SUBMISSION BY THE NORTHERN TERRITORY GOVERNMENT TO THE SENATE ENVIRONMENT AND COMMUNICATIONS REFERENCES COMMITTEE INQUIRY INTO THE IMPACT OF CLIMATE CHANGE ON HOUSING, BUILDINGS, AND INFRASTRUCTURE

Introduction

The Northern Territory represents around one-sixth of Australia's land mass at 1.35 million square kilometres, and a population of around 245 000 equating to approximately 1% of Australia's population. Darwin is the Territory's commercial and administrative centre, and Alice Springs is an important regional hub in central Australia, the second largest town in the Northern Territory. Darwin, Palmerston and Alice Springs are home to around 60% of the Territory population. Katherine, Tennant Creek, and Nhulunbuy are important local towns that service large surrounding areas. Approximately 83 000 people live outside of these five towns in remote towns, permanent and semi-permanent outstations.

The economy of the Northern Territory is concentrated around its major towns, with mining, pastoral, tourism and public service the primary industries and employers in remote areas. The majority of the Northern Territory's financial wealth, buildings and infrastructure are focused on the major towns and regional centres. These are the focus of the Northern Territory's response to this inquiry.

Government spending and employment plays a significant role in the Northern Territory economy. Since self-government in 1978, the Northern Territory has relied upon significant financial support from the Commonwealth to develop and maintain essential infrastructure such as transport, public housing, health services, education, and government services. Anticipating and adapting to climate change will require increased infrastructure investment, more than likely to higher engineering standards. Funding such investment will be a challenge and will require a combined effort from the Northern Territory and Commonwealth governments to ensure the required infrastructure is in place to support a growing economy, maintain standards of living, and protect and support the environment.

The Northern Territory Government is currently developing a whole-of-government framework to respond to climate change, taking into consideration the environmental, economic, social and health implications. This framework is likely to be completed in late 2017 or early 2018 and may be able to leverage some of the insights that may emerge as a result of this Senate inquiry.

Summary of issues the Northern Territory suggests the Inquiry may want to investigate

1. The Inquiry may wish to consider increasing the ability for state, territory and local governments to access emergency resources to respond to future extreme weather events.

2. The Inquiry may wish to consider whether there are mechanisms whereby the increased risks of climate change can be better shared between Governments, the insurance sector, householders, business and infrastructure owners and operators.

3. The Inquiry may also wish to consider whether the insurance industry operating in northern Australia has sufficient access to re-insurance mechanisms so they can redistribute some of the risks they are exposed to in northern Australia at reasonable cost. Higher re-insurance costs may simply be passed through to policy holders in the form of higher insurance premiums, reduced policy coverage, or asset owners choosing to under- or self-insure which increases financial stress and results in economic disruption. This will be particularly important as the uncertainty around the impact of climate change on infrastructure increases over time.

a) Changes in sea level rises and storm surge intensity.

There are forecasts that suggest sea level rises of 1.1 metres are possible by 2100, although these forecasts are far from certain. The tidal range across the Top End coastline is already 8 metres, so a 1.1 metre increase could affect a wide spread of infrastructure in coastal communities. Sea level rise is expected to inundate lower lying areas of the Arnhem and Gulf coasts of the Northern Territory but these areas are undeveloped so the impact will affect local ecosystems more so than infrastructure. The threat to infrastructure will be most evident around Darwin because Darwin's coastal cliffs are comprised of erodible, soft rock necessitating continual remediation and reinforcement by local government (the City of Darwin).

Storm surge maps for Darwin were updated in 2011 to help inform policy and land use planning, the local community and stakeholders. Some low lying areas adjacent to creeks in Darwin currently struggle to access flood insurance because they are in a high risk zone. A flood basin is planned for mid-reaches of Rapid Creek to mitigate future flood effects.

It is estimated that there are around 180 residential buildings in Greater Darwin that would be at risk from a sea level rise of 1.1 metres, and 190 buildings within 110 metres of the high tide mark that are at risk from erosion, mostly in Darwin.

The Northern Territory Planning Scheme (the Scheme) includes high level planning principles regarding flooding and storm surge levels and the need to include the likely effects of climate change on storm surge levels at specific locations. The Scheme also includes specific clauses to control development in relation to hazard from cyclones and storm surge and ensures that development in coastal areas is appropriate in regard to the impact of cyclones and associated storm tides.

Some modelling suggests that cyclonic activity will intensify, but cyclones may be less frequent. However, the combination of more intense cyclones and rising sea levels suggests that storm surges will be more powerful and destructive. More intense cyclones suggest higher rainfall, and in combination with elevated sea levels this suggests greater flooding particularly in downstream areas of catchments as rainfall struggles to drain away in a timely manner. Increased storm surges and flooding suggest increased salt water inundation and potential for increased erosion of coastal infrastructure such as break-walls, retaining walls, jetties, pontoons, marinas, landings, boat ramps, etc.

Many Northern Territory remote coastal and island communities are reliant on barge landings for supply of food, fuel (including fuel for power generation), construction materials, and other goods. During the wet season when roads are closed for lengthy periods, freight can only be delivered by barge to some coastal communities. For isolated island communities, barge landings provide the only means of surface freight transport year-round. Impacts on barge landings resulting from rises in sea level and storm surge will significantly affect essential freight services at these remote and isolated communities.

Storm surge, sea level rise and coastal erosion will have implications for transport infrastructure including impacts on existing roads and bridges within and adjacent to tidal zones. Planning for future transport infrastructure needs to respond to changes in sea level and coastal flooding.

b) Changes in temperature and precipitation.

Data from the CSIRO and the Bureau of Meteorology show that the Northern Territory's average annual temperature has been increasing since 1960 and is 0.6° higher than in the past. The temperature difference between different regions of the Northern Territory is expected to be more marked than in the past. Temperature increases are expected to be more pronounced in the north of the Territory. The number of days where temperatures exceed 35° is also expected to increase. The CSIRO note that models of temperature predictions have a higher degree of confidence than models of rainfall predictions. The CSIRO's general projections for Darwin are as follows:

	Average between 1971 and 2000	2030 average (mid emission scenario)	2070 average (low emission scenario)	2070 average (high emission scenario)
Annual temperature in ^{0}C	27.8	28.8	29.5	31.0
Number of days above 35^{0}C	11	44	89	227
Annual rainfall in mm	1847	1847	1829	1829

Source: Climate Change: Science and Solutions for Australia. Published by CSIRO in April 2011.

The table above includes the median projections of the models, and not the range or the seasonal distribution of these expected changes, which can affect intensity, and the cumulative effect of higher temperature or rainfall within a concentrated period.

The Northern Territory Government has already noted that the Darwin central business district (CBD) is consistently hotter than surrounding areas, largely due to planning outcomes and building designs that collectively contribute to the creation of a significant heat sink and source in today's climate. A heat mitigation study is underway to identify the causes of heat accumulation in the Darwin CBD, and to investigate options to mitigate the heat retention and radiation impacts of the existing built environment. Early analysis suggests there are a range of options that could collectively reduce the average temperature across the entire CDB by up to 3^{0}C, but localised temperature reductions could be significantly greater around options such as water features. This study has progressed to a point where cost-benefit analysis of a range of options is underway. The major benefit of implementing these options is to make the CBD a more accommodating and attractive place to live work and visit, with potential flow-on benefits in better infrastructure utilisation, and lower energy consumption because buildings and roads should remain cooler, radiate less heat, and therefore generate lower ambient temperatures so that air conditioning does not need to work as hard.

It is difficult to predict rainfall, but as with most of Australia the intensity and frequency of drought in the Northern Territory is expected to increase in the future. However, episodes of heavy rain may increase, particularly in the monsoonal north. The CSIRO note that the climate change impact on wet season rainfall in the north of the Northern Territory is uncertain.

Temperature, precipitation and humidity are interrelated with evapotranspiration. Some models suggest that evapotranspiration in the Northern Territory may increase significantly as a result of climate change. If this occurs in combination with reduced rainfall this may contribute to decreased soil and sub-soil moisture, higher humidity during the wet season, and drier dry seasons. It may also intensify local weather systems because of a more intense heat and energy exchange between the land, sea and the atmosphere.

The combined effects of hotter temperatures, increased frequency of droughts, more intense rainfall events, and higher evapotranspiration suggest that the future climate that buildings and infrastructure have to contend with will be much harsher. This is likely to increase the wear and tear on buildings and infrastructure, and older buildings and infrastructure can be expected to deteriorate faster, perhaps even reducing their economic life.

While no house can resist all extreme weather events, those in the tropics need to be designed to function safely and comfortably during extreme weather events, and for periods of extended loss of power and water supply. Building codes already mandate that houses withstand cyclonic winds. However, climate change may require additional legislative or planning requirements, such as requiring that new developments are able to cope with coastal inundation and predicted flood levels. There may be also opportunities for planning to more effectively design for shade, ventilation and temperature optimization, for example.

Higher engineering standards, different building techniques and technology are available to construct new buildings and infrastructure to higher standards which should improve infrastructure resilience and lengthen its economic life. There appear to be sufficient incentives for infrastructure owners and operators to decide for themselves whether constructing and maintaining economic infrastructure to a higher standard is in their economic interests.

The incentives to construct and maintain social infrastructure to a higher standard may not be as strong as the incentives applying to commercial infrastructure. Social infrastructure is defined as infrastructure that does not produce a direct income. This is relevant to a broad range of publicly owned buildings, assets and infrastructure which are funded and managed from the public purse. There is a risk that cash-constrained governments at all levels limit their investment to what they can afford in the short-term, and in doing so forgo the advantages of a longer economic life achievable if higher, yet more expensive engineering and building standards were applied, in addition to more intensive maintenance.

The impact of higher temperatures and heat stress on transport infrastructure such as sealed road surfaces and rail lines has the potential to significantly disrupt freight distribution and export to and from the Northern Territory. The Territory is heavily dependent on long distance road and rail freight for the supply of essential goods with limited alternative routes available in the event of infrastructure failure due to heat stress or flooding. Planning for new infrastructure needs to include consideration of the impacts of increased temperatures and rainfall.

c) Changes in extreme weather, including heatwaves, bushfires, floods and cyclones.

The CSIRO suggest that climate change impacts will increasingly be experienced first through extreme events, rather than gradual increases in temperature or rainfall.

The CSIRO's forecast increase in the number of days in Darwin where the maximum temperature exceeds 35^0C suggests that a succession of extremely hot days, or heatwaves, will become more common. Central Australia is likely to have a similar experience. From an infrastructure perspective this is likely to increase energy demands for the purposes of air conditioning, so the Northern Territory's electricity infrastructure will need to accommodate increased demand for electricity at certain times of the day and year. A succession of extremely hot days has the potential to affect the surface of sealed roads and the integrity of rail lines, which could require road or speed restrictions during these periods. Infrastructure and transport planners will consider these potential impacts when developing long term plans.

Bushfires are an increasing threat in peri-urban and semi-rural areas of Greater Darwin because of the build-up of combustible fuel in residential areas. The reluctance of property owners and managers to manage fuel loads with controlled fires contributes to the uncontrolled spread of weeds and increased density of woody plants in residential areas, meaning that subsequent fires will be much more intense, posing greater threat to life and assets. Local Governments and volunteer fire brigades provide advice on risks and the options available but there are limitations to their ability to influence private land holders. The infrastructure at greatest risk from bushfires is privately owned residential and commercial infrastructure. Hence, there should be sufficient incentive for these landowners to respond to these risks in the future. Intense fires also pose a significant threat to flora, fauna and regional biodiversity, which could be significant, also affecting recreational bushland.

There are expectations that cyclonic activity will intensify, but it is possible that cyclones could be less frequent. More intense cyclones suggest higher rainfall, and in combination with elevated sea levels this suggests greater flooding particularly in downstream areas of catchments as water from rainfall struggles to drain away in a timely manner. Increased flooding has the potential to damage the Northern Territory transport network, particularly roads and bridges, but can also affect airstrips and rail infrastructure as illustrated when Cyclone Grant led to flooding of the Edith River in 2012, washing away sections of the rail line, restricting the supplies of perishable food in Darwin for around a week. Extreme weather events are factored into infrastructure planning undertaken by the Northern Territory Government, and shape infrastructure and maintenance planning such as the NT Roads and Bridges Strategy.

Water infrastructure may be particularly vulnerable to increased flood and cyclone impacts. In the Northern Territory the storm water and reticulated water infrastructure is entirely owned by Government. A significant flood or cyclone could affect many Government owned assets and lead to calls for assistance by residents and the private sector, potentially stretching the resources of the Northern Territory and Local governments beyond their limits.

The Inquiry may wish to consider increasing the ability for state, territory and local governments to access emergency resources to respond to future extreme weather events.

d) Changes in natural coastal defence systems, including coral reefs, kelp and mangrove forests.

Possible climate change impacts on the coastal and marine environment in the Northern Territory include sea level rise, higher storm surge, more intense tropical cyclones, increase in sea surface temperature, and changes to salinity and acidification. This may lead to habitat loss or fragmentation, disruption of ecological function, changes in the distribution of marine species, loss of important commercial fisheries, and a reduction in ecosystem resilience. These outcomes would degrade natural coastal defence systems.

Coral reefs are widespread throughout the Northern Territory and provide important habitat for marine animals. Coral bleaching was observed at numerous locations in the 2015-16 wet season. For example, reefs in the Crocodile Islands off the northern coast of Arnhem Land experienced considerable coral bleaching. Improved mapping and monitoring will improve current and future management of coral reefs.

Kelp forests are not a feature of the Northern Territory coastline, but seagrass meadows are. Seagrass is an important component of coastal ecosystems in the Northern Territory, providing a key food source for species such as the dugong and green turtle listed in the Environment Protection and Biodiversity Conservation Act, an important habitat for fisheries, and carbon storage. Seagrass is at risk from climate change due to increased extreme weather events, and inter-tidal seagrass meadows may suffer from dieback due to increased exposure to solar radiation. Improved mapping and monitoring will aid future management by identifying areas most vulnerable to climate change, although local mitigation options are limited.

The mangrove communities of the Northern Territory cover over 4000 km of the coastline and river systems, comprise over one third of Australia's mangrove resource, and include 51 different mangrove species. They are the most pristine mangroves in Australia, and probably the world. However, we now have heightened awareness of the vulnerability of mangrove wetlands as a result of the unprecedented extent and intensity of mangrove dieback in the Gulf of Carpentaria in 2015:

- Between late 2015 and early 2016 extensive areas of mangrove vegetation died along approximately 700 km of the coastline of Australia's remote Gulf of Carpentaria. The dieback was severe and widespread, affecting around 7000 ha of mangrove vegetation from the Roper River estuary in the Northern Territory to near Karumba in Queensland.

- This dieback event coincided with periods of notably high temperatures and coral bleaching along the north-eastern coastline of Australia. This unusually severe dieback of mangroves is the first recorded instance of its kind attributed to drying conditions and high temperatures, most likely associated with climate change. Recovery of mangrove vegetation is largely dependent on a return to normal wet season conditions, and the damage would be exacerbated if the area was struck by a tropical cyclone within the next 10 years. The CSIRO's forecasts suggest that the incidents of drier conditions, higher sea and air temperatures, and higher cyclone intensity will all become more common in the future. Hence, the risk of experiencing additional experiences of mangrove dieback, and slow recovery from dieback episodes, is likely to increase.

- While the coastline of the Gulf of Carpentaria is a relatively undeveloped area, it is an important fishery for commercial and recreational users. The 2015 episode highlighted factors that could reoccur along other mangrove coastlines along northern Australia. The Northern Territory Government, in partnership with Charles Darwin University project, has committed $200 000 to support urgent research into the cause(s) of the mangrove dieback in the Gulf of Carpentaria. This represents an important opportunity to understand factors contributing to the dieback and will contribute to the future management of mangroves in the Northern Territory and Australia.

e) The impact on the vulnerability of infrastructure in coastal areas.

Many Northern Territory remote coastal and island communities are reliant on barge landings for supply of food, fuel for transport and power generation, construction materials, and other goods. Mangroves help stabilise the environment around barge landings. During the wet season when roads are closed for lengthy periods, freight can only be delivered by barge to some coastal communities. For isolated island communities, barge landings provide the only means of surface freight transport year-round. Impacts on barge landings resulting from rises in sea level and storm surge will significantly affect essential freight services at these remote and isolated communities

Storm surge, sea level rise and coastal erosion will have implications for transport infrastructure including impacts on existing roads and bridges within and adjacent to tidal zones. Planning for future transport infrastructure needs to respond to changes in sea level, coastal flooding and erosion.

f) The impact on water supply and sewerage treatment systems.

The Northern Territory's water supply and demand is strongly influenced by climate and variable yearly rainfall. The forecast impacts of climate change could see drier and hotter years and a potential increase in water use and loss. For example, during the dry season Darwin surface water sources experience in excess of 1 metre of evaporation, and 2.2 metres over the cause of a full year. The vulnerability of Darwin's water resources under a changing climate will depend on the demand for water, the increase in temperatures, and timing of the commencement of the wet season which replenishes both surface and groundwater supplies.

Surface water sources in Darwin and Katherine provide approximately half the volume of the Territory's potable water supply. Little of the substantial wet season rainfall is captured or diverted into man-made storage systems because there are a limited number of potential dam sites in the Northern Territory due to the topography of the landscape.

Groundwater supplements surface water storages in Darwin and Katherine, and groundwater is the primary source of potable water for other centres and remote communities. Groundwater resources also double as emergency supplies. In many locations, including Alice Springs, the water supply is already under stress, with demand outstripping replenishment rates. Increased demand, and water loss increases associated with climate change will exacerbate this situation. Communities that are located close to the coast could also be affected by sea level rise, which could lead to saltwater ingress into groundwater supplies.

The Northern Territory is investigating the potential for diverting surplus water into underground aquifers, otherwise known as managed aquifer recharge, and already employs this technique to store water for a coastal community. The advantage of such a technique is that it captures and retains a valuable resource with minimal environmental impact, and avoids losing the resource through evaporation as would happen if it was retained in a conventional surface storage.

Increasing heat affects evaporation, groundwater replenishment rates and water consumption. This can have a flow on impact of reduced water quality, requiring additional water treatment. Dry conditions also pose a bushfire risk and damage to water infrastructure such as bores.

More frequent and intense cyclones could affect water infrastructure in the top end of the Northern Territory through flooding from intense rainfall and storm surge.

Sewerage infrastructure close to the coast could be impacted by sea water rises. All of Darwin and Palmerston's wastewater treatment plants are located close to the coast and subject to storm surge risk, exacerbated by forecast sea level risk. More frequent and intense cyclones could affect the structural integrity of sewerage infrastructure in the top end of the Northern Territory.

Increasing water temperature in the aquatic receiving environments will decrease dissolved oxygen levels and may require sewerage to be treated to a higher level before being discharged in order to mitigate the risk of potential adverse effects such as fish kills.

Increased water demand associated with hotter conditions will place greater stress on sewage treatment infrastructure.

g) The impact on transportation, including railways, roads and airports.

The Northern Territory has significant of transport infrastructure to manage and maintain over an extensive area, with limited resources. This transport infrastructure is critical for connecting communities, commerce, and ensuring community resilience and health. Annual investment in transport infrastructure is a major component of the Northern Territory Budget, and the allocation for 2017-18 equates to $734 million. The marine, rail, road and air transport networks service extensive areas, but are expensive to maintain and are vulnerable to interruption due to extreme weather events.

The Northern Territory has a coastline of 10 950 kilometres, with relatively shallow coastal waters, dominated by mangroves, and all exposed to cyclonic activity during the October to March monsoon season. There are three deep water ports, and a number of smaller, purpose built facilities.

There is one rail line running north-south through the Territory providing Australia's central freight corridor between Darwin and South Australia.

There are more than 36 000 kilometres of road in the Northern Territory, but only 25% of these roads are sealed, and many are subject to restrictions such as seasonal closures, weight limits, or access restricted to four wheel drive vehicles only.

Air transport plays a critical role in linking the Territory to national and international destinations, as well as regional and remote areas. The Northern Territory has one international airport located in Darwin, 23 certified or registered airports, and over 350 aircraft landing areas or airstrips located at remote communities, regional towns, tourism locations, pastoral properties, mine sites and private properties. There are five airports capable of handling jet aircraft, 106 airstrips registered with the Civil Aviation Safety Authority, 69 regional airstrips maintained by local governments, and many private airstrips on pastoral stations, tourism facilities and private properties.

The Northern Territory Government assists with maintaining 70 remote aerodromes to ensure they are available to supply essential services and goods, as well as emergency medical evacuations. Remote aerodromes vary from basic unsealed airstrips to registered and sealed runways, and are costly to maintain and operate. Air services are particularly important when roads are impassable during the wet season, or for remote island communities, which rely on airstrips to transport people and essential freight to remote areas.

The Northern Territory's transport system is vulnerable to extreme weather events due to geographic and climatic factors. Improving network resilience in response to climate change is challenging issue for the Northern Territory Government.

h) The impact on energy infrastructure, including generators and transmission and distribution lines.

The Northern Territory's existing electricity infrastructure reflects a centrally designed system originally built by past governments.

There are seven different segments of the Northern Territory electricity sector, including three separate regulated networks that are centrally managed, and off-grid standalone assets that support large liquid natural gas processing facilities, mines, remote communities, and commercial enterprises such as pastoral stations, and tourism enterprises. The Northern Territory electricity assets are not connected to any other jurisdiction, and the industry needs to be completely self-reliant.

The 3 separate regulated networks are maintained to high standards and have been engineered to deliver a high level of resilience. Networks assets are designed based on Australian Standards/Building Code of Australia and Power Networks Design Guidelines. For example, zone substation buildings are constructed to Region C, Terrain category 2 standards, transmission lines are built to withstand Category 4 cyclones, and regulated network assets including distribution transformers and ring main units are located so they are above a 1 in 100 year flood level. Compliance with the Australian Standards/Building Code and the flood level maps is assured at the time network assets are designed and constructed.

Network infrastructure funding is subject to approval by the Australian Energy Regulator. Risk assessments are undertaken as part of the network planning process.

Natural gas is the primary fuel used for electricity generation across the three regulated networks, with diesel used as the emergency backup fuel. Solar energy captured via sola photovoltaic panels currently accounts for approximately 4% of the generation capacity across the three regulated networks. Diesel is the fuel predominantly used to generate electricity for approximately 60 communities isolated from the gas-fired networks. Solar is being integrated into the majority of isolated power stations to reduce diesel consumption and transform the standard power station design to a solar-diesel hybrid design.

The Northern Territory Government is currently implementing a policy of achieving 50% renewable energy by 2030, and is in the process of developing a strategy to achieve this whilst maintaining system security and network reliability. Achieving this target will diversify the energy sources, decentralise electricity generation, and may possibly include increased use of energy storage in the form of small and large scale battery or energy storage technologies. A redistribution of generation capacity coupled with the adoption of electricity storage systems may reduce the potential for disruption in electricity supplies for the three regulated networks arising from storm damage, etc.

More frequent and intense cyclones and storms could have an impact on electricity infrastructure, particularly above ground distribution networks. More frequent and intense cyclones and storms may also result in remote communities being inaccessible for longer periods due to disrupted road access. This would require augmentation of diesel fuel storage capacity to meet the community's power demands for longer periods of isolation. The impact of sea-level rises on power infrastructure for low-lying remote coastal communities may be exacerbated by king tides and storm surges associated with more frequent and intense cyclones and storms, requiring relocation of this infrastructure.

Hotter and more humid conditions will drive an increase in electricity demand resulting in a requirement for infrastructure augmentation and additional fuel consumption.

i) The impact on health, education and social services infrastructure, including hospitals, schools and aged care.

Many regional and remote communities are reliant on transport networks for access to health, education and social services infrastructure. Climate change related disruption of transport networks will have impacts on access to social infrastructure and services.

The vast majority of social infrastructure has been located in areas of low risk from flood, storm surge and fire threats because it is recognised that occupants and visitors may have limited mobility or ability to relocate.

In coastal areas each community has access to a cyclone shelter built to withstand Category 4 cyclones, and often these shelters are based on schools or other community facilities.

The Northern Territory Government has in the recent past relocated key emergency infrastructure such as ambulance centres and community halls away from flood prone areas in order to ensure services are still available during extreme weather events, and residents can remain in their communities (e.g. Katherine and Daly River).

j) The impact on private and public housing.

From a planning perspective, the Northern Territory Planning Scheme includes high level planning principles regarding flooding and storm surge levels, including the need to include the likely effects of climate change on storm surge levels at specific locations. The Scheme also includes specific clauses to control development in relation to hazard from cyclones and storm surge, and ensures that development in coastal areas is appropriate in regard to the impact of cyclones and associated storm tides.

From a design and construction perspective the National Construction Code sets the minimum requirements for the design, construction and performance of residential and non-residential buildings in Australia. However, the Northern Territory departs from the energy efficiency provisions of the 2016 National Construction Code, applying the 2009 standard instead. There are likely to be cost implications associated with bringing the Northern Territory into line with the energy efficiency requirements of the 2016 Code.

Guidelines and recommendations have been developed for Northern Territory Government residential housing to promote site-responsive passive designs suitable for Northern Territory climate zones. The Government acknowledges that climatically appropriate design is integral to the liveability and sustainability of urban and remote public housing dwellings.

Design guidelines for both remote and urban public housing state that site layouts and dwelling designs should incorporate passive designs that reflect local site conditions and the regional climate. Appropriate designs can factor in building orientation, construction methods and materials, natural ventilation and lighting, and landscaping. The current design guidelines for remote public housing in the Northern Territory recognise that the design of all buildings, infrastructure and hardware must seek to minimise ongoing greenhouse emissions in remote communities where possible.

k) The impact on public recreation and tourism facilities.

Many tourism and recreational experiences across the Territory are dependent on road, rail, marine and air transport. Climate change disruption to transport networks may therefore also impact on recreation and tourism infrastructure and facilities.

The CSIRO note that rising sea levels and a changing climate will alter many of the natural assets that are a drawcard for tourism visitors to the Northern Territory. Wetland areas such as the Mary River floodplains close to Darwin, or the Kakadu wetlands could experience substantial flora and fauna changes as a result of sea-level rises with some estimates of an 80% loss of biodiversity in Kakadu wetlands from a 30 cm rise in sea levels. Wetland areas are important areas for recreational fishing and tourism and some of the infrastructure to access these areas may need to be upgraded or relocated to maintain access to existing areas, or improve access to new areas.

The Northern Territory has a range of sea water barrages to limit salt water intrusion over fresh water floodplains. It is likely that climate change will increase the damage to barrages requiring them to be maintained and replaced more frequently.

Locations that are expected to experience more intense heat over a longer period may require additional infrastructure to make these areas more amenable and safer for tourists to visit.

l) The impact on financing and insurance arrangements for housing, buildings and infrastructure.

Until 2014, the Northern Territory Government operated the Territory Insurance Office (TIO). In 2014, the insurance arm of TIO was sold to Allianz. The Government of the day felt that the market was able to provide a range of products at a reasonable price, and the Northern Territory Government would be financially over-exposed if there was a natural disaster requiring TIO to pay claims at the same time as Government had to fund significant repairs to public infrastructure.

Since 2014, there is no evidence of a reduction in competition in the Territory insurance market, but some areas and businesses have reported increasing insurance premiums, suggesting insurers are re-evaluating and re-pricing the risks of operating in the Northern Territory. Competition can introduce some useful tension to balance insurance risks and costs, but the Northern Territory is a relatively small market which may limit its appeal to some insurers.

The uncertainty around what the effects of climate change may be on northern Australia may lead to higher risk ratings for northern Australia even before extreme weather events and damage to infrastructure occurs. This could contribute to a creeping increase in insurance costs over time.

The availability and affordability of insurance in northern Australia was highlighted as a concern in the 'PIVOT NORTH' Joint Select Committee inquiry into the development of Northern Australia. The concerns arose from limited competition and high insurance premiums, with some areas experiencing an upward trend in insurance costs over an extended period of time, exacerbated immediately after natural disasters such as Cyclones Yasi in 2011. These outcomes can be explained by a combination of factors, such as a relatively small population and commercial base that constrains the size of the market, insurers re-assessing the risk profile of different regions and choosing to reduce cross-subsidisation across their portfolios, and/or adjusting the scope and cost of policies to allocate the risks differently between home owners, asset owners and managers, and insurers.

However, the insurance industry argue that the high incidence of natural perils across northern Australia results in a higher proportion of claims from the region compared to its contribution to the national premium pool. If there is no change in how these risks are understood and mitigated, the limited competition in the insurance market of northern Australia suggests the likelihood of increasing insurance costs. This poses a threat to ongoing economic growth because the increased insurance costs reduce the disposable income of households, and the operating margin of businesses and infrastructure owners and operators.

Financiers often require insurance to be in place before finance is extended, so the accessibility and affordability of insurance can have implications for access to finance through this relationship.

The Inquiry may wish to consider whether there are mechanisms whereby the increased risks of climate change can be better shared between Governments, the insurance sector, householders, business and infrastructure owners and operators.

It may be possible in some circumstances to mitigate the impact of climate change through engineering solutions such as the construction of flood basins or diversion barriers to limit the impact of flood waters on valuable assets, thereby reducing risks, and presumably insurance premiums. It may be beneficial to improve information, mapping and data to improve forecasts of the impact of extreme events. Reviewing or upgrading engineering and building standards, and more rigorous compliance against these may be other options. Anything that can be done to reduce the uncertainty of whether infrastructure and assets will be affected, and how they will perform when they are, is likely to minimise the upward pressure on insurance premiums.

The Inquiry may also wish to consider whether the insurance industry operating in northern Australia has sufficient access to re-insurance mechanisms so they can redistribute some of the risks they are exposed to in northern Australia at reasonable cost. Higher re-insurance costs may simply be passed through to policy holders in the form of higher insurance premiums, reduced policy coverage, or asset owners choosing to under- or self-insure which increases financial stress and results in economic disruption. This will be particularly important as the uncertainty around the impact of climate change on infrastructure increases over time.

m) The adequacy of Commonwealth, State, and Territory policies to assess, plan and implement adaptation plans and improved resilience of infrastructure.

The National Climate Resilience and Adaptation Strategy released by the Commonwealth Government in 2015 provides guidance on a nationally coordinated approach to responding to and adapting to climate change.

The Northern Territory Government is currently develop a whole-of-government framework to respond to climate change, taking into consideration environmental, economic, social and health implications. This framework is likely to be completed in late 2017 or early 2018 and may be able to leverage some of the insights that may emerge as a result of this Senate inquiry.

The development planning and approvals process in the Northern Territory is more straightforward and offers greater certainty than in other Australian jurisdictions because the majority of processes are governed by the Northern Territory *Planning Act*, which provides a mechanism to ensure appropriate consistency in planning standards, decisions and compliance. The Northern Territory Planning Scheme includes high level planning principles regarding flooding and storm surge levels and the need to include the likely effects of climate change on storm surge levels at specific locations.

n) Any other related matters.

Efforts to anticipate the impacts of climate change on built infrastructure should be complemented by a well-developed, highly skilled, mobile emergency response capability. The Northern Territory Government has a Security and Emergency Response Team (SERT) which coordinates whole-of-government responses to all extreme weather events, including liaising with other supporting governments where required. The value of this capability was demonstrated in the Northern Territory's response to the two cyclones on East Arnhem and Elcho Island in 2015 which allowed government to firstly ensure people were safe, and secondly to ensure professional expertise was on the ground as soon as possible to assess damage and the integrity of buildings and other infrastructure. The Commonwealth and New South Wales governments provided important assistance with recovery efforts at the time, highlighting the value of a national approach.

The Top End of the Northern Territory shares similarities in climate, weather patterns, horticultural crops and ethnic links with the tropical regions of South East Asia. These links increase the likelihood of tropical pests from the region entering and establishing in the Northern Territory. Climate change may increase the rate of arrival of foreign species and associated pests and diseases from countries north of Australia into the Northern Territory, allowing them to expand further south or extend their range. Hence, climate change is likely to increase biosecurity risks for the Northern Territory, so appropriate risk management and supporting infrastructure will need to be enhanced. The extensive landmass and coastal waters of the Northern Territory, and permeable boundaries between regions, make complete exclusion a challenge. Climate change may also change the range currently occupied by species already endemic in the Northern Territory. Any significant changes are difficult to predict and may increase costs for producers in areas currently free from these species.

USEFUL REFERENCES

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