea level rise, increased temperatures and changes in hydrology and fire regimes are likely to have a substantial impact on terrestrial and freshwater ecosystems.

[3] The nature of changes projected under both sets of information is similar and when considered in the context of the approach of this assessment do not change the outcomes or vulnerability narrative.

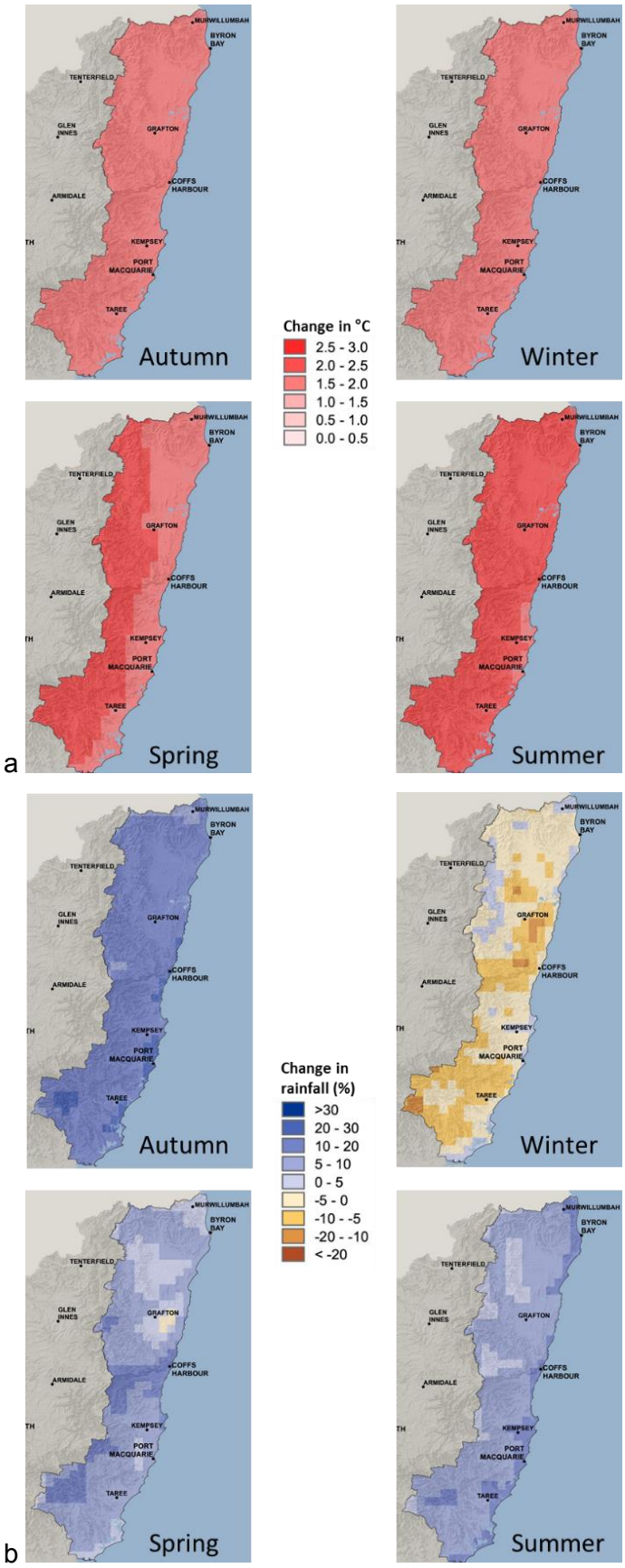


Figure 4: Projected changes in seasonal daytime temperatures (a) and rainfall (b) for the North Coast by 2060–2079

5. Vulnerability on the North Coast

This section reports workshop participants' informed understanding of the impacts and adaptive capacity issues of their region. The collated knowledge of regional officers and decision-makers is presented below and intended as an information base that can be used to inform future planning for adaptation action.

From thematic analysis of information collected at sectoral and integration workshops, six key themes were identified as contributing to the vulnerability of government service delivery on the North Coast:

- narrow coastal plain
- population demographics and change
- infrastructure (development)
- regional networks
- leadership
- funding models and priorities.

These six themes encompass existing sources of vulnerability within systems on the North Coast that will be amplified by climate change. In the following section, the major components of vulnerability, exposure, sensitivity and adaptive capacity will be described. Where potential strategies to reduce vulnerability were highlighted in the workshops, these are summarised.

While these vulnerabilities have been identified for the region as a whole, there are differences in how they manifest at a local scale within the North Coast region. Through the course of the IRVA it emerged that specific subregional variations in exposure, sensitivity and adaptive capacity can play a contributing role in broader regional vulnerability, particularly in relation to the NSW–QLD border. The following sections discuss these subregional variations where they are relevant to regional vulnerability.

5.1 The narrow coastal plain

Précis: The steep hinterland, many river systems and low-lying coastal plains, which give the North Coast landscape its character, make the region particularly sensitive to changes in flooding and sea level rise.

All sectors identified the coastal plain as playing an integral role in the region's vulnerability to climate change. More specifically, it was the interplay between geography, current and future climate, rising sea levels, settlement patterns, major infrastructure, agriculture, and demand for coastal lifestyles that drives this key vulnerability (Figure 5). Participants also identified important links between the coastal plain and some of the region's other key vulnerabilities including the location of critical public infrastructure and changing population demographics.

The steep hinterland coupled with a low-lying coastal plain and relatively high rainfall predisposes the North Coast to riverine flooding with the water levels in the major rivers quick to rise and fall in response to widespread heavy rainfall. This pattern of flooding is typical of coastal rivers in NSW and is markedly different to the slow and more predictable nature of flooding along inland river systems. In addition there are a number of erosion hotspots along the coast; combined, these factors expose the North Coast to changes in climate.

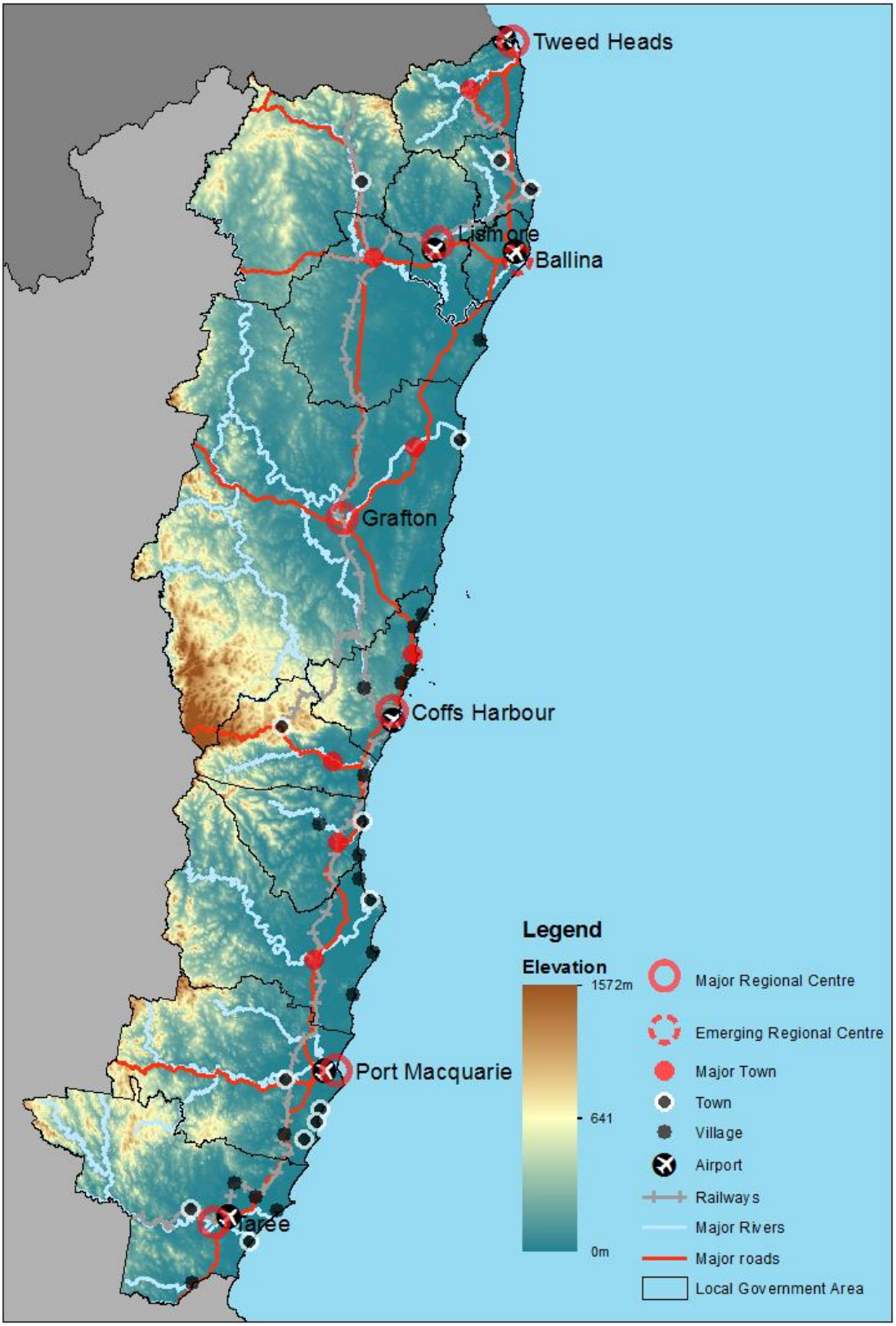


Figure 5: Map depicting elevation above sea level, major rivers and the location of major settlements, airports and road and rail infrastructure on the North Coast

Climate change impacts

Among the projected changes in climate on the North Coast, participants identified the narrow coastal plain as particularly sensitive to increased summer rainfall and rising sea levels. The projected changes in summer rainfall would increase riverine and flash flood risk and slope stability, while changes in sea levels would increase high tide inundation, raise the saline water table, increase coastal erosion and increase flood levels in coastal areas. The region's sensitivity to these changes is derived from:

- major settlements being adjacent to rivers or the coast or both (e.g. Tweed, Ballina, Port Macquarie)
- the region's population being concentrated on the coast
- many unique coastal and floodplain ecosystems being highly impacted by past clearing and urban development and subject to multiple ongoing stressors
- major transport infrastructure being adjacent to the coast and crossing multiple major rivers (e.g. roads, bridges, airports and rail line)
- highly productive agricultural enterprise on the coastal floodplain because of the region's historically favourable climate.

Cross-sectoral impacts

Participants identified the changes to flood behaviour were likely to have significant impacts across multiple sectors, with many of the impacts occurring through damage to infrastructure (public and private) during an extreme weather event and the disruption of services the infrastructure provides. However, impacts were also likely to occur through damage to private property, loss of crops and livestock, nutrient runoff, standing water following flood and sedimentation in rivers and drainage systems.

A range of important public and private infrastructure on the coastal plain was identified as potentially at risk including major transport infrastructure (northern rail line, Pacific Highway and regional airports), health care, education and emergency services infrastructure and utilities infrastructure (water, electricity and sewerage). The loss of services provided by this infrastructure would in turn lead to:

- loss of access to markets
- absenteeism of workers
- people stranded on major highways
- short-term reduction in tourism
- isolation of health care infrastructure preventing access and egress of workers, patients, waste and supplies
- school and campus closures
- isolation of coastal towns, people and communities
- loss of access for emergency services
- loss of local energy and water supply
- poor water quality through sewage and wastewater overflow.

The effects of increased flood incidence on private property, loss of crops and livestock, nutrient runoff, standing water following flood and sedimentation in rivers and drainage systems include:

- displacement of people increasing demand for welfare services
- increased crime associated with looting increasing demand for police services
- poor water quality with impacts on terrestrial, aquatic and marine coastal ecosystems, commercial (e.g. oyster production) and recreational fishing and beach use
- increase in vector borne diseases affecting human and animal health and increasing the demand for health and veterinary services

- loss of income affecting business productivity and viability with flow-on effects to the regional economy
- increased insurance costs affecting access, affordability and coverage
- increased expectations of government intervention and assistance.

Similarly, participants identified that sea level rise would drive a wide range of impacts across multiple sectors, particularly:

- Coastal erosion that would lead to the loss of beaches and fore-dunes, impacting associated ecosystems, decreasing beach amenity and affecting public and private infrastructure and assets located in the coastal zone. These impacts could affect the region's cultural identity and tourism.
- Rising saline water table increasing maintenance costs of roads and pipes, reducing access to fresh groundwater in coastal areas, affecting drainage infrastructure and sporting facilities and leading to salinisation and decline of coastal ecosystems.
- Tidal inundation with associated impacts on pasture productivity in low-lying farmland, damage and maintenance costs of road, sewerage and drainage infrastructure, access and egress of emergency services, public facilities (including police stations, TAFE campuses and schools), availability of habitat for disease vectors, function of sporting facilities and airports, accessibility of coastal towns, private dwellings and shifting freshwater ecosystems to marine/estuarine ecosystems, with impacts on commercial and recreational fishing.

Factors affecting adaptive capacity

Coastal lifestyles are in high demand on the North Coast, driven by the scenic values of the coast and a mild climate when compared to inland. This demand leads to ongoing pressure to develop new areas in the coastal zone, intensification of existing development and the need for additional supporting infrastructure to be located in the coastal zone. The projected rise in temperatures across NSW will further increase this demand for coastal living.

There is community reluctance to accept retreat as a serious option, particularly those directly affected, as they do not want to lose what they value emotionally and economically. For some residents the economic security of their future is linked to the value of their property.

A very large local government infrastructure maintenance and renewal backlog exists on the North Coast, with the Northern Rivers and Mid North Coast regions having the highest and second highest backlogs in NSW. The infrastructure backlog pertains mostly to roads and in part reflects the flood prone nature of the region. Decreased capacity to maintain roads leads to more damage during floods and prolonged road closures and isolation of communities. With the exception of the Pacific Highway the majority of roads in the region are managed by local government, placing a burden on councils. This constraint also represents an opportunity to incorporate consideration of changes in flood behaviour in renewal and upgrade projects.

Wastewater treatment facilities and stormwater drainage in the region are gravity fed. The functionality of these facilities in coastal settlements relies on the movement of water under gravity to discharge at the lowest point in the system, which may currently be at sea level. For many settlements there is nowhere to move these facilities that would maintain the current functionality for the community.

Some participants identified that policy changes around sea level rise make planning for sea level rise and implementation of adaptation responses difficult. Influencing this constraint was broader debate about climate change and sea level rise impacts, and the need for strong leadership on dealing with sea level rise. Having to focus on determining the right numbers takes the focus away from shaping appropriate responses.

Large areas of highly productive agricultural land occupy the low-lying coastal plains, including large areas of dairy and beef production and cropping. Adaptation responses to

rising sea levels, associated inundation and rising saline water tables are limited and become increasingly limited the higher the rise in sea level. Previously, livestock systems included ownership of land in the escarpment and on the coastal plains. This facilitated the movement of livestock to higher ground during flooding. This system no longer operates because of development pressures on coastal land, the cost of land and limited returns on investment in agriculture.

Potential regional responses to reduce vulnerability

A range of options were raised to address vulnerability due to the narrow coastal plain. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- seek ongoing improvements in the accuracy of flood warning systems
- design and build innovative and effective housing and infrastructure that has capacity to withstand flooding
- seek long-term investment options in the region based on a strategy that integrates productivity and landscape resilience
- foster greater appreciation of undeveloped coastal land providing a buffer from effects of coastal erosion and sea level rise
- improve recognition of the unique biophysical attributes of the North Coast that constrain adaptive responses
- recognise the indirect effects of sea level rise on river coastal villages and towns
- seek additional revenue streams to fund infrastructure improvements that incorporate adaptation measures
- ensure sea level rise risk is incorporated into coastal infrastructure planning
- for primary industries in particular, develop state and federal grants for natural events that focus on proactively reducing impacts rather than recovery after an event.

5.2 Population demographics

Précis: The influx of retirees and loss of youth to the major cities mean the North Coast population is ageing faster than many other regions in NSW. This is an age group that is generally considered more vulnerable to the impacts of climate change. Further growth in this age group will present challenges and opportunities for the region. Population demographics also have an influence on leadership and the durability of regional social networks.

Participants identified that demographic trends of the North Coast population were an important driver of vulnerability to climate change for the region. Discussions of demographic trends typically focused on three aspects: 1) what the demographic trends were; 2) the underlying drivers of these trends; and 3) the aspects of these demographic trends that limited the North Coast's adaptive capacity.

The key demographic trends in the population considered to contribute to this vulnerability were:

- an ageing population
- population growth largely driven by migration of retirees into the region
- loss of youth to major cities
- seasonal fluctuation of the population
- relatively large alternative lifestyle community.

An ageing population is a common trend across Australia and is predominantly driven by low birth rates and Australians living longer. This trend is compounded in regional areas, including the North Coast, through a loss of youth to the cities to pursue tertiary education and skilled jobs. In addition, the desirability of the North Coast as a retirement destination further exacerbates this trend with the region's population growth largely underpinned by immigration of inter and intra-state retirees. By way of contrast, by 2031 the NSW population over the age of 65 is projected to increase from 15% at present, to 20%, while for the North Coast this will increase from 20% to 30% (DPE 2014).

Climate change impacts

Participants identified a range of factors linking an ageing population to climate change vulnerability on the North Coast. People over 65 are generally considered a vulnerable group within the community. In the context of climate change they are more susceptible to its direct impacts such as heatwaves (Commonwealth of Australia 2010) and this is expected to lead to an increased demand for health services. During natural disasters, such as flood or fires, their lower mobility means they are less able to move out of harm's way, security concerns mean they are often not willing to leave their homes, posing challenges for the emergency services, and when injured have longer stays in hospital. This age group has lower economic capacity to recover from the effects of a natural disaster. However, those who have resided in the region a long time typically have good knowledge of past events and this can be valuable.



Figure 6: Population density on the North Coast (ABS 2011b)

Factors affecting adaptive capacity

An ageing workforce can hinder adaptation on the North Coast, with the potential to decrease the future supply of staff, contribute to skills and knowledge loss as workers retire, and lead to the closure of small businesses as owners retire without succession plans in place. Each of these aspects can affect productivity on the North Coast. Adding to this adaptive capacity constraint is the need for improved intelligence around the region's demand for skills to support future services.

The ageing and retiree population of the region is reducing the number and availability of active volunteers. This is, in part, due to an increasing demand on aged care services delivered by volunteers and the current generation of volunteers not being fully replaced by younger volunteers. Also playing a role, but not related to ageing, are the increased regulatory environment relating to volunteers (e.g. new work health and safety laws), the dominance of small/self-employed businesses, reducing the ability to replace volunteer staff, and employers becoming less willing to release staff for volunteer activities outside of the region.

Based on their interactions with the community, participants identified people over the age of 65 as less likely to accept the premise of human caused climate change and thus feeling a limited need to respond. This age group was also identified as more likely to perceive the impacts of climate change as occurring well into the future and not affecting them directly, while being expected to bear the costs of adaptation measures that would not directly benefit them. Having a higher proportion of the population in this age group was felt to strongly contribute to lower levels of community support and thus decrease the prominence of climate change as an issue. However, retirees were identified as time rich and if they could be engaged on climate change issues would be a valuable resource in the context of building adaptive capacity.

Information provided around climate change, its impacts and responses to it, needs to be better targeted to the demographics of the community. Contributing to this was an increasing reliance on new technologies to deliver information and education and the difficulties of employing these technologies effectively to engage an ageing demographic.

The demand for health and respite care services will grow with the rapid increase in the number of people over the age of 65, with demand for some health services likely to be exacerbated by climate change. Having a greater proportion of people in this age group leads to current and future reforms around aged care being felt more acutely on the North Coast.

The influx of retirees to the North Coast poses some additional adaptation constraints. New residents generally have less knowledge about the region, and this can lead to reduced levels of perceived risk and poor understanding of what to do and where to go during natural disasters. People new to the region also have a less developed social network and few or no family to call on locally during times of need, making them less resilient to disasters. Similarly, the large temporary population associated with tourism and major projects (e.g. Pacific Highway upgrade) have a lack of knowledge about the region and a poor understanding of what to do and where to go during natural disasters.

Residents emigrating from major cities and large centres have high expectations around delivery of government services. These expectations are often not matched by the level of service available on the North Coast, making them less resilient.

Tourism is a significant industry on the North Coast and leads to large influxes of people, particularly during school holidays. This poses significant challenges for the region as infrastructure and services need to meet the peak demand, yet the costs of providing for the demand must be met locally. Transient school student numbers associated with workers and families temporarily relocating to the North Coast for the staged upgrade of the Pacific Highway make education planning difficult as school funding is tied to permanent student numbers.

The region has a large proportion of small businesses geared toward supporting tourism. These businesses have limited requirements for additional 'up-skilled' employees and tend to offer seasonal work opportunities, limiting availability of permanent fulltime work and career opportunities.

The North Coast has a relatively large alternative community that isolates itself from government and society generally. Accessing and engaging with this community poses ongoing challenges for the delivery of government services, particularly for emergency and health services.

Potential regional responses to reduce vulnerability

A range of options to address vulnerability due to population demographics were identified. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- engage local schools in the need for action on climate change adaptation
- identify suitable platforms to engage effectively with an ageing population
- involve the region's young people in discussions and decisions about their education and post-education employment needs and the employment needs of the region
- provide greater opportunities for on-the-job training to retain regional youth
- seek opportunities to promote the environment sector and develop stable career pathways for sector employees
- seek greater support from regional businesses for training in climate change adaptation linked to sustainability through TAFE
- expand the focus of education services from traditional youth to include the ageing population on the North Coast
- enlist engaged communities to support adaptation action through the wider community
- examine new ways to incentivise private sector employers to release emergency management workers during extreme events, which recognise the constraints on small business and the self-employed
- promote the importance of volunteerism to the region's youth
- improve messaging around climate change: to emphasise its importance, to use language and discuss impacts in a way that holds currency for individual decision-makers (avoid 1:50 or 1:100 year time scales).

5.3 Infrastructure

Précis: The region's resilience and ability to adapt to a changing climate is intrinsically linked to its infrastructure. Significant infrastructure and settlements are exposed to current and future climate related risks with significant investment required to meet the growing needs of the health and aged care sector, provide equitable access to transport and to overcome the infrastructure maintenance and upgrade backlog. Regional geography (narrow coastal plain) and limitations on funding availability were viewed as contributing to this vulnerability.

Participants identified flood mitigation infrastructure, major transport infrastructure (northern rail line, Pacific Highway and regional airports), drainage and sewerage infrastructure, and water and power supply infrastructure, as particularly sensitive to changes in climate. All sectors are dependent on this infrastructure and in the case of the Pacific Highway and the northern rail line other regions are dependent on this infrastructure for transport of goods and visitors into and from the North Coast. Participants identified that this infrastructure needs to be resilient in order for communities to be resilient, as infrastructure:

- underpins economic activity
- facilitates the movement of the emergency services during disasters
- affects the community's ability to manage scarce resources
- supports a rapid return to business-as-usual after an extreme climatic event.

The North Coast climate and geography interact to expose the region and, in particular, its infrastructure to storm and flood hazards, as well as the impacts of rising sea levels.

Increasing the vulnerability of the region's infrastructure is the infrastructure backlog, with the Northern Rivers and Mid North Coast regions having the highest and second highest backlogs in NSW respectively, worth a combined total of $1.5 billion. However, if funds can be made available, this presents an opportunity for the region to incorporate consideration of climate change into the upgrade and rebuilding of infrastructure.

Climate change impacts

Workshop participants identified that climate change may make failure of built assets and system failure more likely, may expand infrastructure maintenance requirements, and increase costs to infrastructure owners and managers.

All aspects of infrastructure management could be affected, from planning through construction, routine maintenance regimes and resources, and upgrade frequency. Assets and maintenance regimes are likely to be primarily exposed through:

- changes to rainfall seasonality, intensity and runoff
- increasing extreme weather related natural hazards, particularly flooding and storm damage
- increasing coastal erosion, inundation and rising saline water tables as a result of sea level rise
- increasing frequency and intensity of bushfires
- heatwaves affecting road and rail infrastructure
- sea level rise inundating assets (long-term).

Cross-sectoral impacts

A range of cross-sector impacts were identified, mostly from loss of services delivered by the infrastructure but also through increased costs to the community. They included:

- damage to local roads increasing safety risks to the community, isolating communities and increasing worker absenteeism, which have flow-on effects to business productivity
- damage to major infrastructure (Pacific Highway, northern rail line and regional airports) affecting supply chains, access to markets and tourism
- increased costs of maintenance and insurance, increasing the costs to businesses and the community
- disruption of water and power supply, affecting the running of households, local businesses, hospitals and other public infrastructure, especially when cooling is essential
- inability to drain stormwater and sewage overflows in coastal towns, leading to health impacts, and
- increased costs to councils, governments and individuals for recovery.

These cross-sectoral impacts have 'downstream' effects, including across the wider economy, and many of these effects were identified under the narrow coastal plain vulnerability.

Adaptive capacity constraints

Participants identified the following factors as affecting the region's capacity to adapt its infrastructure to the impacts of climate change.

Steep topography close to the coastline coupled with the climate of the North Coast results in high infrastructure maintenance requirements, particularly for roads and the many bridges in the region. The many rivers and streams, low-lying coastal plain, and relatively isolated and discrete settlements, and climate also contribute to the large backlog of infrastructure maintenance and upgrade.

Participants identified attempts by local government to rationalise costs through retirement of assets as regularly met with resistance by the community, but also an unwillingness by the community to meet the costs required to maintain them (i.e. through rate increases or reallocation of spending).

Significant infrastructure is located in areas exposed to current and future hazards, with a number of regional airports located on very low-lying land (Port Macquarie and Coffs Harbour), residential aged care facilities on flood prone land and several hospitals prone to isolation during flood events (Coffs Harbour and Bellingen).

Large areas of coastal floodplain are reliant on drainage infrastructure to maintain current agricultural practice and productivity. Rising sea levels will render this infrastructure ineffective requiring a major shift in agricultural practice (e.g. the adoption by extensive graziers of wet pasture systems).

A shift to smaller agricultural lot sizes has led to rural lots on the floodplain losing access to higher country that once acted as a flood refuge for livestock.

There are many older buildings in education (TAFE and schools) and extensive use of demountable buildings. The projected increase in temperatures will likely decrease the thermal comfort of these buildings and increase running costs.

Funding allocation to schools is determined by permanent student numbers. The region's high transient school population makes education planning difficult.

For sectors such as health and education the resource limitations lead to adapting to climate change being given a low priority. This makes getting climate change adaptation on the agenda difficult.

Regional infrastructure for health and respite care will need to continue growing if it is to meet the needs of the community. The demand for these services is increasing and will continue to do so as it is linked to the region's rapid growth in the over 65 segment of the population.

Existing settlements and new developments on the North Coast are dominated by single houses on large blocks near the coast; this increases the land required to meet the demand and the land required for supporting infrastructure. This can affect the region's natural resources and landscapes so consideration of the adaptive capacity of natural systems should be undertaken when developing new release areas.

Coastal towns are reliant on gravity-fed sewage treatment plants and pump stations located at the lowest points in the landscape, making them subject to flooding and inundation. In coastal towns there is often limited scope to relocate this infrastructure.

The difference in rail gauge between NSW and QLD constrains the use of the rail line for freight transport, leading to increased usage of road transport.

The sectors that make up the North Coast economy are highly diverse, which is in general a strength, however, with no one sector/industry to provide a 'critical mass' it can be difficult to attract investment in infrastructure, skilled workers and ancillary businesses.

Potential regional responses to reduce vulnerability

A range of options were proposed to address vulnerability due to infrastructure. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- recognise that the infrastructure backlog will be exacerbated by climate change amplifying legacy effects due to placement and style of existing infrastructure
- re-examine the infrastructure backlog on the North Coast so that it can be informed by adaptation to climate change
- seek support from state and federal governments to address the regional infrastructure repair and maintenance backlog and improve the betterment provisions for disaster recovery
- improve recognition of vulnerability and funding needs for both maintenance and improvement of the region's transport infrastructure
- consider the cost effectiveness of significant investment in drainage infrastructure in light of sea level rise projections and the coastal inundation that will result
- ensure procurement processes reflect the requirement for cost effectiveness, not simply lowest cost, to ensure quality standards of equipment and fitness-for-service in emergency management.

5.4 Regional networks

Précis: Regional networks are considered strong, but are often informal. There is a need for agencies and levels of government to come together regularly to share information on adaptation and solve the common problems it represents. The ageing workforce and imminent retirement of people in these networks needs to be managed to ensure the networks are maintained.

Participants in all the sector workshops identified the existence of good social and professional networks in the region as being important for climate change adaptation because they:

- facilitate the transfer of information and facilitate innovation, both informally and formally
- build trust across the network
- facilitate action through improved access to resources via collaboration and joint funding
- provide support and resilience during natural disasters and personal crises
- allow people to make personal and professional changes
- can facilitate the establishment of formal and informal governance frameworks.

A number of community and professional networks were operating in the region, including:

Sustain Northern Rivers – a collaboration of 26 organisations that formed out of a commitment to communicate, consult and collaborate for action on climate change and which aims to empower local communities to become self-sustaining. This is the only operating group that is dealing specifically with climate change.

Northern Rivers Floodplain Network – covers the coastal floodplain from Taree to Tweed and provides its members with a forum for problem solving, determining common research needs, sourcing funding opportunities, developing project partnerships and enhancing linkages with their colleagues. The network deals with some climate change issues but they progress this under a different banner.

Regional Organisations of Councils – Northern Rivers Regional Organisation of Councils (NOROC) and Mid North Coast Regional Organisation of Councils (MIDROC) are considered important in establishing processes that will enable regional collaboration and action on adaptation. However, adaptation is not currently a priority.

Regional Managers' Network – operates within state government with representatives from the government agencies with a role in delivering regional services. Participants felt there was a strong statewide Regional Managers' Network.

State of regional networks

The delivery of services in the region is supported by strong, often informal, networks across government. The strength of the networks is derived from the people within them knowing each other professionally, and often personally. An example of a sector with good professional networks was emergency services, although they noted there was a tendency to revert to 'doing their own thing' during an event. Importantly, there was a prevailing view across the sectors that there is a need for these networks to come together regularly.

Good connections exist between local government and the community. It was noted that frequent changes in the names and functions of state government agencies leads to confusion in the community about the roles and responsibilities of these agencies.

Some demographic changes within the population, such as young people moving away and retirees moving to the region, were leading to poorer family support networks. This decreases community resilience and increases the reliance on government and volunteer based services in the region.

Local communities vary considerably in their level of cohesion on issues such as sustainability and the environment. On climate change, communities are typically split into two ends of a spectrum – 'believers' and 'conservatives'.

Despite the differences in community beliefs, climate change is not generating much debate in the community, with other issues being considered of greater local importance, for example, the prospect of coal seam gas extraction. Importantly, this issue has seen some groups within the community come together, even those that have been in opposition on other issues.

Adaptive capacity constraints

A range of inter-related factors were identified as driving adverse changes to regional networks or limiting adaptive capacity on the North Coast.

Organisational restructures and the drive for ever greater efficiency have led to changes in the services being delivered by the various state government agencies. Participants, through their interactions with various stakeholders, indicated that this environment of change has led to:

- rates of staff turnover that adversely affect established networks, relationships, expertise and retention of corporate knowledge
- a greater focus on traditional 'core' business, with adaptation not being considered core business
- a poor understanding in the community about what services are delivered or no longer delivered by the various state government agencies.

The continuation of existing population trends of retiree immigrants and youth leaving the region is likely to further weaken social and family networks. Large numbers of workers in the pre-retirement age group will soon leave the workforce and if unmanaged, this could affect many of the professional networks, particularly the informal networks, in the region.

With 13 local government areas on the North Coast the variability in policy approaches to managing some climate change related risks has exposed individual councils to criticism and lobbying pressure to change their policy position. On some issues, such as sea level rise, local councils felt additional support in the form of improved guidance or direction from the state government would assist councils.

There is a growing expectation for instant information – both from external stakeholders and within government. While the community is moving to make greater use of social media, adoption by government is more constrained.

Federal government agencies have limited staff on the ground in the region, making it difficult to coordinate action that requires federal government engagement, and limiting their ability to provide the practical support required for adaptation.

There are different aspirations in the region regarding economic growth. For some, economic growth is a priority, for others natural diversity and environmental sustainability are more important. Where communities seek to pursue sustainability they question how important growth is for community prosperity. Participant experiences indicate these issues can limit social cohesion in the region.

Potential regional responses to reduce vulnerability

A range of options were put forward to address vulnerability associated with regional networks. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- leverage existing cross-jurisdictional leadership groups to coordinate and drive climate change adaptation on the North Coast; appoint a senior officer with responsibility to progress adaptation in the region
- introduce adaptation awards to recognise innovation and progress in local government
- increase use of social media by agencies in the region
- seek a greater recognition of the importance of cross-agency forums in fostering climate adaptation under alternative banners
- support initiatives to promote inter-agency and cross-government adaptive governance of the significant regional environmental issues
- make the case that climate change adaptation is core business of government in the region
- strengthen cross-border communication and networking to avoid contentious development issues
- seek to improve the networking and information exchange opportunities across the emergency management sector
- recognise the value of human capital and how associated networks contribute to delivering services efficiently
- extend research findings on social networks and resilience to demonstrate their importance in climate change adaptation.

5.5 Leadership

Précis: Stronger and more coordinated leadership across all levels of government, business and the community can assist in prioritising, supporting and driving adaptation on the North Coast. Population demographics were viewed as an important contributor to this vulnerability.

Strong leadership on climate change across government, business and the community was viewed as important to progress adaptation in the region. Strong government leadership was seen as being important to:

- bring the community along
- establish adaptation as a priority consideration
- establish appropriate policy and legislative settings
- drive the allocation of necessary funding.

This included leadership at all political levels (federal, state and local) and within government organisations.

A number of other leadership related issues were identified, including:

- changes to agency core business leading to reduced institutional responsibility for issues that are deemed to not be core business
- the divide between local scale management and state scale management, and at times, a lack of communication between federal, state and local governments.

Adaptive capacity constraints

The community's perception of climate change risk, either as a global problem or as a problem requiring their attention, can lead to the community opposing action or action becoming a lower priority than other local issues.

Government policy position needs to be stable and consistent with what is said and the actions taken. If there is dissonance between what is said and the action taken (or not taken) it can lead the community to question both the need and urgency of taking action.

The North Coast has a high proportion of people over the age of 65, which was felt to strongly contribute to lower levels of community support and thus to a dearth of local leadership on climate change issues.

Sustainability is an important focus for many North Coast communities, however, community actions do not always align with stated beliefs. Many communities still seek big houses on large blocks with the impacts of this lifestyle choice on sustainability not being recognised.

The financial sustainability of local governments on the North Coast was an important concern for many participants and hindered the ability of local government to meet the additional costs associated with adaptation and demonstrate leadership through action.

A number of constraints related to climate change messaging were identified by participants:

- government needs to better communicate the actions it is taking to manage climate change and its associated risks
- climate change messaging has focused on the negatives of inaction rather than the benefits of action and a vision for the future.

Potential regional responses to reduce vulnerability

A range of options were proposed to address vulnerability associated with leadership. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- leverage existing cross-jurisdictional leadership groups to coordinate and drive climate change adaptation on the North Coast; appoint a senior officer with responsibility to progress adaptation in the region
- monitor the success of Regional Joint Organisations on climate adaptation
- continue regional and state level support for a strong community engagement model in determining regional priorities
- promote community understanding of the sustainability of current North Coast housing trends and sustainable options.

5.6 Funding models and priorities

Précis: The complexity of adaptation governance, competition for limited resources and 'short-term' financial cycles make it difficult to direct funding to adaptation actions. The financial sustainability of local governments under the current funding model was also a major factor limiting adaptation. Leadership was viewed as an important contributor to this vulnerability.

Climate change impacts and adaptation responses were identified as putting upward pressure on costs and leading to loss of revenue to the state government, community and businesses on the North Coast. The costs were derived through:

- increasing demand for government services
- increased need for maintenance, repair and upgrade of assets (public and private)
- changes in insurance premiums leading to under-insurance of private assets, and
- changes to building and house design.

Revenue was affected through:

- temporary loss of market access
- temporary loss of tourism
- worker absenteeism
- water and energy supply outages
- loss of agricultural and fisheries production.

In acknowledging these potential costs and losses to revenue, participants identified concerns about the existing funding models being unsustainable, not supporting resilience or adaptation, or leading to maladaptive outcomes.

Adaptive capacity constraints

Financial viability of local governments in the region was a concern for participants. Councils may lack the people, time and finances to deal with climate change in addition to other responsibilities.

Disaster recovery funding provides for rebuilding infrastructure to current building standards. Improving on the standards by making infrastructure more resilient or to accommodate future

climate change is supported in-principle, however, experience on the North Coast indicates it is not uniformly supported in practice with the required funding.

Emergency services rely on access to volunteers. During protracted events the goodwill of employers fades, particularly with the emerging trend of deploying volunteers outside of the region. There are no incentives in place to support businesses that release employees for protracted events or out of region deployments.

Vulnerable social groups (such as the elderly, disabled and the chronically ill) have complex needs and providing services that meet these needs is expensive. With the older population increasing disproportionately to the rest of the population and at higher rates on the North Coast, this will increase significantly the costs of delivering health services.

The North Coast region is significant to NSW – but in comparison to metropolitan areas it is large geographically, with a relatively low population density, ensuring that investment is either localised or spread thinly across the region.

Potential regional responses to reduce vulnerability

A range of options were put forward to address vulnerability associated with funding models. These suggestions could be considered in an adaptation plan, where their appropriateness would be assessed in the context of other initiatives and priorities. Suggestions included:

- provide additional support for community engagement in emergency management
- examine new ways to incentivise private sector employers to release emergency management workers during extreme events, that recognise the constraints on small business and the self-employed
- emphasise to industry the long-term benefits to cost structures of many adaptation actions, in particular in relation to energy efficiency
- seek ways to account for environmental assets on local government balance sheets
- align the funding to projects that access funding from multiple sources with longer timeframes to improve project outcomes
- reduce the time lag between application for funding and decisions by funding bodies
- provide funding support for local government to implement climate change adaptation actions
- design and deliver research and development incentives to stimulate development of technology for climate adaptation
- consider strategic investment in climate change adaptation actions to maximise the flow-on to the broader community
- factor into infrastructure funding the ability to fund the ongoing costs of asset maintenance
- explore ways that public–private partnerships could be used to fund climate adaptation projects and allow councils to recoup costs of protective infrastructure for at risk communities
- encourage development of a strong regional investment case to attract a greater share of federal and state government funding.

Appendix A: Agencies and organisations represented at the sector workshops

Table A.1: List of organisations that participated in the workshops

Note: An asterisk denotes organisations represented on the project steering committee.

	Organisation
1	Australian Defence Force
2	Ballina Shire Council
3	Bellingen Shire Council
4	Byron Shire Council
5	Clarence Valley Council
6	Coffs Harbour City Council
7	Department of Education and Training
8	*Department of Family and Community Services
9	*Department of Planning and Infrastructure
10	*Department of Premier and Cabinet
11	*Department of Primary Industries
12	*Department of Trade and Investment
13	Environment Protection Authority
14	Kempsey Shire Council
15	Kyogle Shire Council
16	Land and Housing Corporation
17	Lismore City Council
18	Marine Parks Authority
19	*Mid North Coast Regional Organisation of Councils (MIDROC)
20	Mid North Coast Volunteer Rescue Association
21	*Ministry of Police and Emergency Services
22	North Coast Area Health Service
23	*Northern Rivers Local Land Services
24	*Northern Rivers Regional Organisation of Councils (NOROC)
25	NSW Forestry Corporation
26	NSW Office of Water
27	NSW Police
28	NSW Public Works

	Organisation
29	*Office of Environment and Heritage
30	Port-Macquarie Hastings Council
31	*Regional Development Australia Mid North Coast
32	*Regional Development Australia Northern Rivers
33	Richmond River County Council
34	Richmond Valley Council
35	Roads and Maritime Services
36	Rural Fire Service
37	State Emergency Service
38	TAFE NSW
39	Tweed Shire Council

Appendix B: North Coast regional context

Climate and hydrology

The climate of the North Coast region is generally subtropical, with warm humid summers and mild winters. The region is the wettest in NSW, with an average annual rainfall of over 1200 millimetres that peaks in summer and early autumn and is lowest in winter and spring. The far north-east of the region has an average annual rainfall above 2000 millimetres. Generally, average annual rainfall decreases inland away from the coast, but the trend is modified by topography, with higher rainfall on the mountainous areas and lower rainfall in the low-lying valleys and the extensive floodplain areas. The greatest runoff occurs in autumn, followed by summer, winter and spring. The seasonal pattern of runoff differs slightly from that of rainfall due to higher evaporation in spring and summer.

There are eight major river catchments in the region – the Tweed, Brunswick, Richmond, Clarence, Bellinger, Macleay, Hastings and Manning. These large catchment areas provide a diversity of natural landscapes, biodiversity, soils and extensive floodplains which support a range of natural resource based livelihoods including grazing, horticulture, fishing, timber production and tourism. The overall health of these catchments is vital to the quality of the natural environment and industry.

Landscapes and ecosystems

The North Coast contains a diverse range of landscapes that are highly valued for their scenic quality. These landscapes include Mt Warning, an ancient volcanic caldera, World Heritage-listed Gondwana Rainforests of Australia, small coastal settlements, waterways, coastal lakes and lagoons, beaches, fertile river plains and historic river towns.

The variable topography, rainfall and soils of the region enable a high diversity of ecosystems. Native vegetation ranges from high elevation forests, including rainforests along the Great Dividing Range escarpment, through wet and dry sclerophyll forests, coastal and floodplain forests, and littoral rainforests, dune scrubs and heaths, to wetlands and estuarine and aquatic vegetation. The diversity of habitats supports a high diversity of native flora and fauna, including numerous threatened species (DECCW 2010c&d). The region's ecosystems are recognised nationally and internationally for their diversity and uniqueness with the Border Ranges South Biodiversity Hotspot (DEWR 2007) and World Heritage Gondwana Rainforests of Australia.

Land use

The North Coast is characterised by coastal alluvial flood plains, rocky headlands, dune fields, lakes and estuaries, to midland hills and, in the west and north, escarpment ranges. The coastline is varied and includes islands, coastal reefs, cliffs and headlands, beaches, estuaries, coastal lagoons and wetlands.

Areas about Cudgen, the Byron hinterland and the Alstonville Plateau are particularly significant for horticulture, while timber production, including plantation forestry and private native forestry is an important industry on less fertile or steeper land. The region also includes large areas used for cropping around Casino, Coraki, Cudgen, Maclean and Murwillumbah (Figure 7).

Areas about Coffs Harbour and north to Corindi are particularly significant for horticulture, while timber production, including plantation forestry and private native forestry is an important industry on less fertile or steeper land. Grazing is widespread throughout the region, while cropping is relatively limited.

Urban development covers a relatively small area but is increasing as the area experiences population growth rates that are among the highest in Australia.

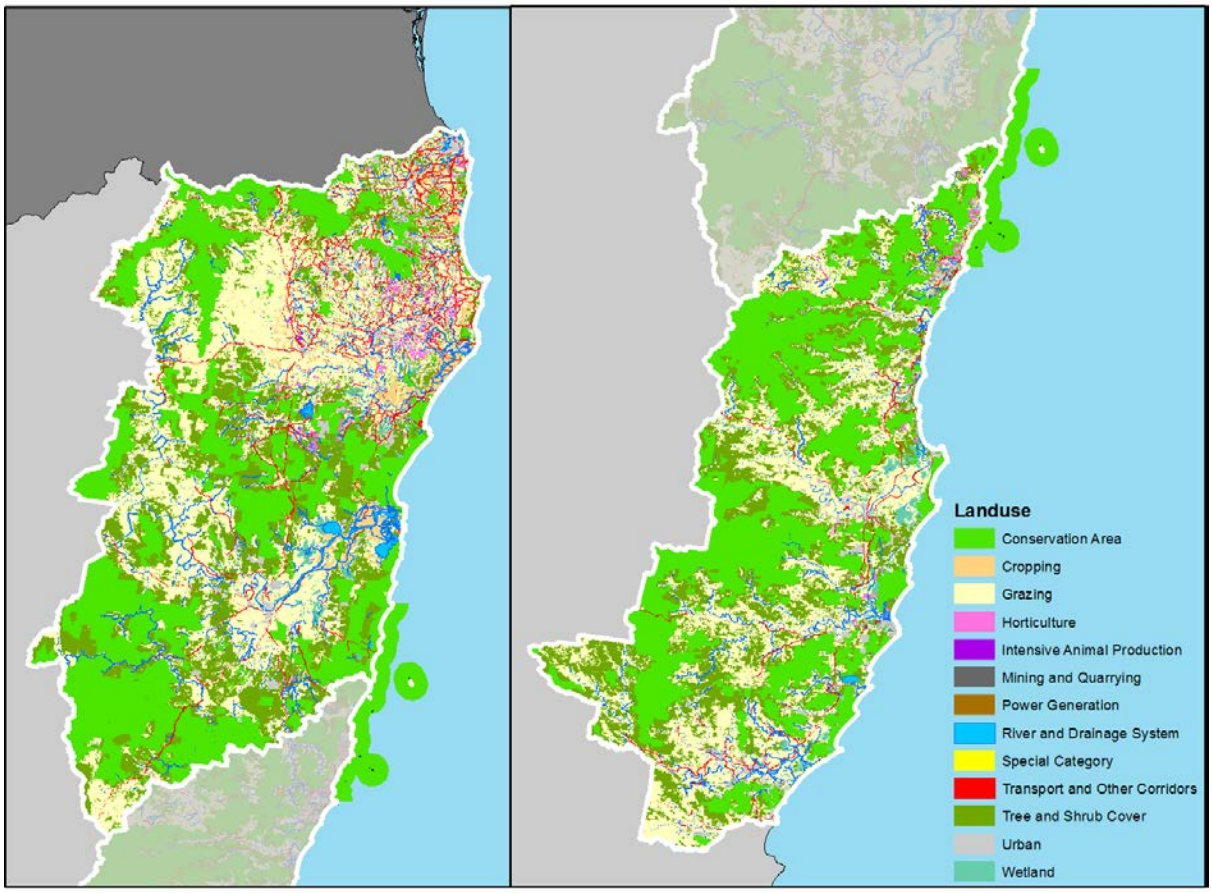


Figure 7: Land use in the Northern Rivers (left) and Mid North Coast (right)

Population and demographics

The Northern Rivers population is 277,283, ranging from 85,107 people in the Tweed Local Government Area (LGA) to 9,227 people in the Kyogle LGA (Figure 8). Between 1996 and 2001 the Northern Rivers population increased at a modest rate of 4.4%. The population expanded more quickly (5.6%) during 2001–06, with growth falling back to 3.7% over 2006–11. The rate of growth was fastest in the Tweed LGA.

The Mid North Coast population is 246,900, ranging from 72,698 people in the Port Macquarie–Hastings LGA to 12,516 people in the Bellingen LGA (Figure 8). Between 1996 and 2001 the Mid North Coast population increased at a modest rate of 5.7%. The population expanded somewhat more quickly (6.2%) during 2001–06, with growth falling back to 4.6% over 2006–11. The rate of growth was fastest in the Port Macquarie–Hastings LGA.

The Northern Rivers and Mid North Coast have a considerably older population, with a significant gap in the younger, working-age population. This is reflected in the high proportion of people in their later working years (50–64 year olds) or over the retirement age (over 65 years of age), and the small share of people 20 to 44 years old (Figure 9).

The North Coast population is projected to grow by 15% over the next 17 years (to 2031). The rate of growth varies across the age profiles with the number of young people (less than 15 years old) growing by ~6%, people of working age (15–64 years old) staying roughly the same and people 65 years or older growing by 68%. This will see the proportion of people aged 65 years or over grow from 20% to 30% of the total population by 2031 (DPE 2014).

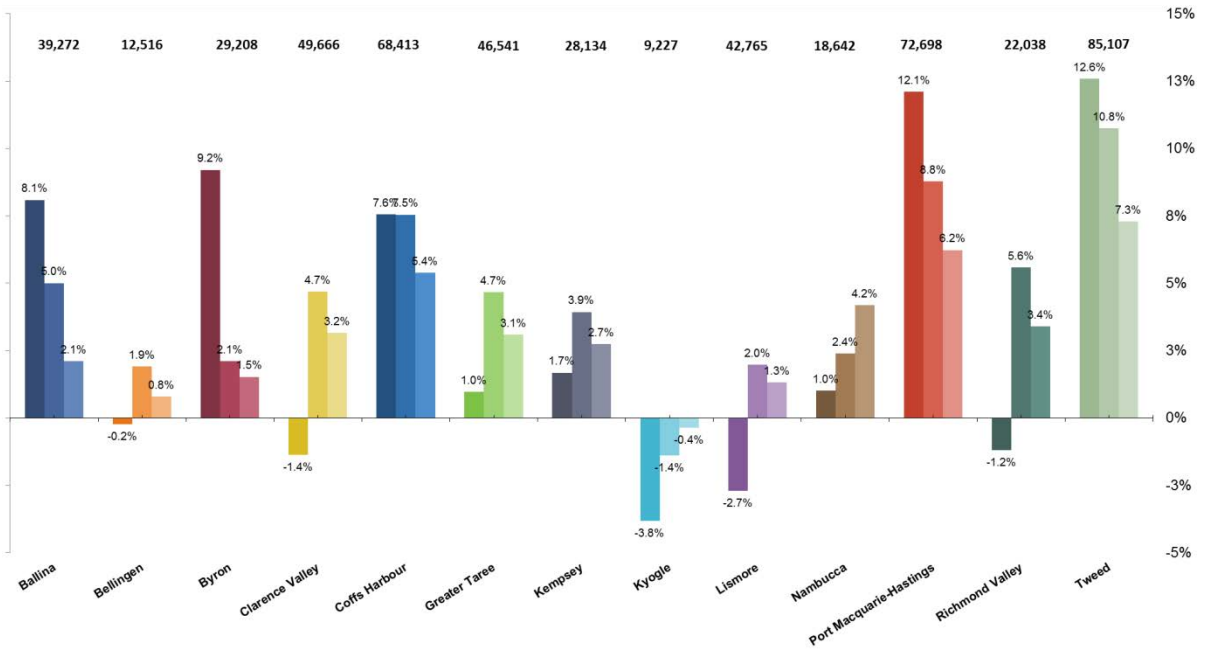


Figure 8: Change in population growth between census years for each local government area, 1996–2001, 2001–06, 2006–11 (ABS 2011b)

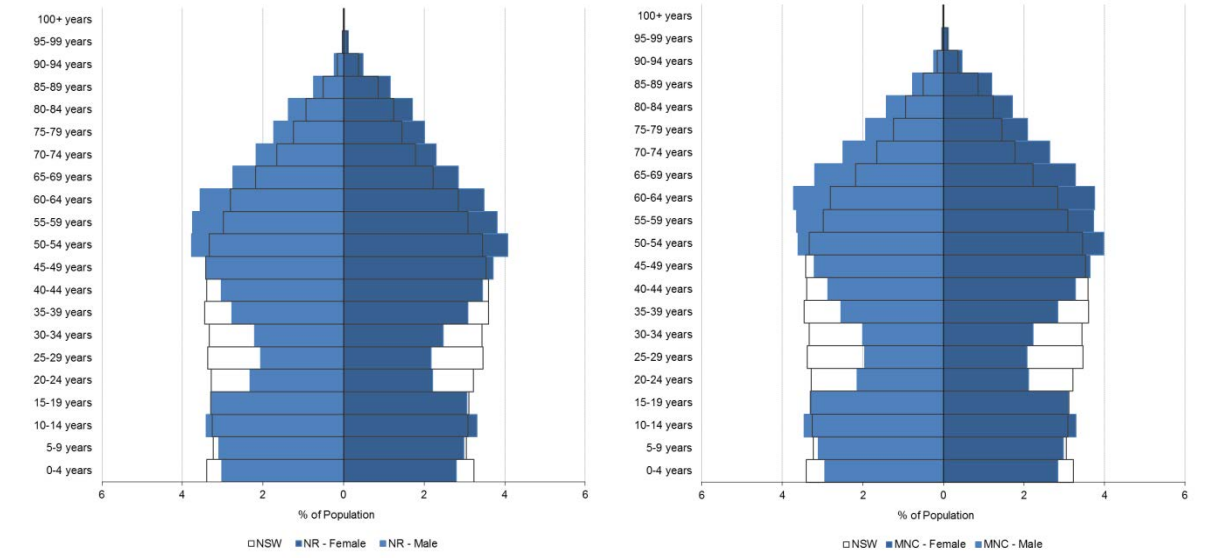


Figure 9: Age distribution of the Northern Rivers (left) and Mid North Coast (right) populations compared to NSW as a whole (ABS 2011b)

Regional economy

Industry on the North Coast is quite diverse, with the major employment sectors being health care and social assistance, retail trade, education and training, and accommodation and food services (Table 3). These employment sectors reflect the services provided to an ageing population and the popularity of the region as a tourism destination. Other employment sectors employing more than 4% of the workforce include agriculture, forestry and fishing, manufacturing, construction, professional, scientific and technical services, and public administration and safety.

The region's business profile differs to the employment profile, with agriculture, forestry and fishing accounting for 19% of regional businesses and construction accounting for 17%. There

are also high numbers of businesses involved in rental hiring and real estate services (9%), professional, scientific and technical services (8%) and retail trade (8%) (RDA-NR 2013).

Table 3: Top five industry sectors on the North Coast by number of people employed

Industry	Northern Rivers	Mid North Coast	North Coast
Health Care and Social Assistance	14,772	13,600	28,372
Retail Trade	13,010	11,532	24,542
Education and Training	9,102	7,431	16,533
Accommodation and Food Services	8,641	7,540	16,181
Manufacturing	6,539	5,267	11,806

Data source: 2011 Census of Population and Housing (ABS 2011b)

Tourism also plays an important role in the region with 12 million people visiting the North Coast, in total spending approximately $3.76 billion annually (TRA 2013). While not an ABS reported industry, tourism contributes to employment in accommodation and food services and retail trade.

One of the traditional industry sectors for the North Coast, agriculture, is valued at about $1.3 billion and supports other industry sectors like manufacturing (2005–06 & 2010–11 Agriculture Census; ABS 2006&2011a). Regionally significant production, in terms of its contribution to agriculture's economic value, were: sugar cane (9.8%); nurseries, cut flowers and cultivated turf (10.6%); berry fruit (11.8%); milk production (17.4%); and meat production (31.4%), mostly cattle. In terms of its contribution to NSW, the North Coast accounts for 5.2% of the state's agricultural production. The industry has been in decline on the North Coast, reflecting a broader national pattern, although the rate of decline is faster than the national average. There are some examples within the sector that are opposing this trend, with recent growth in berries, cattle and calves, and poultry.

Appendix C: Climate change projections and biophysical impacts for North Coast region

Below are listed the climatic changes, biological and physical responses that were considered as part of this assessment. These projections were sourced from the NSW Climate Impact Profile 2010 (DECCW 2010a).

Expected regional climatic changes

The North Coast has a very variable climate. When considering climate change projections, it is important to keep in mind that climate change will occur against the backdrop of existing climate variability.

Climate variable	Trend	Projection
Atmospheric CO_2	Increase	A2 IPCC emissions scenario
Average daytime temperature	Increase	Spring and autumn – increase 1.5–2.0°C Summer – increase 1.0–1.5°C Winter – increase 2.0–3.0°C
Average night time temperature	Increase	All seasons 2–3°C
Annual rainfall	Increase	Annual increase but varies across the seasons – detail below
Rainfall seasonality	Increase (wetter summer, drier winter)	Spring – no change Summer and autumn – increase 5–20% Winter – decrease 5–10%

Expected physical responses

Physical response	Trend	Projection
Sea level	Rising	This study assumed a sea level rise of 0.4 m above the 1990 mean sea level by 2050 and a 0.9 m rise by 2100.
Evaporation	Increase	Likely increase across all seasons.
Soil moisture	Decrease	Despite projected increases in rainfall in summer and autumn, soil conditions are likely to be drier for most of the year, particularly in spring and winter.
Drought	Variable	Short-duration droughts are likely to become more severe, while medium and long-term droughts will about as likely as not remain similar to current conditions.
Runoff	Varies seasonally	Substantial increases in runoff depths and the magnitude of high flows are very likely in summer. A moderate decrease in runoff depths is likely in spring.
Flood	Increase	The combination of rising sea levels and catchment-driven flooding is likely to increase flood frequency, height and extent in the lower portions of coastal floodplains.
Fire	Increase	Higher temperatures and changes to rainfall patterns will more likely than not lead to increased fire frequency. Very high to extreme fire danger days are projected to increase by 10–50%, currently 10–15 a year inland and fewer than 10/year in coastal and higher mountain areas.

Regionally specific impacts

The climate changes and physical responses described above are expected to result in the following impacts on land, settlements and natural ecosystems.

Category	Impact
Impacts on land	• Rising sea level is virtually certain to increase coastal recession • Wind erosion is likely to continue on coastal dunes • Saline incursion into subsoils is likely on the coastal plains • Higher rainfall is likely to increase sheet and rill erosion, leading to increased sedimentation of coastal floodplains • Gully erosion is likely to decrease, and mass movement of soil to increase in localised areas • Problems of acid sulphate soils are likely to continue in the short term but reduce over the longer term • Organic matter in soils is likely to increase in most areas, but decline in some coastal swamps • Sea level rise and changes to soils are likely to have implications for agriculture • Sea level rise and flooding are likely to affect Aboriginal cultural heritage values
Impacts on settlements	• Community assets, residential property and associated infrastructure are virtually certain to be threatened by coastal inundation and recession • Most property boundaries referenced to the high water mark will change • Urban streams are likely to flood more frequently • Sea level rise is virtually certain to exacerbate flooding on the coast • Some levees are likely to become less effective at protecting property from floods • Water supplies and sewerage infrastructure are at risk
Impacts on ecosystems	• Sea level rise is likely to alter estuarine communities • Some fish species are likely to decline • Habitat loss and alteration are likely to impact on shorebirds • Sea level rise is likely to alter ecosystems on shores and coastal lowlands • Higher temperatures, altered hydrology and altered fire regimes are likely to cause major changes to ecosystems • High-altitude ecosystems are likely to change or contract • Altered fire regimes are likely to cause changes in wetter ecosystems • Fragmented and degraded ecosystems are likely to have poor adaptation potential • More subtle but widespread changes are likely for more resistant ecosystems

It should be noted that the analysis was completed prior to the release of updated projections in December 2014, however, the nature of changes projected under both sets of information is similar and when considered in the context of the approach of this assessment will not change the outcomes or vulnerability narrative.

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