

Tāmaki Makaurau Economic Climate Change Risk Assessment

Updated August 2021 (superseding report delivered in
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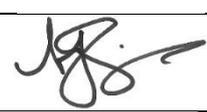
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Executive Summary

AECOM has delivered this final Economic Climate Change Risk Assessment (CCRA) for Auckland Unlimited. This work builds upon the preliminary CCRA undertaken in 2020. This CCRA adds to the knowledge of climate change risks already identified by Auckland Council in their technical report series and extends this knowledge into key priority sectors for Auckland Unlimited through a qualitative literature review.

The assessment considers both risks and opportunities arising from physical climate change hazards as well as those arising from the transition to a low carbon economy. This CCRA has focused on key sectors of Auckland's economy based on Auckland Unlimited's remit. Key physical risks across the food and beverage, construction, screen and visitor economy sector have been included below.

Sector	Risks
Food and beverage	<ul style="list-style-type: none"> Water supplies are reduced disrupted or contaminated – this risk was rated moderate for the primary sectors in 2040 and major for horticulture and viticulture in the primary sectors in 2110. Reduction in outputs from livestock and crop production due to changing seasonality – this risk was rated minor for the primary sectors in 2040 and major for horticulture and viticulture in 2110. Assets such as crops and livestock, are damaged or destroyed – this risk was rated minor for the primary sectors in 2040 and major for horticulture in 2110.
Construction	<ul style="list-style-type: none"> Partially constructed buildings and infrastructure, construction sites and equipment are damaged or destroyed. This risk was rated minor in 2040 for all subsectors rising to moderate/major in 2110. Maritime infrastructure and maritime transportation assets are damaged or destroyed disrupting the construction sector supply chain. This risk was rated minor in 2040 rising to moderate in 2110. Changes to seasonality and average climatic conditions which result in failure of buildings and infrastructure to meet or maintain the level of service expected by owners or end users. This was rated minor in 2040 rising to moderate in 2110 for the residential and non-residential subsectors.
Screen	<ul style="list-style-type: none"> Information and Communication Technology systems are disrupted. This risk was rated minor in 2040, rising to moderate in 2110. Electricity supplies are disrupted. This risk was rated minor in 2040, rising to moderate in 2110. Large scale ecosystem change. This risk was rated minor in 2040, rising to moderate in 2110
Visitor Economy	<ul style="list-style-type: none"> Information and Communication Technology systems are disrupted. This risk was rated moderate in 2040 and major in 2110. Flights to and from Auckland International Airport are disrupted. This risk is rated minor in 2040, rising to major in 2110. Large scale ecosystem change. This risk was rated minor in 2040, rising to moderate in 2110.

For the advanced manufacturing and screen sector, a high-level climate risk screen was undertaken to assess whether the sector was exposed to the physical climate change risks. No risk rating was undertaken. There was very limited data available from both literature and workshop content, therefore findings for this sector are preliminary. Given the complexity of this industry, key climate change risks identified were those associated with major infrastructure risks identified through the assessment, such as ICT and electricity risks, where the consequences of these risks are digital failure and power

outages respectively. International supply chain impacts either via maritime (risk 1) or aviation (risk 5) delays were also identified as crucial due to the specific inputs required for these high-value industries.

Transitional climate change risks and opportunities are those that may result from the process of adjustment towards a low-carbon economy. In contrast to the physical climate change risks posed by climate change, climate-related transitional climate change risks and opportunities are highest in the next few decades (as action is taken to reduce emissions), are broader in scope, and are dependent on the speed and scale of transition. Transitional climate change risks and opportunities arise from policy and litigation, technology, markets and reputational change. Transitional risks have been drafted based on the following key shifts underpinning New Zealand's transition to a low carbon economy (Productivity Commission, 2018 and MBIE, 2017):

- A transition from fossil fuels to electricity and other low-emission fuels across the economy
- Substantial afforestation
- Changes to the structure and methods of agricultural production; and
- Changes to international transport.

While transition risks specific to each sector are contained in the body of the report, across the priority sectors, uniform transition risks are as follows:

Transition risk	Commentary
Increased costs of transporting input materials across the sectors due to increasing fuel costs	Risk depends upon the distance inputs to production must travel, the distance to consumer markets, and the mode of transportation. This risk applies to land-based transportation, aviation and shipping
Higher electricity costs causing reductions in demand, or reductions in profit margins	Risk depends upon the energy intensity of the production of a good or service, the ability of the business to absorb costs or to pass costs on to consumers, and the sensitivity of consumers to changes in price
Increased costs of inputs to production due to price on carbon	Risk depends upon the volume of material inputs, the emissions intensity of the material, and the technological viability of decarbonising the relevant production and supply chains.
Additional capital outlays required for fuel switching and energy efficiency retrofits in response to policy, regulation, consumer demand or market signals, stressing balance sheets and cash flows	Risk depends upon the magnitude of the capital outlays required, and the ability of the business to access necessary capital.
Stranded assets: Investments see their economic life curtailed due to technological, regulatory and/or market changes, stressing balance sheets	Risk depends on current or likely future existence of substitutes for production processes or goods and services, the emissions intensity of assets, asset adaptability, asset useful life, and the capital intensity of sector outputs.
New costs of compliance associated with carbon-related regulation such as the TCFD causing reductions in profit margins via increased operating costs	Risk depends on the size of the business (i.e. employees, market capitalisation) and ownership structure (i.e. public, private), and emissions intensity of sector.
Reputational risk if skills required to the transition, or prosper from the transition, are not present in the labour market	Risk depends on the need for new skills (i.e. is the transition driven through changes to labour, or capital, the adaptability of the labour-force, the ability to attract appropriately skills workers from outside the Auckland region.

Transition risk	Commentary
Increased risks from wildfires due to afforestation efforts	Risk depends upon locations of assets and workforce exposure to smoke. Risk may also flow through transport networks and other linear infrastructures.
Reduction in the competitiveness of exports if other markets do not take action to reduce emissions	Risk depends on importance of exports to the sector
Increased Directors and Officers (D&O) liability insurance costs	Risk depends on size of the business and likely liability under transition scenarios

Results from both the physical and transition risk assessments provide AU with an understanding of the implications of climate change related risks and opportunities. Across both the physical and transitional domains, each of the key sectors has different priority risks, based on their individual sector attributes. Understanding these priority climate change risks, their associated consequences and potential adaptation actions can assist AU to incorporate relevant measures into economic recovery planning in light of COVID-19. It can also assist AU with resilience planning for each sector, ultimately increasing the economic resilience of Auckland.

1.0 Introduction

1.1 Context

Warming of the climate system, driven by anthropogenic greenhouse gas emissions, is unequivocal (IPCC, 2019). The world has already experienced significant climatic changes due to emissions from the combustion of fossil fuels and land-use change. Auckland is already experiencing climate change impacts. Over the past century, Auckland's mean annual temperature has increased by approximately 1.6 °C and sea levels have risen by approximately 16 centimeters. If global emissions continue to rise, sea levels are projected to continue to rise by up to one metre by the end of this century. On 21st July 2020, Auckland Council adopted Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan. As Te Tāruke-ā-Tāwhiri states, in a region with 3,200 kilometres of coastline, this means serious threats of coastal erosion, storm surges and flooding. Such changes are expected to continue, with far reaching consequences across all sectors of the economy and communities.

Risks arising from climate change can be divided into two major categories: risks related to the transition to a low carbon economy and risks related to the physical impacts of climate change (TCFD 2018). Assessments are underway to understand the broader social, economic and cultural impacts of climate change at both national and regional levels. The purpose of Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan is to increase Auckland's resilience to the impacts of climate change and reduce emissions that cause climate change. To support the Climate Plan, the Climate Change Risk Assessment technical report series produced by Auckland Council considered risks across a range of areas, however, there has been no specific climate change risk assessment of impacts to the region's economy.

As a signatory to the Paris Agreement, New Zealand has committed to the global transition to net zero emissions, and to reaching net zero emissions sometime in the second half of this century. New Zealand has further committed to the Paris Agreement by introducing the Climate Change Response (Zero Carbon) Amendment Act 2019. This Act sets out overarching goals for New Zealand to reach the Paris Agreement by setting new domestic greenhouse gas emission reduction targets. It encourages New Zealand to: reduce net emissions of all greenhouse gases (with the exception of biogenic methane) to zero by 2050; and to reduce emissions of biogenic methane to 24-47% below 2017 levels by 2050, including to 10 per cent below 2017 levels by 2030. In addition to setting these targets, the Zero Carbon Act also:

- Provides long term certainty across sectors about the direction we are headed in the long term.
- Includes some accountability through the Climate Change Commission and provision for government to respond – note at the time of writing the Climate Change Commission's draft advice and first series of emissions budgets has been released for consultation and will be set by the Government in 2021.
- Ensures the Crown-Māori partnership is central to the low carbon transition.

Auckland too has targets to reduce greenhouse gas (GHG) emissions by 50 per cent by 2030 and reach net zero GHG emissions by 2050. The most significant sources of emissions are related to transport, energy use in industry and buildings, and industrial processes. While the transition to a low carbon economy will mean dramatic change across all industries, it is recognised that emissions must decrease rapidly over the next decade and that the sooner they decline the better the physical impacts of climate change can be managed.

Findings from Westpac's Climate Change Impacts 2018 report (Westpac, 2018) demonstrate that New Zealand can transition to a net zero greenhouse gas emissions economy using both an early, planned transition and a delayed (until 2030) but abrupt transition. However, taking earlier, planned action is modelled to increase GDP by \$30 billion cumulatively from 2020 to 2050. Furthermore, the pressure of a faster transition (i.e. a sudden, 'shock' transition) will reduce GDP growth to below 2% after the 2030 shock event. The emissions price is also projected to be 32% lower by 2050 if an early, planned transition is implemented rather than a shock transition at 2030. Although the Climate Change Commission's draft advice (see Section 8.0 for more detail on this) uses different metrics and pathways than the Westpac report, it comes to a similar conclusion regarding the benefits of an early,

planned transition. Aside from the economic implications, an abrupt transition makes New Zealand less able to plan for a just transition to ensure that affected businesses and communities are appropriately supported (CCC, 2021). Early signaling about the transition will provide greater certainty to businesses and will provide them with more time to adapt and transition, finding solutions that work for them (CCC, 2021).

Businesses are the backbone of the Auckland economy. They provide employment, education and training, produce a wide range of goods and services, generate investment and innovation, and contribute to social and cultural life in Auckland. Auckland's business community is made up of a diversity of business types; large businesses as well as many small and medium-sized businesses.

Small and Medium-scale Enterprises (SMEs) form a significant portion of Auckland's economy. These enterprises employ many people and are often well-positioned to meet consumer needs. However, SMEs by definition, are small in scale, with relatively limited human and financial resources. These limited resources can, but do not always, manifest in a variety of ways that can increase vulnerability to climate change, including; limited forward planning; limited capital for recovery; limited access to expertise and information; lack of influence across supply chains; and limited risk management activities. Accordingly, within each sector, SMEs are likely to be more impacted by climate change than larger organisations. Sectors with a higher proportion of economic activity driven by SMEs may also be more vulnerable to climate change than sectors with less SME activity.

The global response to COVID-19 has had profound economic and social implications across New Zealand. As Auckland recovers from COVID-19, there is a unique opportunity for this recovery to drive transition to a low carbon economy and to adaptation to physical climate change risks. To realise this opportunity, an understanding of risks and opportunities from climate change is required so that business can be supported and prepared for transition and build resilience to future climate risks.

It is critical that investments to stimulate the economic recovery do not lock the region into increasing emissions or greater vulnerability to future physical climate risks. Both physical and transitional climate change risks are likely to incur costs, as well as potentially generate benefits, to the sectors considered. The wider economic implications of both physical and transitional climate change risks in terms of the region's GDP, employment, and indicators such as the consumer price index, depend on the nature of the sector and its products, as well as the physical and transitional climate change risks occurring outside the Auckland region. Whether the costs are borne by the supplier, or are passed on to the consumer, depends on the extent of competition and the ability to import goods and services. If the sector has few competitors from outside the Auckland region then they may be able to pass any costs directly onto consumers. However, if substitutes or alternatives exist in regions that are not facing the same risk, and trade is able to occur, consumers will switch to these if Auckland suppliers attempt to pass on costs. Businesses may move to other locations if the risks become too high. This assessment does not make assumptions regarding the situation outside the Auckland region, or internationally, however, this will clearly play an important role in the ultimate effect on Auckland's economy and the well-being of its people.

1.2 Purpose and Objectives

This Auckland Economy Climate Change Risk Assessment (CCRA) adds to the knowledge of climate change risks already identified by considering risks and opportunities arising from both physical climate change risks and risks from the transition to a low carbon economy. Risks to five sectors: construction; food and beverage; visitor economy; screen; and advanced manufacturing and technology, were considered. An understanding of risks and opportunities from climate change will also support Auckland Unlimited (AU) and Auckland Council to integrate climate change considerations into economic recovery planning in response to COVID-19.

The objectives of the Auckland Economy CCRA were to:

- Identify and rate physical climate change risks and opportunities that may result from climate change;
- Identify risks and opportunities that may result from a transition to a low-carbon economy;
- Explore potential interactions between physical and transitional climate change risks;

- Enhance AU's understanding of how Small and Medium-sized Enterprises (SMEs) within each sector may be impacted differently by climate change compared with larger businesses; and
- Explore the implications of climate change related risks and opportunities for economic recovery from COVID-19 to enable the incorporation of relevant measures into economic recovery planning.

This Economy CCRA was undertaken in two distinct phases. The first Phase was undertaken between April and June 2020. The second Phase was undertaken between February – June 2021. Phase 1 was limited to risks and opportunities in relation to four priority sectors in the Auckland region and limited engagement was undertaken due to COVID restrictions. Phase 2 involved additional stakeholder engagement, expansion to consider risks to additional sectors (namely advanced manufacturing and technology) and specific consideration of risks and opportunities to Māori businesses. Literature available on the financial costs of not transitioning was also reviewed.

An additional report has been produced that details the review and findings of the risks and opportunities for Māori businesses in the context of the ECCRA. This is titled 'Climate change in Tāmaki Makaurau: Understanding how risks and opportunities may be different for Māori Businesses.' A summary of the report has been included in Section 3.0. Please refer to Appendix B for the complete report.

1.3 Project Method

1.3.1 Phase 1

The first Phase of the project included a risk assessment of priority sectors and review workshops with AU and Auckland Council. This was preceded by context setting, which established the overall objectives of the assessment and the assessment process, scope, and method. A summary of the phase 1 workshop approach is outlined in Table 1. Further detail on the method, including the parameters used for the risk assessment is located in the *Assessment Method Statement* in **Appendix A**.

Table 1: Phase 1 assessment overview

Activity	Objective
Context setting	<ul style="list-style-type: none"> • Set the context of the project; • Define the project objectives; and • Confirm the scope and the methodology.
Risk assessment	<ul style="list-style-type: none"> • Desktop review to identify the physical climate change risks and opportunities to the four priority sectors; • Analyze and evaluate physical climate change risks using an agreed risk framework; • Identify transition related risks and opportunities to these sectors; and • Analyze implications of findings for Auckland's economic recovery from the impacts of COVID-19.
Review workshops	<ul style="list-style-type: none"> • Validate transitional climate change risks to the priority sectors; • Present the findings of the desktop review; and • Explore the implications of these findings for economic recovery from the impacts of COVID-19.

1.3.2 Phase 2

As well as extending the assessment to include new sectors and subsectors, Phase 2 also involved stakeholder engagement with external stakeholders within the Auckland business community. Through both workshops and targeted interviews, inputs were gathered from businesses and industry representatives to understand key climate risks to each sector and their adaptation and transition priorities.

1.3.3 Advanced Manufacturing and Technology Screen

The climate risk screen considered, at a high level, whether the Advanced Manufacturing and Technology sector is exposed to the physical climate change risks identified in Phase 1 of the ECCRA. This assessment was predominately qualitative. Using literature, AECOM assessed the industry against pre-identified criteria to assess whether the industry is exposed to climate change risks. There were limited documents available to identify exposure and estimate significance of risks. Due to limited literature being available, the screen was also populated with data from the virtual workshop as well as the limited available literature. The virtual workshop had 7 participants attend from this sector.

1.3.4 Engagement

As well as extending the assessment to include new sectors and subsectors, Phase 2 also involved stakeholder engagement with external stakeholders within the Auckland business community. Through both workshops and targeted interviews, inputs were gathered from businesses and industry representatives to further understand the nuances of the sector. Table 2 below summarises the workshops that were held over the course of Phase 2. To provide attendees flexibility, two workshops were held face-to-face during the day and one workshop was held online during the evening. The online workshop was half the length of the face-to-face workshops. To keep within the time constraints, only Breakout Activity 1 and 3 were included in the online workshop.

Table 2: Workshop dates

#	Workshop	Location	Delivery dates
1	Food & Beverage and Screen	Hatchbox	30 March 2021 (9:30-12:30)
2	Construction and Visitor Economy	Hatchbox	8 April 2021 (1:30-4:30)
3	Advanced Manufacturing and Technology sector workshop (and other attendees where participants are unable to make their sector workshop)	Virtual	20 April 2021

Content from the workshops has been used in the June 2021 update of this report. The consequences and risk rating data has been used to update the sector-specific consequences sections. The adaptation and transition data has been incorporated into additional subsections 6 and 7 respectively).

1.3.5 Literature Review

To supplement understanding of the transition scenario a literature review was undertaken of 6 readily available pieces of literature. The literature review was used to update the context and or 'Climate Change in Auckland' section of the ECCRA report and was summarised in a short memo provided to the client prior to the delivery of this Report.

1.3.6 Report Update

Following the assessment, we used information from engagement and the literature reviews to update this report. This report consists of the following key sections:

- A summary of current and possible future climatic conditions in Auckland (Section 2.0)
- An overview of risks facing Māori businesses (Section 3.0)
- An overview climate change risks to the five key sectors of the economy (Section 4.0)
- The consequences of these risks in relation to each relevant economic sector (Section 5.0)
- The results of the advanced manufacturing and technology screen (Section 6.0)
- A summary section on adaptation actions identified through engagement (Section 7.0)
- A summary of transitional climate change risks and opportunities for each relevant sector (Section 7.1), including a summary of transition actions identified through engagement (Section 8.2).

- The implications of the assessment for COVID-19 recovery planning (Section (9.3)¹; and
- An overall conclusion (Section 10.0).

1.4 Limitations

- This assessment was based on publicly available information. No modelling was undertaken for this assessment.
- There is a high degree of uncertainty looking out to 2110 – in general, government policies, technological and demographic change, consumer and market pressures are likely to exert a greater influence on the economic prospects of the assessed sectors than climate change.
- This assessment did not analyse the implications of cascading risks, risks that may arise outside of the Auckland region, or risks outside of the value chains within each sector.
- A single high emissions scenario, and a single transition scenario was used to assess physical climate change risks and transitional climate change risks.
- This assessment identified and rated risks. Adaptation actions were only identified through engagement.

¹ Note this hasn't been updated following the first Technical Report.

2.0 Climate change in Auckland

2.1 Auckland's current climate

The following information on Auckland's climate was sourced from Chappell (2013) and represents an average or estimated average over a 30-year period between 1981-2010.

Table 3: Auckland's current climate

Variable	Description
Temperature	The Auckland region has a relatively mild climate with few extremes of temperature. Most of the region experiences mean annual temperatures between 14°C and 16°C. The annual mean daily temperature range for Auckland is small, averaging 7.9°C. Eastern areas are generally warmer than western areas, and higher elevation regions such as the Hunua Ranges are colder, experiencing mean annual temperatures as low as 12°C.
Rainfall	Annual rainfall ranges between approximately 900 mm and 1500 mm across the region. There is a distinct seasonal distribution of rainfall; 32 per cent of annual rainfall occurs in winter months, and 20 per cent in the summer months. The average number of days each year on which 0.1 mm or more of rain is recorded varies from around 180 days in coastal areas to over 210 days in inland areas. Heavy rainfall is sporadic and occurs with thunderstorms or with the passage of depressions of tropical origin over or close to Auckland. North-easterly flows between ridges of high pressure to the east and troughs over the Tasman Sea also bring rain.
Dry spells	Dry spells – periods of fifteen days or longer with less than 1 mm of rain on any day – are common in Auckland during summer and early autumn. Dry spells last for 20 days on average, and there are usually one to two spells each year, occurring between December and March.
Wind	Mean monthly wind speeds in Auckland range from 8 to 21 km/hr. Coastal areas tend to be windier than sheltered inland areas. Spring is generally the windiest season throughout the region. Auckland experiences strong gusty westerlies which may be accompanied by thunderstorms, and rarely tornadoes. Tropical cyclones that reach Auckland and still retain hurricane force winds are very rare, however other tropical storms affect Auckland about once or twice each year, bringing heavy rain and strong easterly winds.
Frosts	Compared with many parts of the country, Auckland has a mild climate and frosts are generally light and infrequent.
Sunshine	Most of Auckland receives approximately 2000 hours of bright sunshine per year. In general, central and eastern areas receive more bright sunshine than western and southern areas of the region, and islands in the Hauraki Gulf receive even higher sunshine hours – over 2100 hours in some places.
Humidity	Relative humidity is high in all seasons throughout the region. This, combined with the warmth, gives the Auckland climate a different character to that of other areas of New Zealand.
Sea surface temperature	Sea surface temperature is defined as the water temperature in close proximity to the surface of the ocean.

2.2 Auckland's future climate

2.2.1 Emissions Scenario

This assessment used projections prepared for the Auckland region by Pearce (et al., 2018). This assessment used projections based upon a high emissions scenario characterised by increasing greenhouse gas emissions driven by population growth, increased use of land for agriculture, a heavy reliance on fossil fuels and a high energy intensity and low rates of technology development. Additional information on the climate change scenario is contained in **Appendix A**.

2.2.2 Summary of climate projections

Under a high emissions scenario, by 2110, the Auckland region is projected to be 3.25-3.75°C warmer than at the beginning of the century. Most of Auckland is projected to experience more than 90 hot days per year (days > 25°C) and there may be approximately 12 more days with very high or extreme fire danger. The volume of annual rainfall is likely largely unchanged, but more rainfall is likely to occur in autumn, and less in spring. When rain falls, it is likely to be more intense. Most of the Auckland region will experience between 12-21 more dry days per year. Oceans will be more acidic, and sea levels will be 1.2 metres higher than the 1990s. A summary of climate change projections, and related climate hazards is contained in Table 4. Additional information on variability of projections across the Auckland region can be found in Pearce et al. (2018).

Table 4: Climate change hazards and climate change projections

Climate change related hazard	Baseline period ²	Climate change projections	
		2040 ³	2110 ⁴
Increase in frequency, duration, and magnitude of heatwaves	<ul style="list-style-type: none"> 19.7 hot days per year 18.7°C mean annual temperature 18 - 20°C median annual average daily maximum temperature 8-13°C median annual average daily minimum temperatures 	<ul style="list-style-type: none"> 15-20 more hot days⁵ per year 0.75-1.00°C increase in annual mean temperature 0.75-1.25°C increase in annual mean daily maximum temperature 0.75-1.00°C increase in annual mean daily minimum temperature 	<ul style="list-style-type: none"> 70-90 more hot days per year 3.25-3.50°C increase in annual mean temperature 3.25-3.75°C increase in annual mean daily maximum temperature 3.00-3.25°C increase in annual mean daily minimum temperature
Increase in frequency of wildfires ⁶		<ul style="list-style-type: none"> 10-30 per cent increase in Seasonal Severity Rating⁷ Very High and Extreme forest fire danger increases by 40-50% 	<ul style="list-style-type: none"> 10-30 per cent increase in Seasonal Severity Rating Very High and Extreme forest fire danger increases by 50-100% for the Auckland Region north of the isthmus and by 40-50% south of the isthmus
Increase in frequency and extent of flooding	<ul style="list-style-type: none"> 7.5 heavy rain days⁸ per year annual average of the 99th percentile of daily rainfall is 48.2mm 6-8 days with consecutive heavy rainfall days⁹ per year 	<ul style="list-style-type: none"> 0-5 more heavy rain days per year Increase of 5-15 per cent in the magnitude of 99th percentile daily rainfall Increase in intensity of short duration, rare rainfall events by 14 per cent per degree of warming. 	<ul style="list-style-type: none"> 0-5 more heavy rain days per year increased frequency of consecutive days of heavy rainfall across the Auckland Region of about one occurrence every two years Increase in of 10-25 per 99th percentile of daily rainfall is projected to increase by between 10-25 per cent for most of the region, with some parts of the southeast projected to experience greater than 25 per cent increase

² The baseline period is an average of a period of between 20 and 30 years, depending on the climate variable, centred on the year 1995.

³ Projections are the average of the 20 year period 2031-2050

⁴ Projections are the average of the 20 year period 2101-2120

⁵ Days over 25°C

⁶ Projections for wildfire are in relation to a 1980-1999 baseline and are for the 20 year periods centred on 2050 and 2080.

⁷ Seasonal Severity Rating (SSR) is a seasonal average of the Daily Severity Rating (DSR), which captures the effects of both wind and fuel dryness on potential fire intensity, and therefore control difficulty and the amount of work required to suppress a fire.

⁸ Days where rainfall is above 25 mm.

⁹ Consecutive days that experience above 40 mm per day.

Climate change related hazard	Baseline period ²	Climate change projections	
		2040 ³	2110 ⁴
		<ul style="list-style-type: none"> Increase in intensity of long duration rainfall events by 5-6 per cent per degree of warming. 	
Increase in coastal inundation		<ul style="list-style-type: none"> Increase by 0.3 metres¹⁰ 	<ul style="list-style-type: none"> Increase by 1.2 meters¹¹
Less frequent but more intense storms	<ul style="list-style-type: none"> 18.6 windy days¹² per year 9 cyclones every 10 years 	Two fewer windy days per year	Three to four fewer windy days per year Increase in intensity and reduction of frequency of tropical cyclones
More frequent and intense drought	<ul style="list-style-type: none"> PED¹³ is 225 mm–375 mm per year 237 dry days¹⁴ per year in Auckland 	60-100 mm increase in PED 3-9 more dry days per year Annual relative humidity increases by 1 per cent	100–140 mm increase in PED 12-21 dry days per year Annual relative humidity decreases by up to 2 per cent for the majority of the region
Changes to seasonality	<ul style="list-style-type: none"> Few frosts each year across most of the region. More frosts in high elevation and northwest regions 		<ul style="list-style-type: none"> 0 frosts across the isthmus and eastern areas of Auckland. Few frosts per year in high elevation areas, and the northwest of the region Spring arrives earlier, winters are shorter and summers longer Spring becoming drier and autumn becoming wetter

¹⁰ By 2045 (Golubiewski et al, 2019)

¹¹ By 2100 (Golubiewski et al, 2019)

¹² A day with daily mean wind speed of 10 m/s or more

¹³ Potential evapotranspiration deficit (PED) is the gap between water demand and water availability.

¹⁴ Days with less than 1 mm of rainfall

3.0 Climate change in Tāmaki Makaurau: Understanding how risks and opportunities may be different for Māori Businesses

3.1 Introduction

This assessment contains a summary of the approach and findings of the standalone report: Climate change in Tāmaki Makaurau: Understanding how risks and opportunities may be different for Māori Businesses (Whetū Consultancy Group, 2021). The primary aim of the assessment was to provide insight of how risks and opportunities identified within the **Tāmaki Makaurau Economic Climate Change Risk Assessment (ECCRA)** (AECOM, 2021), may differ in the context of Māori business and considers what drivers may be contributing to these differences. For physical climate change risks, the analysis considers drivers of vulnerability. For physical climate change opportunities, the analysis extends to looking at why Māori businesses may be more poised to take advantage of opportunities.

3.2 Physical climate change risks – non-sector specific

Māori businesses are likely to be more vulnerable to physical climate change risks. This is because of the following drivers:

- Māori businesses face challenges related to accessing financial capital (including accessing funding) (BDO, 2020).
- In most sectors, Māori businesses also appear to be operating with significantly lower margins than non-Māori businesses (TPK, Te Matapaeroa, 2019), which may also impact their ability to prepare, transition and adapt to physical climate change risks.
- Both small and medium enterprises and larger commercial entities are clearly guided by specific principles and focused on people and te taiao over profit but acknowledge the importance of profit in achieving these purposes (Interviewee(s), 2021). These principles fuel their characteristics of employing significantly more Māori within their businesses than their non-Māori owned industry businesses (TPK, 2019 and Interviewee(s), 2021). These unique 'business as usual' approaches influences their decision making and with smaller margins often comes greater vulnerability and fewer options to adapt.
- Resourcing gaps: finding appropriate staff to fill resource gaps is another challenge for Māori businesses (BDO, 2020 and Interviewee(s), 2021).
- Governance remains critical for Māori businesses at all levels and is highlighted as one of the major factors of influence for vulnerability and either increasing or decreasing consequences (MfE, 2019).

These challenges may equate to an increase in vulnerability, impacting upon the adaptive capacity of Māori businesses and their ability to access the resources necessary to achieve their aspirations in all areas, including reducing exposure to climate change risks.

3.2.1 Assessment of risks for Māori Businesses against Te Ora ō Tāmaki Makaurau Wellbeing Framework

The Te Ora ō Tāmaki Makaurau Wellbeing Framework (Framework) was used as a tool to understand whether physical climate change risks may impact Māori Businesses differently from other businesses. This framework was developed in response to Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan (Auckland Council, 2020). It is therefore regionally specific and was developed with the Mana Whenua Kaitiaki forum, providing insights from mana whenua in the region.

The values and principles that underpin Te Ora ō Tāmaki Makaurau Wellbeing Framework when applied in practice are also categorised as 'Ngā Mahi a te Ora' (Wellbeing Activities) in the context of the framework. Considering how the identified physical climate change risks impact on these well-being activities (and particularly on Māori businesses and their owners' ability to put these principles into practice) is an appropriate way of contextualising and considering the physical climate change risks and their impact for Māori businesses in this context. In most cases the values and principles increase the consequences these risks have on Māori businesses.

The analysis found that each of the identified physical climate change risks clearly impacts on all elements of Ngā Mahi a te Ora (Wellbeing Activities) for Māori business, therefore each risk is not considered in isolation against these principles. A broader assessment using this framework indicates that all risks identified within the ECCRA may in fact impact Māori businesses in additional ways. In most cases this increases the consequences the identified risks have on Māori businesses because these are additional considerations for Māori businesses.

Table 5 below summarises how this Framework has been used to further identify physical climate change risks across the sectors.¹⁵ The following table discusses the ECCRA in *terms of how they relate to the Te Ora ō Tāmaki Makaurau Wellbeing Framework*.

Table 5 Summary of analysis using Te Ora ō Tāmaki Makaurau Wellbeing Framework Principles for Māori Business across the sectors.

Te Ora ō Tāmaki Makaurau Wellbeing Framework Principle	Analysis against ECCRA physical climate change risks
Manaakitanga	The risks may impact on the ability for mana whenua operated businesses to fulfil their responsibilities to care for visitors and the population of Tāmaki Makaurau. This principle also drives mataawaka businesses in the region and will have similar impacts across these sectors. Ensuring manaaki of their staff, clients and consumers will impact all sectors equally, but those who provide services to external customers will be more deeply impacted, such as Māori businesses in the visitor economy and food and beverage sectors. Generally, damaged road networks and contaminated water supplies will impact upon accessing, caring for, hosting and keeping people safe. The principle of manaakitanga means Māori are innately driven to care for those in their rohe. This culture of looking after each other will mean Māori face increased consequences if they are unable to fulfil these obligations. This culture of manaakitanga has been seen during the recent COVID-19 lockdown and associated impact period. For example, Ngāti Whātua have been distributing food parcels to their constituency.
Kaitiakitanga / tiakitanga	The risks may impact on the ability for mana whenua operated Māori businesses as well as mataawaka to fulfil their responsibilities to care for their natural environment. The consequences of larger scale physical climate change risks include infrastructure and assets being destroyed. Being able to prioritise kaitiakitanga and the environment over people, and

¹⁵ This table is informed by a combination of te Ao Māori perspectives and based on the research reviewed and undertaken as detailed within the body of this report.

Te Ora ō Tāmaki Makaurau Wellbeing Framework Principle	Analysis against ECCRA physical climate change risks
	repairing damages such as those to physical built assets will be a challenge. Additionally, the whakapapa connection between Māori and their whenua may result in additional emotional and spiritual impact as Māori experience these physical impacts on their whenua. There may also be conflict between Māori and tau iwi approaches: such as wanting areas protected against coastal inundation and allowing natural reclamation by the sea. This issue is particularly relevant to mana whenua.
Whanaungatanga	Impacts on connectivity will impact the physical outworking of whanaungatanga in some cases and the ability for Māori businesses to rely on their existing networks. For example, disruption of ICT systems and road networks will impact physical and digital kanohi-ki-te-kanohi interactions that Māori businesses rely upon. The ability to hold and attend tangi will also be impacted, and in turn this will have a significant negative impact for Māori. This was a challenge that was experienced during the recent COVID-19 lockdowns.
Rangatiratanga	All physical climate change risks identified may impede the ability for Māori businesses to assert their rangatiratanga: to be leaders in their industry and participate in their business communities. With the consequences of larger scale physical climate change risks such as infrastructure and assets being destroyed, and potential emergencies resulting, exercising rangatiratanga will need to be intentional and provide an opportunity for Māori businesses to lead across their sector.
Mātauranga	Expressing, educating, and enabling the use of mātauranga in relation to stories, whenua and taonga will be compromised within industries such as visitor economy and food and beverage, where these physical climate change risks typically occur. Damaged road networks will impact upon accessing and engaging with clients and sharing mātauranga, knowledge systems and practices which form part of the experiences Māori businesses offer.
Ōritetanga and Tōnuitanga	Social equity will be further compromised within Māori businesses. While some businesses have both support networks and access to capital, others do not. This inequity will be further entrenched through the identified differences in operational practices and environment of Māori businesses. This will compromise the ability of Māori businesses to enhance the wellbeing of whanau that they both support and serve.

3.3 Physical Climate Change Risks – Sector specific

Table 6 below summarises the sector-specific risks for each priority sector.

Table 6: Summarising the risk considerations for Māori Businesses within the ECCRA Sectors.

Sector	Summarising the risk considerations for Māori Businesses within the Sectors
Food and Beverage	<ul style="list-style-type: none"> The presence of fisheries and aquaculture as a subsector within the food and beverage sector lifts the relevance of risks to maritime infrastructure and maritime transport assets being damaged or destroyed, due to significant Māori ownership of assets within this subsector (KPMG, 2020). This is a significant risk for fisheries assets, ports and vessels and may impact directly on supply chain, catch, business continuity and profit. Large scale ecosystem change increases the risk for Māori with commercially valuable Quota Management System (QMA) species migrating south, out of northern QMAs. This may have a significant impact on Māori fisheries businesses and shareholdings (KPMG, 2020). This is reduced by the fact that 20% of the new species quota will be transferred to Māori, but with close to 50% ownership in current species, this loss has the potential to significantly impact Māori (Te Ohu Kaimoana, 2017).
Construction	<ul style="list-style-type: none"> On the basis of the more limited diversification of business interests within Māori entities in the Tāmaki Makaurau region (MBIE, 2015, TPK, Te Matapaeroa, 2019) and the resulting consequences of these risks all being highly relevant, the risk for Māori may be increased. With both large numbers of Māori employees in the industry (MBIE, 2015) as well as Māori owned businesses, alongside the significant iwi/hapū asset base in the sector (Interviewees, 2021, Ngāti Whātua ō Ōrakei and Waikato-Tainui Annual Reports), the consequences for Māori business across all relevant physical climate change risks may be significant. Given the value of the industry to the Māori economy and the factors detailed above the Māori businesses in the sector may have increased vulnerability. However, the values baseline of operations for most Māori businesses (Interviewees, 2021), often with a key focus on environmental impacts, means that they may be acknowledging, prioritising and planning for the identified risks to the industry.
Screen	<ul style="list-style-type: none"> The non-sector specific barriers already identified above apply to the screen industry.
Visitor Economy	<ul style="list-style-type: none"> The tourism sector is heavily reliant on Māori taonga, sites of significance, culture and people in Tāmaki Makaurau and the ability for Māori businesses to be front and centre in telling their own stories and histories. This reliance within the tourism sector may only increase over time. With technological advancements and increases in commercial asset bases, these business opportunities may increase thus increasing their exposure. The consequences for Māori further increase due to the emotional and cultural connection to these sites over and above the financial impacts of changes to business operations that they are dependent on. The importance of the industry to Māori business and culture within the region is noted, due to the number of Māori businesses and iwi and hapū commercial entities that exist within the sector and subsectors (TPK, Te Matapaeroa, 2019).

3.4 Physical Climate Change Opportunities – Sector specific

Māori businesses may also be more resilient to physical climate change risks and may in turn be positioned to benefit from opportunities arising from physical climate change risks. Data sourced through both desktop literature reviews and interviews has identified the following sectoral opportunities for Māori business from physical climate change risks (see **Table 7**). The opportunities identified within the ECCRA all apply (AECOM, 2021), and these opportunities may not be specifically unique to Māori business. The report considers the opportunities identified within the ECCRA alongside the unique contexts, operational nuances and areas where Māori businesses show resilience. In addition, the opportunities have been further highlighted either within the research or during interviews.

Table 7: Physical Climate Change Opportunities.

Sector	Physical Climate Change Opportunity
All	<ul style="list-style-type: none"> Opportunity for unique Māori provenance stories throughout export markets. Opportunity for remote Māori businesses to secure more efficient and reliable power supply through increased onsite electricity generation.
Food and Beverage	<ul style="list-style-type: none"> Creating plant-based alternatives to meat through driving greener production systems aligns well with obligations as kaitiaki.
Construction	<ul style="list-style-type: none"> Māori have an increased focus on protecting their people and using valuable sources of profit to achieve their aspirations for their people. They are likely to be involved in innovative construction technologies as Māori are keen early adopters of technological advancements. Opportunity for Māori businesses to work together in sustainable infrastructure ventures, such as green waste and recycling – also opportunities to partner/procure this work to others.
Visitor Economy	<ul style="list-style-type: none"> Increased opportunity for authentic cultural tourism owned and operated by Māori. Enhance connections between the Visitor Economy and Māori research institutions, for Māori businesses to benefit from the increased funding for mātauranga Māori or Māori perspectives in climate adaptation/mitigation-based research, as well as these new career pathways being developed. This evolving knowledge economy provides opportunity for enhancing and growing the visitor economy.
Screen	<ul style="list-style-type: none"> Increased opportunities for Māori artists and creatives both on and behind the screen. Increased opportunity for advancing the knowledge economy and mātauranga Māori within this, including owning these stories and their presence in the industry. To strengthen more digital or weightless exports and supporting development of these industries.

3.5 Transitional climate change risks and Opportunities

Although this review prioritised physical climate change risks, transitional climate change risks were also considered in a Māori context. For Māori, many of the consequences for transitional climate change risks identified were general rather than sector specific. Often these consequences were related to the vulnerability drivers identified above in terms of financial challenges. With Māori small and medium enterprises experiencing greater financial exclusion (TPK, Microfinance, 2019), their access to additional capital required to transition may be limited. Access to human capital may also be

difficult for Māori businesses, especially where knowledge gaps and resources are already stretched. This labour gap may be compounded where Māori have not been supported through the necessary educational pathways to meet the future needs of the market.

The opportunities arising from the transitional climate change risks identified in the ECCRA and from the realities of the changes that climate mitigation will bring are significant for Māori across all of the sectors reviewed.

3.6 Opportunities from these challenges

Facing these challenges provides an opportunity to enable and prioritise further work to resolve these issues in a consistent manner. This will assist future work programmes and kaupapa within Auckland Unlimited to be better aligned to meet the needs of Māori business. It will enable effective planning, policy and projects to specifically reach Māori business for positive impact.

Opportunities to work with Māori advisors already exist within Auckland Unlimited. Using these networks to co-design future projects may ensure clarity and consistency of approach for future work in these areas. Further, working to create specific connections with iwi and hapū in the region to gain insights into their business profiles, needs and aspirations, as well as the development of localised transition plans alongside mana whenua, may improve data availability in addition to increasing Māori businesses resilience. Undertaking the same approach for each industry sector and reaching and connecting with Māori businesses to gain thorough and specific insights into their needs and their contributions to the region, will improve relationships as well as improving current data availability.

A focus on seeking Māori specific data across all industries and clearly defining what a Māori business is to Auckland Unlimited should be prioritised. This definition should be developed collaboratively with internal and external insights. These are by no means new challenges or opportunities, but will when addressed, go a long way to better serving Māori businesses within Tāmaki Makaurau.

3.7 Limitations

In this section, we have outlined the challenges that have impacted the assessment of the report. It is important to understand these challenges, and the report to be reviewed with them in mind. These need noting to ensure this report is understood and considered in context.

There was no universal agreement from a range of sources as to what constitutes a Māori business. The differing ways that local and central government and their advisors, Māori organisations and Māori business owners qualify what constitutes a Māori business, differs considerably. We have therefore had to use multiple definitions of what constitutes a Māori business, depending on the source used. This issues has had a significant impact on the way in which this review could be undertaken and on its output. The inability to align these differences with the available data and how it was collected, as well as the lack of this data being regionally specific, compounded this challenge further.

There were also conflicting perspectives around what should constitute a Māori business within the context of this report, mana whenua or mataawaka, within the Auckland region and how these perspectives should be prioritised.

4.0 Physical climate change risks

This section outlines key physical climate change risks that have the potential to arise across the Auckland region over the coming century. These risks are likely to impact different sectors in slightly different ways. This section provides a broad overview of the risks while the consequences of these risks to each subsector are explored in further detail in Section 5.0.

4.1 Maritime infrastructure and maritime transport assets are damaged or destroyed

- Damage to port, ferry, marina and mooring infrastructure due to storm surges, waves and increased corrosion due to sea level rise.
- Disruption of sea-based activities due to storm events.

The Auckland region has benefited greatly from its extensive access to the coast; the Auckland Port is a hub of international and coastal maritime trade; ferry services have increased the mobility of residents within urban Auckland and between Auckland's islands; and marinas and docks support a vibrant pleasure-craft leisure sector.

Climate change is likely to impact port, ferry, marina and mooring infrastructure and the activities they support. Coastal transportation assets are, in general, more sensitive to extreme events, such as storm surges and waves, heavy rain and wind events and heatwaves, than to incremental changes in mean climatic factors. However, sea level rise, and increased destructiveness of storm surges and waves can damage coastal infrastructure as a result of inundation, or increasing corrosion in the inter-tidal splash zone, requiring additional maintenance funding and engineering upgrades (UNECE, 2013; UNECE, 2015).

4.2 Information and Communication Technology systems are disrupted

- Damage to towers, wires and fibre, exchanges, underground pits, data centres and cable landing stations due to high winds, flooding, and coastal inundation.

New Zealand's businesses rely on information and communications technology (ICT), such as the internet and telephone networks to connect to customers, communicate, manage operations, improve productivity, and develop new and exciting products. Businesses in New Zealand have relied on ICT services for some time. In 2008, 91 per cent of New Zealand's businesses had broadband access, 60 per cent had a web presence, 74 per cent used the internet to place orders, and 42 per cent used the internet to receive orders (Statistics New Zealand, 2009). The importance of ICT to businesses continues to grow. Since 2011, monthly data consumption, a proxy for the importance of ICT, has grown by 61 per cent per annum (MBIE, 2017). Now 98 per cent of 'economically significant firms' have websites, 44 per cent of these firms receive more than 10 per cent of sales via the internet. Having a reliable and stable internet connection Auckland-wide is of paramount importance now that working from home has become commonplace at many workplaces around the region.

Some telecommunications infrastructure - towers, wires and fibre, exchanges, underground pits, data centres and cable landing stations - are at risk from high winds, floods and coastal inundation (CSIRO, 2007) or loss of power. Increased extreme rainfall events and storm surges in the Auckland region have the potential to lead to the flooding of telecommunications exchange stations. Mobile telecommunications towers may be adversely affected by an increase in wind events. These hazards have the potential to cause damage and may lead to increases in the cost of telecommunications supply due to an intensified infrastructure maintenance regime. These impacts can flow through to business via increasing costs, lower performance, or disruption.

ICT infrastructure in New Zealand is well regulated through the Telecommunications Act 2001, and the Telecommunications (New Regulatory Framework) Amendment Bill 2017, increases the likelihood that risks to ICT infrastructures will be managed over the 21st century. More importantly, critical components of ICT systems are designed to 'fail over' to the remaining sites if one fails, and main exchanges and cell sites have back-up power systems (New Zealand Lifelines Council, 2017). Accordingly, the climate related disruptions are likely to be infrequent and short-lived even by the end of the century.

4.3 Electricity supplies are disrupted

- Damage to transmission lines, structures, and substations due to storm events, wildfires, flooding and coastal inundation.

A survey of 77 SME's in Auckland found that 96 per cent of businesses are unable to operate without electricity (Shaikh, 2018). Power outages, even those of a relatively short induration can be disruptive and costly for businesses. In 2018 the North Island of New Zealand experienced 66 power outages which had an average duration of 4.5 hours. These outages each affected on average 6,026 people (EATON, 2019).

Climate change may increase the risk of electricity supply due to more intense storm events, wildfires, flooding and coastal inundation. These hazards can damage above ground transmission lines, reduce the stability of structures, or inundate substations and other infrastructure (CSIRO, 2007). Weather and tree-related incidents, which in 2018 accounted for one third of disruptions, could drive additional disruptions throughout the century (EATON, 2019). As the majority of Auckland's power is hydroelectric, water shortages across New Zealand may also impact hydro-based power production (The Pacific Institute, 2009). In addition to disruption, these hazards may also increase the costs of electricity.

There is a high degree of adaptive capacity within the electricity network, and resilience is influenced by strong regulation. In general, investment in transmission and distribution services is governed by the Commerce Commission and other parts of the supply chain are governed by the Electricity Authority, and both regulators have statutory objectives to promote reliability.

4.4 Road networks are damaged or destroyed

- Damage to roads due to flooding and coastal inundation.

Auckland's population relies upon more than 7,000 kms of road to move people and goods more than 8.3 billion kilometres each year (Auckland Transport, 2018). The road network allows 74 per cent of people to commute to work in private vehicles (Richard Paling Consulting, n.d.), and for a large proportion of economic activity to take place. Climate change related hazards, particularly sea level rise and flood events may cause temporary or permanent damage to the road network.

A small proportion of Auckland's total road network is exposed to sea level rise, as shown in Table 8. Over the 21st century, inundation of roads is likely to occur more frequently, to more of the road network. In 2011 a storm coincided with a high tide which caused submerged lanes on Auckland's northern motorway (Chappell, 2013). Given there is only one main highway in Auckland, events such as these do have the potential to substantially impact the road network.

Table 8: Exposure of roads in Auckland to sea level rise (Paulik et al., 2020)

Sea level rise	Exposure of roads (km)
0 m	48
0.1 m	55
0.2 m	62
0.3 m	71
0.4m	80
0.5 m	90
0.6 m	100
0.7 m	112
0.8 m	124
0.9 m	137
1.0 m	149

Sea level rise	Exposure of roads (km)
1.1 m	163
1.2 m	176

Flooding can also damage road networks, or interrupt travel. Paulik et al. (2019) found in 2019 that 1,259 km of Auckland's roads lie within area prone to flooding. Both Paulik et al. (2019) and Auckland Transport, (2018) have noted that the risk of flooding is increasing due to urbanisation, which adds pressure to drainage systems, as well as climate change.

Auckland Transport has started assessing the vulnerability of roading infrastructure to climate change and sea level rise (Auckland Transport, 2018). However, the length of road per person in New Zealand is one of the highest in the world (Learnz, nd)¹⁶, which could pose a constraint to the funding of adaptation (MfE, in press).¹⁷

It was suggested by stakeholders during workshops that rail also be included within this risk. However, analysis of literature available has indicated that there is only a minimal risk to Auckland's rail network from extreme heat, flooding and coastal inundation. Only 2.1% of all land in Auckland is rail network, and none of it is affected by sea level rise at any level of sea-level rise projection (Golubieswki et al, 2019). In terms of inland flooding, a 2009 report on climate change impacts identified that between 2004-2008 there was only one major flood event that affected Auckland's rail. (Gardiner et al, 2009).

4.5 Flights to and from Auckland International Airport are disrupted

- Damage to Airport runways, and electrical infrastructure due to flooding and coastal inundation.
- Disruption of flights due to high-wind events.

Auckland Airport is the busiest airport in New Zealand, with almost 21 million passengers in the year ended January 2020 (Auckland Airport, 2020). It is one of New Zealand's most important infrastructure assets directly providing thousands of jobs for the region, as well as supporting New Zealand's tourism sector, international education and business events. The airport is also crucial for freight movement. In 2013 it accounted for \$13 billion in annual freight movements (Insight Economics, 2014).¹⁸

Auckland Airport however, is both exposed and sensitive to a range of climatic hazards. These include flooding and sea level rise, which can cause temporary or permanent inundation of runways and taxiways, loss of ground transport access, and inundation of electrical infrastructure. Higher temperatures can cause heat damage to infrastructure and increase cooling requirements. While changes in wind direction which may increase crosswinds and cause implications for capacity, and change noise distribution (AECOM, 2019; Williams, 2016; International Civil Aviation Organization, 2016). These hazards have the potential to cause disruptions to airport services or increase costs of air travel due to intensified maintenance requirements, or high capital expenditure retrofits. These impacts can flow through to business via increasing costs for importing and exporting, additional costs for prospective customers, or costs associated with increased disruption.

¹⁶ Learnz. (nd). New Zealand Roads. <http://www.learnz.org.nz/memorialpark134/bg-standard-f/new-zealand-roads>.

¹⁷ NCCRA Learnz. (nd). New Zealand Roads. <http://www.learnz.org.nz/memorialpark134/bg-standard-f/new-zealand-roads>
Auckland Airport. (2020). January 2020 (Updated) Monthly traffic update
Insight Economics. (2014). Estimating the Regional Economic Importance of Auckland Airport. Prepared for Auckland International Airport Limited

¹⁸ <file:///C:/Users/james.odonnell/Downloads/EconomicImportanceofAucklandAirport.pdf> Estimating the Regional Economic Importance of Auckland Airport

Auckland Airport has a high capacity to manage the risks posed by climate change, as the benefits of adaptation are likely to be internalised, and the costs of adaptation are likely to be minor relative to the value of the airport. Without adaptation, sea level rise may lead to major impairments to airport functionality by 2110.

4.6 Water supplies are reduced, disrupted or contaminated

- Reduction and contamination of urban and rural water supplies due to drought, flooding, and changes to evapotranspiration.

Water is a key input to many sectors of Auckland's economy. Climate change related hazards, such as drought, changes to humidity and evaporation, and changes to rainfall regimes have the potential to reduce supplies of water and lead to contamination of freshwater resources.

Due to increased humidity, an increase in the number of annual dry days, increased rainfall variability and increased PED, Auckland is expected to become more drought-prone in the future (refer Section 2.2) (Pearce et al, 2018). An increasing incidence of drought will reduce the availability of water for both residential and commercial purposes (Ministry for the Environment, 2004). Businesses are more likely to face increased costs resulting from the increasing variability in water availability. The 2020 drought in Auckland highlighted just how vulnerable Auckland's water supplies are, as Auckland experienced the worst drought in 25 years and faced city-wide water restrictions.

The risk of water contamination is likely to increase under current climate projections. Heavy rainfall events can cause pollution and fertiliser to runoff into rivers and streams, resulting in contamination via pathogens such as giardia, cryptosporidium and campylobacter (Royal Society, 2017; Eyles et al, 2003) and eutrophication.

Despite these changes, Auckland's proximity to the Waikato River, a reliable and significant water source means it would be unlikely Auckland businesses will face severe water constraints in the long-term. However, they will likely face increased costs and may be affected by short-term water restrictions.

The majority of primary production systems are outside of the rural urban boundary and therefore rely on either local or on-farm water catchment systems, which may include consented takes from bores and streams. These systems are not affected by regional water restrictions but will be affected by reductions in rainfall variability as this could reduce localised supply.

4.7 Built assets that are necessary for service provision are damaged or destroyed

- Damage to built assets due to flooding, coastal inundation, wildfire, storms, erosion and drought.

All sectors of Auckland's economy rely upon built assets¹⁹, whether they are offices, factories, warehouses, university campuses, barns, commercial buildings, or huts along a walking trail. Coastal inundation and flooding have the potential to cause significant impacts to Auckland's built assets. Other hazards such as wildfire, storms, erosion and drought may also damage built assets.

An analysis by Paulik et al. (2020) revealed that 1,790 buildings in Auckland are, at 2020, exposed to a 100-year extreme sea-level flood event. By 2110, with 1.2 m of sea level rise, the number of buildings exposed is projected to quadruple to 7,296. The replacement values of these assets increases in parallel to exceed \$5 billion, as shown in

¹⁹ For the purpose of this risk assessment, the built environment has been disaggregated to allow for a more nuanced understanding of risk across the economy. 'Built physical assets' is taken to mean all assets across the Auckland region that are not related to transport (e.g. roads, rail, ports, airports), or lifeline infrastructure (e.g. electricity, water, ICT).

Table 9: Exposure of buildings in Auckland to sea level rise (Paulik et al., 2020)

Sea level rise	Number of exposed buildings	Replacement value of exposed buildings (NZ\$ million)
0 m	1,790	607
0.1 m	2,047	726
0.2 m	2,360	900
0.3 m	2,719	1,212
0.4 m	3,061	1,377
0.5 m	3,420	1,646
0.6 m	3,831	1,851
0.7 m	4,316	2,173
0.8 m	4,820	2,622
0.9 m	5,371	3,225
1.0 m	5,921	3,828
1.1 m	6,559	4,801
1.2 m	7,296	5,323

Low-lying coastal areas, including parts of the Central Business District, eastern bays (e.g. Mission Bay), Onehunga, Mangere Bridge, Devonport, and Helensville are the most vulnerable to coastal inundation (Pearce et al., 2018). Across Auckland, sea level rise will increase the nuisance caused by smaller and more frequent flooding events, and cause higher magnitude impacts from larger low frequency events.

Built assets are also at risk from flooding caused by extreme rainfall events. Paulik (2019) found that 48,167 buildings, with a replacement value of \$27.6 billion are located within a flood hazard area. Climate change may increase flooding risk, as rainfall events become more intense, however there is considerable uncertainty about projections for future flood risk.

4.8 Assets such as construction sites, crops and livestock, are damaged or destroyed

- Damage to construction sites, crops and livestock due to floods, storms and wildfire.

Some sectors of Auckland's economy depend upon assets that are seasonal, such as certain crops, or produce assets that are highly exposed to climatic elements during their production, such as buildings and infrastructure under construction or repair. The temporary and unfinished nature of these assets may increase their vulnerability to wildfire, floods, and storms. Businesses that use or produce these assets already plan for many of these risks. For example, the construction sector is accustomed to working in inclement weather, and many businesses across the construction and food and beverage sector insure construction sites and crops and livestock respectively. The increasing frequency and intensity of climate change hazards may increase costs of insurance, or increase risks to personnel, and render current actions to reduce exposure and sensitivity insufficient.

4.9 Disruptions to systems that are sensitive to seasonality and changes in climatic parameters

- Changes to the timing and characteristics of Auckland's seasons, due to changes in climatic means.

The seasons exert a strong influence on a number of sectors of Auckland's economy. For example, they influence heating and cooling requirements, determine when it is best to plant and harvest crops, and influence tourist behaviour. As Auckland's climate continues to change, it is projected that spring will arrive earlier, winters will be shorter, and summers longer. Changes in seasonality are driven by multiple climate variables (Pearce et al, 2018). The Auckland region faces risks to sector productivity and output due to gradual loss of production from increased rainfall variability, warming temperatures, increased PED and increased humidity (Pearce et al, 2018). Both the primary production and tourism sectors are particularly vulnerable to changes to seasonality and average climatic parameters.

4.10 Large scale ecosystem change

- Changes to, or degradation of New Zealand's ecosystems due to pests and diseases, coastal inundation, and changes in climatic means.

Healthy ecosystems and rich biodiversity are fundamental to life on our planet, and directly support several sectors of Auckland's economy. Much of New Zealand's biodiversity and ecosystems face stresses from population pressures, land-use change and fragmentation, and pests and diseases. Climate change is projected to add to the stresses these ecosystems face. For example, sea level rise will inundate many of Auckland's coastal ecosystems, and erode beaches and cliffs (Fernandez & Golubiewski, 2019); warmer temperatures are likely to increase the incidence of pests and diseases, placing additional pressure on ecosystems (McGlone and Walker, 2011), and a changing climate may also impact upon species distribution although evidence that explores the implications of climate change on Auckland's ecosystems is limited.

4.11 People are exposed to environmental hazards

- Risks to the health and safety of workers and customers due to wildfire, floods, heatwaves, droughts and storms.

All sectors of Auckland's economy rely upon healthy, safe and productive workers, and businesses must be able to assure the safety of customers. There are many climate change related hazards that already pose risks to the welfare of employees and customers across Auckland, including wildfire, floods, heatwaves, droughts and storms (Jones et al., 2014). These events do not generally lead to many deaths, and there is limited evidence to suggest that deaths or injury will substantially increase over the 21st century (MfE, 2020).

Some climate change related hazards have the potential to cause illness or reduce welfare and productivity. For example, an increase in average temperatures will extend the suitability of climate for exotic vectors, encouraging their migration and subsequent transmission of disease (Derraik and Slaney, 2007). Higher temperatures also have the potential to reduce labour productivity, however in the near-term it is unlikely that New Zealand will lose working hours to heat stress (International Labour Organization, 2019).

5.0 Sector consequences

5.1 Overview of sector consequences

This section describes the consequences of the physical climate change risks identified in Section 3.0 for each priority sector. Each priority sector is addressed separately beginning with an overview of the sector, description of sector characteristics followed by a summary of the key physical climate change risks to the sector. Each expression of consequence includes:

- A description of how the risk relates to the sector.
- A description of the consequences of that risk on the sector
- A risk rating table and confidence rating.

Risks were rated in accordance with the risk framework presented in **Appendix A**. The framework accounts for both the likelihood of the occurrence of a hazard, or series of hazards that give rise to the risk, and the scale and intensity of the impact of the risk. Risks are a function of the number of businesses exposed within a subsector, or the percentage of economic activity exposed within the subsector, and the severity of the consequences that stem from the exposure. A level of confidence in the risk ratings based on the literature reviewed is also provided for each risk rating. See **Appendix A** for further detail.

Table 10: The applicability of risks to the four sectors of Auckland's economy assessed

Risk	Food and Beverage	Construction	Screen	Visitor Economy
Maritime infrastructure and maritime transport assets are damaged or destroyed	X	X		X
Information and Communication Technology systems are disrupted	X	X	X	X
Electricity supplies are disrupted	X		X	X
Road networks are damaged or destroyed	X	X	X	X
Flights to and from Auckland International Airport are disrupted	X		X	X
Water supplies are reduced, disrupted or contaminated	X	X	X	X
Built assets that are necessary for service provision are damaged or destroyed	X	X	X	X
Assets, such as construction sites, crops and livestock, are damaged or destroyed	X	X		
Disruptions to systems that are sensitive to seasonality and changes in climatic parameters	X	X	X	X
Large scale ecosystem change	X		X	X
People are exposed to environmental hazards	X	X	X	X

5.2 Food and Beverage

5.2.1 Sector overview

The Food and Beverage Sector in this report is comprised of the following subsectors: manufacturing, wholesale, food technology, supply chain, horticulture, viticulture and agriculture and aquaculture and fisheries. Table 11 below outlines the definition and geographical spread of each of the eight subsectors.

Table 11: Food and beverage subsectors

	Definition	Geographic locations
Manufacturing	This sub-sector includes the five subcategories (M.E Consulting, 2019): Meat and meat product manufacturing; Seafood processing; Dairy product manufacturing; Fruit, oil, cereal, bakery and other food product manufacturing (called other food product manufacturing); and Beverage manufacturing.	Auckland is home to 23 per cent of national food and beverage manufacturing employees and 30 per cent of national F&B manufacturing businesses (M.E Consulting, 2019). Most manufacturing occurs in South Auckland (M.E Consulting, 2019).
Wholesale	Wholesalers includes both large and small distributors who sell products to retailers. We have included farmers markets within this definition.	There are four main wholesalers in Auckland who dominate the Northern region produce trade; T&G Global, Fresh Direct, Market Gardeners and Freshmax. All are based in Mt Wellington. ²⁰ Farmers' markets are widespread across the region.
Food technology	Food Bowl is an open access facility available to support food and beverage companies in Auckland. This facility allows companies to undertake research and design, pilot processes and commercial runs of food and beverage products. (New Zealand Food Innovation Network, 2020).	FoodBowl is based in Mangere (New Zealand Food Innovation Network, 2020). FoodBowl has been the only physical asset assessed for the food technology sector. Larger companies may have their own in-house facilities.
Supply chain	Includes both linear domestic infrastructure (roads) and infrastructure used for supply of imports/exports (sea and air). For the purposes of this subsector the focus here is on distribution. Other activities in the supply chain are covered under primary production, manufacturing and wholesale subsectors.	Auckland Airport is located in Mangere, South Auckland. Auckland's main commercial port is located in Auckland CBD.
Agriculture	This sector includes dairy and beef and sheep livestock industries.	Spread throughout peri-urban and rural areas of Auckland
Horticulture	Auckland's main horticultural produce includes onions, potatoes, kiwifruit, lettuce, broccoli, wine grapes, cabbage, olives, cauliflower, pumpkin, carrots, avocados and strawberries (Auckland Plan, 2019).	Franklin in the south has the majority of Auckland's quality soils and a significant proportion of Auckland's horticultural produce is grown here (Deloitte, 2018). Kumeū is the second market gardening hub in Auckland.
Viticulture	Wine both grown and processed in Auckland.	There are over 100 vineyards in Auckland. The main wine-growing

²⁰ Based on personal communications with industry professionals.

	Definition	Geographic locations
		regions are in Matakana, Kumeū, Clevedon and Waiheke Island (Auckland Plan, 2020). Although 20 per cent of New Zealand wineries are in Auckland, only 1 per cent of hectares of grapes are grown in Auckland (Coriolis, 2017).
Aquaculture & Fisheries	<p>Aquaculture is more specifically defined as the farming of both aquatic plants and animals; farming can either be marine or land-based (MPI,2020).</p> <p>Fisheries are defined as the management of fisheries resources, fishing and fish farming (Fisheries Act 2006, s 2).</p>	<p>Aquaculture farms around Auckland Certain locations include:</p> <ul style="list-style-type: none"> • Waiheke Island (aquaculture) • Maraetai (aquaculture) <p>We have considered aquaculture and commercial fishing that is occurring within the geographical location of the Auckland Region (12 nautical miles from land, which is the territorial sea boundary).</p>

5.2.2 Characteristics of the Auckland's food and beverage sector

In 2015 the food and beverage sector generated \$3,245 million for the Auckland economy, which is 4 per cent of Auckland's total gross domestic production (Infometrics, 2015a). The Auckland region accounts for the largest number of food and beverage businesses compared to all other regions in New Zealand (Infometrics, 2015a). The number of businesses in the sector is an indicator of economic health, and the number of business units in the food and beverage sector is growing faster than the rate of growth of other business units across the entire Auckland economy (Infometrics, 2015a).

Businesses within the food and beverage sector are larger than the average business size within Auckland (Infometrics, 2015a).²¹ However, based on data between 2010-2015, business size within this sector is decreasing. The average number of employees in each food and beverage business decreased from 11.6 employees in 2010 to 10.7 in 2015. Smaller businesses are less resilient to economic shocks and decreasing business size within the sector may decrease sector resilience.

Despite the large number of businesses, the sector only employs a small proportion of the total workforce in Auckland. In 2015 the sector employed just 3.6 per cent of the total Auckland workforce (Infometrics, 2015a). The sector experiences lower productivity than Auckland's economy as a whole (using Gross Domestic Product (GDP) per full-time equivalent (FTE) as an indicator of labour productivity). GDP per FTE decreased by 0.2 per cent per annum between 2010-2015 in the food and beverage sector compared to growth of 0.6 per cent GDP per FTE per annum across the total economy (Infometrics, 2015a).

In terms of demographics, employees in this sector are most likely to be male, older, without higher qualifications and non-Māori or Pasifika²² (Infometrics, 2015a). Employees working in this sector in Auckland are predominantly born in New Zealand (56.7 per cent of the total workforce), with the second highest category of employees coming from Asia (16.2 per cent) (Infometrics, 2015a). However, within the primary sector, there is an increasing proportion of migrant workers especially within the horticulture and viticulture sectors (Sriramaratnam, 2008).

²¹ Based on the number of employees.

²² The source report doesn't specify ethnicity of workers but rather excludes these two ethnic groups (Māori and Pasifika).

5.2.3 Overview of most significant risks and consequences for the food and beverage sector

Auckland's Food and Beverage sector faces risks to built assets (such as factories and warehouses) and key infrastructure assets (such as roading and ICT infrastructure). These assets are necessary for primary production, manufacturing, food technology, wholesale and supply chains. Risks to these assets may affect primary production in addition to movement of goods (and to a lesser extent, labour). The horticulture, agriculture and viticulture subsectors (primary sectors²³) may predominantly be affected through changes to environmental conditions, extreme weather events and sea level rise which may reduce primary production outputs. An increasing incidence of the invasion of pests, diseases and weed species may increase input costs for primary producers, and contamination and/or disruption of water supplies may pose additional hazards to both the primary production and manufacturing subsectors. Changes to environmental conditions also pose hazards to workers, particularly those working in outdoors in the primary sectors.

The three most significant physical climate change risks to the food and beverage sector have been identified as:

- Water supplies are reduced disrupted or contaminated – this risk was rated moderate for the primary sectors in 2040 and major for horticulture and viticulture in the primary sectors in 2110.
- Reduction in outputs from livestock and crop production due to changing seasonality – this risk was rated minor for the primary sectors in 2040 and major for horticulture and viticulture in 2110.
- Assets such as crops and livestock, are damaged or destroyed – this risk was rated minor for the primary sectors in 2040 and major for horticulture in 2110.

Projections indicate there are future growth opportunities for New Zealand's food and beverage sector. Asia is the largest destination region for food and beverage exports, and growth in these markets is projected to increase (Coriolis, 2019). New Zealand is facing increasing demand for food products due to its high-quality brand. This is due to New Zealand's clean and green image, which is supported by a primary sector which is relatively free of pests and diseases that are seen in other countries (Coriolis, 2019). The swift elimination of COVID-19 in New Zealand compared to the global impacts is only likely to enhance this image. Market shifts by 2050 project that the majority of exports will be consumer-ready processed food and beverage products (Coriolis, 2019). To take advantage of this economic opportunity, the sector will need to ensure it is resilient to the impacts of climate change.

5.2.4 Maritime infrastructure and maritime transport assets are damaged or destroyed

Maritime infrastructure and maritime transport assets for this sector include ports and port assets associated with sea freighting food and beverage products. These assets may face damage from extreme weather events such as storms. More permanent damage may be caused by sea level rise. Damage to coastal assets used to export food and beverage products may, depending on the severity of the damage, limit or disrupt Auckland's ability to export produce.

Sea freight is the most common type of export transport used to import and export goods (Statistics New Zealand, 2016).²⁴ Nationally, approximately 98 per cent of dairy, 95 per cent of meat, 90 per cent of fruit and nuts, 100 per cent of beverages, 63 per cent of fish and 80 per cent of miscellaneous edible preparations²⁵ are sent by sea freight; the remaining percentages for all these subcategories are sent by air (Statistics New Zealand, 2018).

In addition to exporters, manufacturers that rely on imported goods as manufacturing inputs may also be constrained in their ability to supply outputs, unless they are able to find a comparable local substitute in both price and quality. The sector self-reported that if marine infrastructure was damaged, the supply of key inputs such as seeds, machinery, chemicals and packaging would be disrupted, which would either impact or halt production depending on the importance of the input.²⁶

²³ Excludes forestry.

²⁴ Based on data between 2005-2015.

²⁵ Tea/coffee.

²⁶ Self-reported from Food and Beverage sector workshop attendees.

The food and beverage sector generates significant revenue from exporting primary and manufactured products. Damage to coastal assets that are crucial for export processes may either reduce or eliminate the revenue streams of exporters, which may have flow-on impacts for producers, manufacturers and wholesalers who sell directly to exporters. New Zealand has a strong reputation internationally for high quality food and beverage exports and future economic projections indicate that income from food and beverage export earnings is likely to continue to increase (Corilois, 2019). To take advantage of this projected growth it is important that export infrastructure is resilient to climate change.

Infrastructure such as ports and jetties are integral assets used in seafood production and the aquaculture process, as they are used for transferring catch to processing facilities and cool stores for distribution. Due to the high level of perishability of this stock, damage to maritime infrastructure will delay the transfer of products to these end locations which may, in extreme circumstances, spoil an entire catch. From an exporting perspective, the majority of seafood (63%) is sent via sea freight (Statistics New Zealand, 2018). Damage to key port infrastructure will delay the export of produce; there is a risk that optimal storage conditions are not met and the product may be rejected at borders.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Maritime infrastructure and maritime transport assets are damaged or destroyed				
Manufacturing	Insignificant	Minor	Minor	Limited agreement, limited evidence
Supply Chain	Minor	Minor	Minor	
Food Tech	Insignificant	Insignificant	Minor	
Wholesale	Insignificant	Insignificant	Insignificant	
Agriculture	Insignificant	Insignificant	Insignificant	
Horticulture	Insignificant	Insignificant	Insignificant	
Viticulture	Insignificant	Insignificant	Insignificant	
Aquaculture & Fisheries	Insignificant	Minor	Moderate	

5.2.5 Information and Communication Technology systems are disrupted

ICT systems are crucial inputs to modern businesses, both within the primary sector and across the manufacturing, supply chain, food technology and wholesale sub-sectors. These systems allow data to be stored and recorded and communications to be sent between various stakeholders across the sector. The ICT sector may face disruption from increased rainfall and extreme weather events. Disruption to ICT systems may reduce overall efficiency of the sector.

As modern manufacturing processes become increasingly automated, this increases the sector's reliance on ICT systems (Ministry of Business, Innovation and Employment, 2018). The manufacturing subsector may face disruptions to manufacturing processes that rely on ICT systems, which may reduce manufactured outputs.

If ICT systems are disrupted, the supply chain subsector may face delays to the processing of orders and routine commerce activities, which may in turn affect export efficiency and subsequent returns.

The food technology subsector may face infrequent disruptions to operations, and storage and communication of data, which, depending on the severity of the disruption, may hinder sector innovation.

The wholesale subsector may also face infrequent disruptions to the processing of orders and routine commerce activities, which may affect sector revenue.

In the primary sectors, farm automation is increasing the output of agriculture, horticulture and viticulture systems (MBIE, 2019). ICT disruptions may provide constraints on the ability to monitor field conditions and collect and track production output data, which reduces production system

efficiency. Primary sectors also rely on technology that uses ICT systems, for example in-ground meters that measure the soil moisture content and satellite imagery used in monitoring land.²⁷ ICT disruption, whether due to electricity outages or other impacts (including storm damage) will render such technology and accompanying results ineffective and inaccurate. Commercial fisheries rely on ICT for communication, location services and to discharge their obligations under the Fisheries Act 1996 (which includes recording and reporting their monthly harvest returns).

Subsector	Risk rating			Confidence
	Present	2040	2110	
Information and Communication Technology systems are disrupted				
Manufacturing	Insignificant	Insignificant	Minor	Limited agreement, limited evidence
Supply Chain	Insignificant	Insignificant	Minor	
Food Tech	Insignificant	Insignificant	Minor	
Wholesale	Insignificant	Insignificant	Minor	
Agriculture	Insignificant	Insignificant	Insignificant	
Horticulture	Insignificant	Insignificant	Insignificant	
Viticulture	Insignificant	Insignificant	Insignificant	
Aquaculture & Fisheries	Insignificant	Insignificant	Minor	

5.2.6 Electricity supplies are disrupted

Although electricity is an important input into this sector, it is not the main energy source across either the manufacturing or the primary sectors. The main energy source for manufacturing is process heat and the main energy source for farming systems is diesel (Fitzgerald, n.d). Nevertheless, all subsector activities within this sector rely upon a stable electricity supply. Supply may be disrupted by extreme weather events. Disruptions to electricity supplies across the manufacturing, food technology, wholesale and primary sectors may impact key processes associated with processing, innovating and growing. This may in turn cause decreases in subsector efficiency and decreases in resultant outputs.

Food and beverage production is an energy-intensive sector. Approximately 30 per cent of New Zealand's primary energy use is associated with food production processes (Fitzgerald et al, n.d). This 30 per cent is relatively equally proportioned between growing, processing and distributing food to consumers (Fitzgerald et al, n.d). Productivity is increasing across the sector, which increases the sector's energy requirements (Fitzgerald et al, n.d).

Food and beverage manufacturing is also energy-intensive. The food and beverage manufacturing industries consume 10 per cent of New Zealand's primary energy, and dairy and meat processing sectors consume 70 per cent of this 10 per cent. The majority of energy in food and beverage manufacturing is used for process heat which is largely supplied by fossil fuels such as reticulated gas (Fitzgerald et al, n.d). However, there are likely to be key manufacturing processes that rely on electricity – without electricity as an input such processes may fail, resulting in overall processing/manufacturing delays. The manufacturing process is essentially a system of various subcomponents, and electric outages/disruptions have the potential to halt all manufacturing processes until repaired.

Disruptions to electricity supplies may interfere with the ability of the food technology sector to engage in routine activities, such as recording data on computer systems and using lighting to undertake

²⁷ Self-reported from Food and Beverage sector workshop attendees.

testing and trials in laboratories. Frequent or prolonged disruptions may impede innovation. For the wholesale sector, goods requiring refrigeration may perish in the absence of generators or backup power.

Electricity is the second most consumed energy source on farming systems, with diesel having the highest level of on-farm consumption (Fitzgerald et al, n.d).²⁸ Diesel is typically stored on site, either above or below ground. Consumption of electricity and diesel in primary production systems is increasing while consumption of petrol and natural gas remains relatively stable (Fitzgerald et al, n.d). As with manufacturing, the vulnerability of the primary production subsectors depends on whether key processes rely on electricity. For dairy systems, milking sheds typically rely on electricity and any temporary disruption to electricity supplies may constrain milk production outputs. Depending on the length of electricity outages, there is also a risk of spoiling agricultural products that require refrigeration, especially during the summer months.

For the horticulture subsector, electricity supply disruption could affect producers' ability to maintain/store crops due to disruption to air conditioning units and refrigeration rooms. Electricity disruptions may also result in a failure to maintain appropriate temperatures in greenhouses. It is evident that local producers use natural gas as well as coal and oil to heat their greenhouses; there is insufficient data available to discern whether this is common practice across Auckland and whether some greenhouses run off electricity (NZ Hot House, 2018). For the viticulture subsector, electricity disruption can result in potential disruption to air conditioning units and cool rooms used to maintain and store grapes.

Primary sectors also rely on electricity to power technology. Examples include in-ground meters that measure the soil moisture content and satellite imagery used in monitoring land.²⁹ Electricity disruption will render such technology and accompanying results ineffective and inaccurate.

Most commercial fishing boats run off a generator and disruption to electricity supplies is less pertinent on commercial boats. However, it becomes more of an issue from a storage perspective once catch is removed from commercial vessels and needs storage in temperature-controlled environments. Electricity is also important to the aquaculture industry, where electricity is used for many key aquaculture processes such as refrigeration and on-site processing. Given the high level of perishability of seafood, if cooling fails, the consequences are more significant than they are for other primary sector produce, as even temporary failing in cool stores can spoil stock.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Electricity supplies are disrupted				
Manufacturing	Insignificant	Insignificant	Minor	Limited agreement, limited evidence
Supply Chain	Insignificant	Insignificant	Insignificant	
Food Tech	Insignificant	Insignificant	Minor	
Wholesale	Insignificant	Insignificant	Minor	
Agriculture	Insignificant	Insignificant	Insignificant	
Horticulture	Insignificant	Insignificant	Insignificant	
Viticulture	Insignificant	Insignificant	Insignificant	
Aquaculture & Fisheries	Insignificant	Minor	Moderate	

²⁸ Based on a summary of several primary production energy use profiles.

²⁹ Self-reported from Food and Beverage sector workshop attendees.

5.2.7 Road networks are damaged or destroyed

Approximately 1 per cent of roads in Auckland are exposed to 1 metre of sea level rise and 5 per cent of roads are exposed to 3 metres of sea level rise (Golubiewski et al, 2019). Although this is a low percentage, past storm events have damaged Auckland's road network. In 2011 a storm coincided with a high tide which resulted in Auckland's northern motorway having submerged lanes (Chappell, 2012).³⁰ Damage or destruction to main highways can impact domestic supply chains. If businesses have to reroute to use alternative local roads, these routes may be less direct and more prone to congestion than state highways, leading to slower transportation times. Damage to state highways may result in delays to the transport of both food and beverage products and inputs necessary for activity within each subsector.

Damage to road networks may place constraints on both the manufacturing and supply chain subsectors to efficiently transport inputs to manufacturing plants and outputs to distribution facilities and across domestic and international supply chains. Auckland's proximity to both the international airport and port are key to supporting the largest manufacturing sector in New Zealand (ATEED, 2020). This proximity also facilitates efficient domestic and international supply. Additional costs associated with disruption and re-routing may reduce the efficiency of these subsectors.

For the food technology subsector, disrupted domestic distribution may impact upon inputs needed for innovation, which may vary depending on the product being tested or trialed. However, in contrast to manufacturing, as only small amounts of inputs are needed, disruption to this subsector is likely to be limited.

In relation to the wholesale subsector, the majority of wholesalers are based in Mount Wellington, in South Auckland, at the nexus of both the southern motorway and roads leading to the south and east of Southern Auckland. If any of this key roading infrastructure is damaged or destroyed due to climate hazards, the wholesale sector may face potential constraints on the ability to connect consumers to products.

For the primary production subsectors (agriculture, horticulture, viticulture and aquaculture & fisheries) damage or disruption to road networks may result in supply chain impacts – both upstream and downstream. Upstream, primary producers may face short-term delays in obtaining raw inputs necessary for production. This could include fertiliser use, livestock feed and labour supply. Downstream, meat, milk, crops and wine may face delays in connecting to manufacturers and/or wholesalers.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Road networks are damaged or destroyed				
Manufacturing	Insignificant	Insignificant	Moderate	Limited agreement, limited evidence
Supply Chain	Insignificant	Minor	Moderate	
Food Tech	Insignificant	Insignificant	Insignificant	
Wholesale	Insignificant	Insignificant	Minor	
Agriculture	Insignificant	Minor	Minor	
Horticulture	Insignificant	Minor	Minor	
Viticulture	Insignificant	Minor	Minor	
Aquaculture & Fisheries	Insignificant	Insignificant	Insignificant	

³⁰ This is the Auckland Climate NIWA report filed in future_plans_projections

5.2.8 Flights to and from Auckland International Airport are disrupted

The food and beverage sector relies on Auckland International Airport for shipping goods by air freight in addition transporting labour resources from abroad and receiving key inputs necessary for production. Disruptions to airport services from extreme weather events can lead to highly perishable foods spoiling, which may lead to reduced sales. Disruptions may also temporarily prevent workers from entering New Zealand.

Only a small proportion of food and beverage exports are sent by air freight: 2 per cent of dairy, 5 per cent of meat, 10 per cent of fruit and nuts and 27 per cent of fish (Statistics New Zealand, 2018). It is possible for the majority of New Zealand's food and beverage exports to be sent via sea freight in chilled or frozen form rather than sending goods via air freight. However, this is not possible for some perishable products, such as fresh milk, which is air-freighted directly to China. For these products, local markets would need to be found (potentially flooding the local market and disrupting the domestic market). The export sector may lose income from high value perishable food and beverage products that are typically air freighted (Infometrics, 2015b). Exports sent by air freight include cherries, tomatoes and avocados.³¹ Key inputs such as machinery are also typically supplied via air freight, and delays for crucial components may affect on-farm productivity and yields. For machinery parts in particular there is more reliance on just in time distribution which further exacerbates supply chain risks.³²

The primary sectors may face labour constraints if flights to and from Auckland airport are disrupted longer-term. Based on 2013 data, one fifth of new entrants to the primary industries workforce comprised of temporary migrants, and the vast majority (35 per cent) of these migrants went into the horticulture sector (Ministry for Primary Industries, 2019). Both the horticulture and viticulture sectors in particular rely on seasonal labour to ensure crops are either picked, packed and/or pruned at the end of each growing season (Sriramaratnam, 2008).

Subsector	Risk rating			Confidence
	Present	2040	2110	
Flights to and from Auckland International Airport are disrupted				
Manufacturing	-	-	-	Limited agreement, limited evidence
Supply Chain	Insignificant	Insignificant	Moderate	
Food Tech	-	-	-	
Wholesale	-	-	-	
Agriculture	Insignificant	Insignificant	Minor	
Horticulture	Insignificant	Insignificant	Minor	
Viticulture	Insignificant	Insignificant	Minor	
Aquaculture & Fisheries	Insignificant	Insignificant	Minor	

5.2.9 Water supplies are reduced, disrupted or contaminated

The primary sector is expected to face reduced water availability, as indicated under the drought and water variability projections. Within this sector, the most severe consequences from water reduction and contamination may be experienced by the primary sector. Under the *Resource Management Act 1991* water is not allocated strategically, but rather on a first-come-first served basis – there is no water safeguarded for food production (Deloitte, 2018). Without any prioritisation among users, food

³¹ Self-reported from Food and Beverage sector workshop attendees.

³² Self-reported from Food and Beverage sector workshop attendees.

producers at both 2040 and 2110 may likely face water shortages and/or increased water costs due to associated scarcity, increasing the overall food production costs for producers (Deloitte, 2018).

Water is crucial to food production systems. Many primary industries are sensitive to changes in rainfall and seasonal variability (Cradock-Henry and Fountain, 2019). Livestock, horticulture and viticulture industries use water as a key input to their production processes and future water constraints may have downstream implications on these production systems. Food production systems are likely to use their own water sources which means that if such sources become contaminated, food producers may need to purchase temporary uncontaminated water, adding additional costs to production. These costs may likely be passed on to wholesalers, manufacturers and consumers. Both water shortages and contaminated water supplies can affect livestock health, causing diseases such as leptospirosis, which reduces milk production and in extreme cases can lead to livestock death (Dairy NZ, n.d). New Zealand livestock farming systems rely on rainfall to grow pasture to feed their herds (Cradock-Henry and Fountain, 2019). If there is insufficient water to grow pasture, producers may need to purchase feed which may increase input costs. In the horticultural subsector, water is used for growing the plants, fighting frosts and processing the output to take it to market (Deloitte, 2018). Water is crucial for growing horticultural crops. While some businesses rely on municipal water supply, some have their own supply sources such as bores on site, which decreases their vulnerability to water shortages.³³

Inconsistent weather conditions impact upon food production; the reliability of water supply for vegetable crops during growth periods is very important to ensure quality as well as yield (Deloitte, 2018). The horticultural subsector in Auckland is typically comprised of family-owned and multi-cultural businesses (Deloitte, 2018). Current competition for water is one of the many reasons why growers are moving out of Auckland to ensure the profitability of their businesses (Deloitte, 2018).

Water is crucial to growing high-quality wine (Ministry of Agriculture and Forestry, 2009). Vineyards need water for irrigation, sanitation and cleaning (Gabzdylova et al, 2009). Presently, the south-eastern areas of Waiheke Island and north-eastern areas of Auckland have the lowest levels of rainfall in the region (Chappell, 2013 - based on a 30-year period between 1981-2010). Both these areas are key viticulture regions. Waiheke Island is not connected to Auckland's water infrastructure system. When water shortages occur on the island, water has to be shipped in from the mainland, which causes additional costs for viticulture producers.

Soil runoff can also affect the health and quality of surrounding waterways, as surrounding waterways receive both sediment and nutrient run-off (MPI, 2020). A 1997 study on erosion and sediment in the Pukekohe region found that although erosion occurs locally, within paddocks, little of this sediment is transported downstream to larger waterways such as the Manukau Harbour (Basher et al, 1997). However, with climate projections demonstrating an increasing incidence of heavy rainfall, the sediment load may travel further, contaminating larger streams and harbours and placing additional pressure on water sources.

For the aquaculture and fisheries subsector, changes to rainfall and storm patterns may cause a decline in water quality due to increased sediment runoff (Foley et al, 2019). Heavy and more frequent rainfall events will increase sediment runoff into streams and streambanks, which may alter the community composition of these ecosystems, and may cause changes to the food web (Foley et al, 2019; MPI, 2020b). This is most likely to impact aquaculture farms given their proximity to the coastline and surrounding tributaries.

In the manufacturing sector, water is used for a range of processes including material processing, cooling and washing and cleaning (Pacific Institute, 2009). Assuming that the costs of water may increase during times of scarcity, this may result in increased costs to food and beverage production, which in turn would be passed onto consumers. The consequences of contaminated water supplies would impact upon the ability to manufacture food and beverage products. Alternative water sources could be procured at high cost assuming that cost may be exacerbated during times of scarcity. The risk of contamination is generally low for those business attached to the municipal supply. There is minimal water involved in supply chain management, food technology and wholesale subsectors

³³ Self-reported from Food and Beverage sector workshop attendees.

hence the consequences of water scarcity for these subsectors may be much less severe than manufacturing.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Water supplies are reduced, disrupted or contaminated				
Manufacturing	Insignificant	Minor	Moderate	Limited agreement, medium evidence
Supply Chain	-	-	-	
Food Tech	-	-	-	
Wholesale	-	-	-	
Agriculture	Minor	Moderate	Moderate	
Horticulture	Minor	Moderate	Major	
Viticulture	Minor	Moderate	Major	
Aquaculture & Fisheries	Insignificant	Moderate	Moderate	

5.2.10 Built assets that are necessary for service provision are damaged or destroyed

Built assets within the food and beverage sector include buildings, factories, warehouses, milking sheds, packing equipment, dams and irrigation systems. Extreme weather events such as storms, floods and heavy rainfall can damage infrastructure that is crucial to all subsectors. Damage to built physical assets from extreme weather events can delay economic activity and increase repair and maintenance costs to asset owners. Slow-onset sea level rise can also damage built physical assets by resulting in the permanent destruction of sites.

For the supply chain subsector, both warehouses and cool stores are necessary for service provision. Damage to these built physical assets may cause products in these facilities to perish and may result in reduced storage facilities available. Warehouses and cool stores are also key built physical assets for the wholesale sector. Damage to warehouses and cool stores from extreme weather events may cause products in these facilities to perish and may result in reduced storage facilities available.

For the manufacturing subsector built physical assets necessary for service provision include manufacturing plants used to process primary food into secondary products. Damage to these by extreme weather events may affect sector productivity by causing delays and subsequent decreases in the output of secondary products. Damage to built physical assets for both the wholesale and manufacturing section may be unable to meet retail demand, which may in turn increase consumer prices due to supply shortages (Deloitte, 2018). Small wholesalers include farmers markets. Farmers markets are predominantly held outdoors in Auckland. These markets may be more exposed to extreme weather events which may make outdoor markets unviable during warmer months. Small, niche food producers depend on produce markets for their livelihoods (Bell and Beaston, 2008). Closure of these markets may result in the closure of small food-producing businesses.

FoodBowl is the only type of built physical asset considered for the food technology sector. Its purpose is to provide facilities to foster development of innovative processed food and beverage products and it has space and equipment for hire (Coriolis, 2019). Damage to this asset from extreme weather events may place constraints on innovation, as small and medium-sized businesses may be unable to use this facility to engage in experiments and trials of new food and beverage products.

For the primary production subsector, damage to key primary sector inputs necessary for service provision may constrain producers' ability to produce primary outputs. Damage to dams and irrigation systems may constrain the ability of food producers to provide water to livestock, crops and grapes respectively. Damage to milking sheds, pens and buildings key for livestock and crop housing/storage

which may cause short-term disruption to the ability to raise livestock and process and pack crops. If greenhouses are damaged due to extreme weather events, they can be out of production for at least half a year.³⁴ Damage to packhouses can spoil large quantities of crops. One farmer self reported that up to 1000 tonnes of onions and a week's supply of potatoes are typically stored in their packhouses.³⁵

By 2040 and 2110 the intensity of storms is projected to increase (specifically wind speed and rain rates) and more intense storms pose a higher risk to key infrastructure (Pearce et al, 2018). Based on these projections, it is unclear whether storms may increase in an intensity significant enough to damage key infrastructure. Poorer quality infrastructure is likely to be less resilient to extreme weather events, increasing the infrastructure's vulnerability. No research was available on the quality of this sector's infrastructure.

While extreme weather events may cause temporary damage to all key infrastructure involved in any of the food and beverage sectors listed gradual sea level rise and coastal inundation resulting from extreme weather events may result in the permanent destruction of sites, which may render economic activity unviable among any of these subsectors.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Built assets that are necessary for service provision are damaged or destroyed				
Manufacturing	Insignificant	Minor	Minor	Medium agreement, limited evidence
Supply Chain	Insignificant	Minor	Minor	
Food Tech	Insignificant	Minor	Minor	
Wholesale	Insignificant	Insignificant	Insignificant	
Agriculture	Insignificant	Insignificant	Insignificant	
Horticulture	Insignificant	Insignificant	Insignificant	
Viticulture	Insignificant	Insignificant	Insignificant	Limited agreement, limited evidence
Aquaculture & Fisheries	Insignificant	Minor	Moderate	

5.2.11 Construction sites, crops and livestock are damaged or destroyed

Crops, livestock and soil are considered temporary outdoor assets within the food and beverage sector. All of these assets may be affected by erosion and extreme weather events. Erosion affects the productivity of land as it removes topsoil, which is the most nutrient-dense component of soil (MPI, 2020). Primary producers may face reductions in productivity from increased soil erosion due to reduced growth of pasture and crops. Although erosion is a natural process, extreme weather events, drier conditions and farming practices all increase the rate of erosion (MPI, 2020).

Crops, livestock and soil may also be exposed to extreme weather events, such as storms, drought, hail and floods and severe rainfall. Severe rainfall can exacerbate soil erosion, reducing the productivity of the soil (MPI, 2020). Storms, droughts, hail and floods can cause injury to livestock and damage to crops. Depending on the severity and magnitude of the extreme weather event, producers may lose significant numbers of livestock or entire crop seasons.

The agricultural subsector can be impacted by erosion due to a reduction in topsoil which may reduce the amount of pasture grown in farming systems. Reduced pasture decreases the amount of feed available for livestock and may require producers to purchase additional feed as an input. The

³⁴ Self-reported from Food and Beverage sector workshop attendees.

³⁵ Self-reported from Food and Beverage sector workshop attendees.

impacts of extreme weather events can also lead to injury or death of livestock. In 2017, producers in Clevedon, a rural town in South Auckland, lost entire livestock herds due to rising flood waters (Hurley, 2017).

The horticulture subsector may also face reduced productivity from soil erosion. Horticultural production in particular requires continual disruption to the soil, including deep ripping and various phases of hoeing, which makes the soil more vulnerable to erosion (Basher et al, 1997). Producers experiencing high levels of soil erosion may have reduced crop outputs which may in turn affect producers' profitability. Storms, fires and floods can damage crops grown outdoors, which may impact the horticulture subsector (Clothier et al, 2012). Some crops, such as tomatoes, are already grown in greenhouses which may protect them from exposure to extreme events (Deloitte, 2018).

The viticulture subsector may also face reduced productivity from soil erosion in the form of reduced growth of vines and grapes. As with horticulture, producers experiencing high levels of soil erosion may have reduced crop outputs which may in turn affect producers' profitability. Extreme weather events, including storms, drought, hail and floods can damage vine and fruit. Fruit in particular is vulnerable to damage from extreme weather events (Clothier et al, 2012), and the viticulture subsector in Auckland may face a reduction in crop output. However, although 20 per cent of New Zealand's vineyard are in Auckland, only 1 per cent of grapes are grown within the region, as many grapes are shipped in from other regions (Coriolis, 2017). The ability to obtain grapes from other areas of New Zealand reduces the risk to this subsector.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Crops and livestock are damaged or destroyed				
Manufacturing	-	-	-	Medium agreement, medium evidence
Supply Chain	-	-	-	
Food Tech	-	-	-	
Wholesale	-	-	-	
Agriculture	Insignificant	Minor	Moderate	
Horticulture	Insignificant	Minor	Major	
Viticulture	Insignificant	Minor	Moderate	
Aquaculture & Fisheries	N/A	N/A	N/A	N/A

5.2.12 Disruptions to systems that are sensitive to seasonality and changes in climatic parameters

Primary industries within the food and beverage sector are climatically-sensitive and New Zealand's economy is particularly sensitive to impacts on the food and beverage sector given New Zealand's reliance on primary sector exports (Cradock-Henry and Fountain, 2019). The agriculture, horticulture and viticulture sector may be impacted by changes to seasonality and average climatic parameters, which may affect production output. The sector may also face a risk of increasing input costs due to increasing incidence of invasion of pests and diseases and increased growth of weed species, which may have varying consequences across the three different primary industries. Raw products in New Zealand account for 7 per cent of all exports and total 79 per cent of all export earnings (Statistics New Zealand, 2018). Any reductions in output of raw produce may have significant economic implications for food producers (Clothier et al, 2012).

The consequences of this risk to the food and beverage sector fall into three areas:

1. Reduction in outputs from livestock and crop production due to changing seasonality

2. Increasing input costs due to increasing incidence of invasion of pests and diseases and increased growth of weed species
3. Changes to sea surface temperature and changing macronutrient conditions in the marine environment that may affect species survival and growth rates within the aquaculture and fisheries subsector.

Reduction in outputs from livestock and crop production due to changing seasonality and climatic parameters

Changes in temperature and seasonality can influence the length of growing seasons. A combination of decreased rainfall, warmer temperatures and increased droughts may reduce yields and increase production costs for producers. Changing seasonality can also impact the quality of horticulture products, such as size, shape and taste (Cradock-Henry, 2017). Mean minimum temperature changes may impact upon the winter dormancy period of some crops, having downstream impacts on quality and yields, impacting upon production costs and resultant profits (Clothier et al, 2012). Many horticultural businesses in Auckland are family-owned, and producers currently experience challenges to food production in the form of increasing land costs, intensive growing, competition for water and sourcing labour (Deloitte, 2018). Some of these challenges may be exacerbated by climate change constraints.

Soil moisture in Auckland may decrease as a result of increased evaporation and changing rainfall patterns (Lorrey et al, 2018). Reduced soil moisture may have significant implications for horticulture, agriculture and livestock management (Lorrey et al, 2018). Drier soils can affect soil functionality, which in turn may reduce pasture and crop growth (Lorrey et al, 2018). Reduced soil moisture can also increase the risk of erosion - the consequences of this are discussed in Section 5.2.13. Changing seasonality may also disrupt the timing of harvesting, availability of labour and processing at key times and movement of labour between sectors.

Higher concentrations of carbon dioxide stimulate carbohydrate production and plant growth and may lead to larger crop outputs (Benschop et al, 2018). Although carbon dioxide isn't a climatic parameter itself, it is a driver of the changes in climatic parameters. However, this can lead to reduced nutrition in outputs, which can cause adverse implications on human nutrition. In particular, potatoes are at risk of increased growth and resultant decrease in nutrient density – 20 per cent of the nationwide potato crop is grown in Pukekohe (Deloitte, 2018). Nutrient deficit crops could affect consumers' willingness to pay an increased price for a decreased crop size. Due to this conflict, increased crop growth has not been identified as a key opportunity for the primary sectors.

Dairy and horticulture producers may also be affected by changes in average climatic parameters such as mean minimum and maximum temperatures. Increases in mean maximum temperatures and heatwaves can cause heat stress in cattle. Heat stress in dairy cattle can cause weight loss, decreased feed intake and lower reproductive rates (Davison et al, 1996). Heat stress can also lower the immune systems of beef and dairy cattle increasing their vulnerability to illness (Benschop et al, 2018). Housing animals indoors could lead to overcrowding which may facilitate establishment of new pests and diseases, the establishment of which may result from increasingly warmer temperatures and increasingly humidity (Benschop et al, 2018).

Subsector	Risk rating			Confidence
	Present	2040	2110	
Reduction in outputs from livestock and crop production due to changing seasonality and climatic parameters				
Manufacturing	Insignificant	Insignificant	Minor	High agreement, medium evidence
Supply Chain	-	-	-	
Food Tech	-	-	-	
Wholesale	Insignificant	Insignificant	Minor	
Agriculture	Insignificant	Minor	Moderate	

Horticulture	Insignificant	Minor	Major	
Viticulture	Insignificant	Minor	Major	
Aquaculture & Fisheries	N/A	N/A	N/A	

Increasing input costs due to increasing incidence of invasion of pests and diseases and increased growth of weed species

Warming temperatures may result in an increasing likelihood of invasion of exotic pests and diseases that could harm food production systems (Benschop et al, 2018). Auckland is one of the most vulnerable areas in New Zealand to the establishment of new invasive species due to warmer temperature projections (Kean et al, 2015). Weed species are also projected to increase growth in Auckland's climate due to a combination of warmer temperatures and reduced frosts (Kean et al, 2015). Species invasion from both diseases and weeds may increase the costs of inputs needed to control threats, such as fertiliser (Benschop et al, 2018). The primary sectors may be particularly affected by these seasonality changes.

For the agriculture sector, increased incidence of diseases in livestock may require additional animal pest control activities resulting in increased costs. Due to an increase in weed species in Auckland, there may be reduced feed for animals due to reduced grass and feed productivity. This may require producers to purchase additional feed, increasing production costs.

The horticulture and viticulture sectors are also vulnerable to the invasion of exotic pests and diseases. In Auckland, subtropical fruit flies are significant threat to the horticultural subsector (Deloitte, 2018) and pose an increased threat under a warmer climate. There is slightly reduced exposure for the horticulture sector to this risk, as some crops are grown indoors in greenhouses, which reduces the exposure of these crops to pests and diseases.

Increases in pest management inputs and the associated labour inputs across all sectors may result in higher costs of production. An increase in fertiliser use may have negative implications for water quality due to fertiliser run-off from food-producing land (Pearce et al, 2018). An increase in inputs may lead to a resultant increase in production costs for producers; these costs may in turn be passed on to consumers (Deloitte, 2018). Small and medium-sized enterprises may be less likely to cope with increasing costs of inputs which may place economic pressure on these businesses.

The perception of New Zealand as a country that is clean and safe contributes to New Zealand's high quality reputation in overseas food and beverage markets (Coriolis, 2019). New Zealand is free of diseases that are in other countries' food production systems, such as foot and mouth, blue tongue and classical swine fever). This reputation may be impacted by an increasing incidence of pests and diseases.

The consequences from a changing climate may result in either reduced outputs or increased input costs which may impact food producers' profits. Smaller businesses generally have lower financial reserves than larger businesses which may result in smaller horticultural producers being pushed out of the market, leading to greater market corporatisation. Climate change may require primary food producers to adapt their production processes which may add additional costs to producers, particularly those that are small to medium-sized. (Cradock-Henry and Fountain, 2019). These increased costs may then be passed on to consumers, which will in turn affect other industries and their respective profitability.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Increasing input costs due to increasing incidence of invasion of pests and diseases and increased growth of weed species				
Manufacturing	-	-	-	High agreement, medium evidence
Supply Chain	-	-	-	
Food Tech	-	-	-	
Wholesale	-	-	-	
Agriculture	Insignificant	Minor	Moderate	
Horticulture	Insignificant	Minor	Moderate	
Viticulture	Insignificant	Minor	Moderate	
Aquaculture & Fisheries	N/A	N/A	N/A	

Disruptions to systems that are sensitive to seasonality and changes in climatic parameters

Increasing Sea Surface Temperatures (SST) and changing macronutrient conditions have been classified as hazards relevant to this risk. Changing SSTs may affect both species survival and growth rates of marine life (Foley et al, 2019). By 2050, mean SST may increase by 1°C; by 2100 it may increase by 2.5°C (Law et al, 2016). Those species that are close to their thermal tolerance will be disproportionately affected by these increased temperatures (Doney et al, 2009). Large fish species and macroinvertebrates have a higher sensitivity to increased temperatures; the most sensitive species include adult banded kokopu and koaro (adult whitebait species). SST can also cause thermal stratification, when nutrient flows between surface and deeper ocean are interrupted by thermal stratification. This thermal stratification can increase the volatility of key commercial fish species, including hoki and ling (KPMG, 2020c). Fishing vessels may have to increase their inputs (such as distance travelled, trawling length) to obtain the same level of catch as previously acquired (KPMG, 2020c).

Marine life will also be exposed to changing macronutrient conditions (Foley et al, 2019) due to both increasing water temperatures and changes in patterns of circulation (Polovina et al, 2011, as cited in Foley et al, 2019). NIWA projections indicate that levels of both nitrate and phosphate in marine environments will decline, by 9.2% and 7.8% respectively (Foley et al, 2019). The productivity of marine ecosystems can be limited by concentrations of nitrate or phosphate (Foley et al, 2019). Although too much of these nutrients can result in harmful algae blooms, too little of these nutrients can stifle growth, affecting food chains which can affect interaction and food webs in these communities (Foley et al, 2019). Climate change projections indicate Auckland will experience fewer windy days at both 2050 and 2110 (Pearce et al, 2011). Changing nutrient levels can be compounded by fewer windy days which results in fewer nutrients being cycled around the waterbody (Foley et al, 2019).

Marine heatwave events are described as an extended period of increased ocean temperatures; this warm area can extend up to thousands of kilometres (NIWA, 2020). Marine heatwaves can be caused by a range of factors, including increasing sea surface temperature (NIWA, 2020). Marine heatwave events may cause commercially valuable species such as snapper and kingfish may be able to migrate further south, moving out of northern Quota Management Areas, which may impact northern fisheries, altering the composition of marine food webs (KPMG, 2020c).

Reduced ecosystem services from intact aquatic systems may have downstream implications for multiple sectors within Auckland's economy (Foley et al, 2019). Intact aquatic ecosystems provide a range of ecosystem services that Auckland relies on every day, including oxygen production, climate regulation, and food and clean water provision. The health of these aquatic ecosystems is fundamental to human wellbeing and these changing ecosystems will impact human's ability to adapt to a changing climate (Foley et al, 2019). There is limited information as to what this means for businesses.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Increasing input costs due to increasing incidence of invasion of pests and diseases and increased growth of weed species				
Aquaculture & Fisheries	Insignificant	Minor	Moderate	Medium agreement, medium evidence

5.2.13 Large scale ecosystem change

Auckland may experience large scale ecosystem change from rising sea levels (Pearce et al, 2018). The primary sector faces risks to productivity and output from sea level rise. Loss of land is presently a key constraint to food production in Auckland, with urban sprawl placing downward pressure on the amount of food producing land available (Deloitte, 2018; Chibnall and Curran-Courngage, 2014). Slow-onset sea level rise may exacerbate the shortage of food producing land, placing pressure on producers to either increase the intensity of the food production systems or to move their production systems outside of Auckland. Sea level rise may also result in loss of major infrastructure for businesses; many insurance companies do not provide compensation for damage from coastal inundation and sea level rise given insurance trends overseas (Iorns, 2018).

The most recent report on Auckland's exposure to sea-level-rise looks at Auckland's rural subsector exposure to sea level rise by both land use capability classes (LUCs) and land use types (Golubiewski et al, 2019). Rising sea levels may reduce the amount of land available for primary production processes.

In terms of the agriculture subsector, the land use types most exposed are rural subsector and grazing land (used by mixed sheep and beef, beef and dairy) (Golubiewski et al, 2019). Dairy farming contributes 10 per cent of Auckland's total land use (Chibnall and Curran-Courngage, 2014). Between 3-6 per cent of mixed sheep and beef, beef and dairy land may be exposed to 1 metre of sea level rise, and between 4 -11 per cent of this land may be exposed to 2 metres of sea level rise. Rising sea levels may reduce the amount of land available for livestock grazing, which may lead to higher stock rates on the remaining land. Increasing the intensity of dairy farming production systems is already a current trend in Auckland (and New Zealand as a whole). Between 2002-14, the average herd size increased by 32 per cent; yet the land used for dairy farming decreased by 20 per cent. Sea level rise may exacerbate these trends and in extreme cases may result in farmers selling land and moving production out of Auckland.

Animal genetic diversity is crucial for food security and for rural development, as it allows farmers to develop new breeds in response to external factors, including a changing climate (Hoffman, 2010). A frequently changing climate may mean farmers have to frequently change on-farm genetics to focus on breeding adaptable species.³⁶

Elite and prime soils in Auckland are typically used for horticulture production (Deloitte, 2018). From a land use capability perspective, land with elite and prime soils is exposed to sea level rise (Golubiewski et al, 2019). Approximately 5 per cent of all land with elite and prime soils may be exposed to sea level rise of between 0.25 and 0.5 metres by 2050. In 2100, more than 6 per cent of all land with elite and prime soils may be exposed to sea level rise. Sea level rise may force growers to grow more produce on reduced land sizes, which has downstream implications for both soil and

³⁶ Self-reported from Food and Beverage sector workshop attendees.

water quality in addition to crop performance (Deloitte, 2018). The horticulture subsector in Auckland is presently facing increasing constraints on horticultural land supply due to an increasing urban sprawl yet contributes significant economic value (Deloitte, 2018). Prime soils, proximity to a significant market (Auckland) and key transport routes are key reasons why the horticulture subsector has such a significant contribution to Auckland's GDP (Deloitte, 2018). If producers are forced to move out of Auckland due to sea level rise this may reduce the subsector's profits.

The viticulture subsector is less exposed to sea level rise. Only 1.1 per cent of this land class may be exposed to 1 metre of sea level rise, with 2.1 per cent of this land class potentially being exposed to 2 metres of sea level rise (Golubiewski et al, 2019). Exposed vineyards may lose tracts of grape-producing land which may reduce profitability. However, this sector is less vulnerable to sea level rise as the majority of grapes used to process wine are imported from outside of Auckland. Although 20 per cent of New Zealand's vineyards are in Auckland, only 1 per cent of grapes are grown within the region, as many grapes are shipped in from other regions (Coriolis, 2017). The ability to obtain grapes from other areas of New Zealand reduces the risk to this subsector.

Aquatic systems are highly vulnerable to effects of climate change (Foley et al, 2019). From a marine environment perspective, large scale ecosystem changes including ocean acidification and sea level rise may result in potentially profound changes in both the number and distribution of commercial fish species (KPMG, 2020c). Both commercial fisheries and aquaculture operations will be impacted by these climate change hazards. The industry may need to increase their inputs to maintain their current catch (KPMG, 2020c).

Ocean acidification occurs due to an increasing concentration of carbon dioxide in the atmosphere. Oceans act as carbon sinks to absorb this carbon dioxide from the atmosphere, and the chemistry of this absorption causes the water to become more acidic. The ocean will continue to acidify over time; by the end of the century there is projected to be an 116% increase in acidifying hydrogen ions (Law et al, 2016). As the concentration of carbon dioxide in the atmosphere has increased, the oceans have subsequently increased their absorption of CO₂, chemistry of this absorption causes the water to become more acidic (Arup, 2019). Ocean acidification affects the condition and survival of marine species, especially those with hard carbonate structures such as shellfish and crabs, as they can struggle to form shells under increasing acidic conditions. This can in turn affect their growth and reproduction rates (Foley et al, 2019) which reduces their overall population rate.

Sea level rise has already been discussed in the hazards section of this report (Section 2.0). Sea level rise may disproportionately impact coastal habitats that sit at the margin between land and sea, particularly intertidal and mangrove habitats (Swales et al, 2008 as cited in Foley et al, 2019). The marine life that lives in these coastal habitats relies on exposure throughout the tidal cycle; this exposure may be reduced or compromised by sea level rise (Foley et al, 2019). Although marine aquaculture does not typically sit at this particular margin, they are relatively close to the shoreline and may be affected by sea level rise.

There is limited evidence on the impact of sea level rise on aquaculture habitats such as marine shellfish. Marine shellfish in particular are highly sensitive to changes in their environment, especially in relation to decreasing pH levels, as well as increasing water temperature and rainfall (Foley et al, 2019). Marine shellfish are highly valuable as an economic commodity (Foley et al, 2019).

Subsector	Risk rating			Confidence
	Present	2040	2110	
Reduction in land available for primary sector activities due to sea level rise				
Manufacturing	-	-	-	Limited agreement, medium evidence
Supply Chain	-	-	-	
Food Tech	-	-	-	
Wholesale	-	-	-	
Agriculture	Insignificant	Minor	Moderate	

Horticulture	Insignificant	Insignificant	Insignificant	
Viticulture	Insignificant	Insignificant	Insignificant	
Impacts of ocean acidification and sea level rise				
Aquaculture & Fisheries	Insignificant	Minor	Extreme	Medium agreement, medium evidence

5.2.14 People are exposed to environmental hazards

Exposure to extreme heat is the most significant environmental hazard to food and beverage sector employees (Pearce et al, 2018). The majority of primary sector employees work outside, undertaking physical activities and are therefore highly exposed to extreme heat (Parsons, 2014). Exposure to extreme heat can cause heat stroke, dehydration, exhaustion and can also worsen pre-existing diseases such as cardiovascular diseases (Orlov et al, 2020). Across all sectors, heat stress may likely result in reduced productivity of workers via an increase in breaks, which may reduce the quantity of outputs produced (Fernandez & Golubiewski, 2019). During heatwaves there may likely be periods where employees are unable to work outside during the heat of the day which may affect subsector productivity by reducing the number of working hours. Aside from reduced working hours, there are additional impacts that hot weather has on workers cognitive functions, which further reduces worker productivity and can lead to an increase in workplace accidents (Zander et al, 2015). These reduced working hours may compound labour shortages within the industry.³⁷

Increasing heat may also result in additional business compliance costs. Under New Zealand law, a 'person conducting a business or undertaking' (PCBU) has a duty of care to identify any hazard and to eliminate such risks emanating from the hazard as far as is reasonably practicable (Worksafe, 2019). PCBUs across the food and beverage sector are legally required to mitigate risks such as extreme heat. Mitigating risks from an increasing incidence of hot days may add additional costs to businesses' health and safety requirements, from associated paperwork through to investment in cooling equipment such as air-conditioning.

There is variability in exposure across the subsectors. Employees in the food technology and manufacturing subsectors are typically involved in sedentary work. They are less adversely affected by heat stress than employees working outdoors, such as those in the primary sectors (Orlov et al, 2020). Despite the sedentary nature of manufacturing, this subsector attracts employees from low socioeconomic backgrounds and the socioeconomic characteristics of the workforce increases the workforce's vulnerability to heat stress (Fernandez & Golubiewski, 2019). Those from low socioeconomic backgrounds typically have a higher incidence of chronic health conditions, including cardiovascular conditions and diabetes and these conditions make them more vulnerable to heat stress and heat-related illnesses (Fernandez & Golubiewski, 2019; Royal Society, 2017).

It is much harder to mitigate the risks for workers exposed to heat stress outdoors. Many employees within the primary sector work outdoors in physically active jobs, increasing their exposure to heat stress. Employees in the horticulture subsector are particularly vulnerable given they may spend time in extreme heat environments such as greenhouses. Workers in both the fisheries and aquaculture sectors are primarily outdoors – therefore they have higher exposure to increased temperatures. Health and safety of fishing crews may be affected by storms and extreme weather events. (KPMG, 2020c). This increased exposure to extreme events can reduce the productivity of workers, through either heat or storm-related illnesses or injuries. Storms and extreme weather events may also reduce the ability of these workers to venture out to sea.

For the supply chain and warehouse subsectors, there is likely to be great variability in exposure of workers to extreme heat. Some workers may work in air-conditioned environments (such as truck cabs and warehouses) doing sedentary activities, such as transporting food and beverage products. Others may spend time in the outdoors engaging in physical labour, including loading food and

³⁷ Self-reported from Food and Beverage sector workshop attendees.

beverage products into domestic and international carriers and manning farmers market stalls. A proportion of these subsectors may therefore have greater exposure to outdoor temperatures than manufacturing and food technology workers who may typically be housed indoors.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Employees are exposed to environmental hazards				
Manufacturing	Insignificant	Insignificant	Minor	Medium agreement, medium evidence
Supply Chain	Insignificant	Insignificant	Insignificant	
Food Tech	Insignificant	Insignificant	Insignificant	
Wholesale	Insignificant	Insignificant	Insignificant	
Agriculture	Insignificant	Insignificant	Minor	
Horticulture	Insignificant	Insignificant	Moderate	
Viticulture	Insignificant	Insignificant	Minor	Limited agreement, limited evidence
Aquaculture & Fisheries	Insignificant	Minor	Moderate	

5.3 Construction

5.3.1 Sector overview

The Construction sector in this report is comprised of the following subsectors: residential, non-residential, and infrastructure. Table 12 below outlines the definition and geographical spread of the three construction subsectors considered in this report.

Table 12: Construction subsectors

Construction Subsector	Definition
Residential	Preparation, clearing and development of land for residential use; and the construction, installation, alteration, repair and deconstruction/demolition of domestic residential buildings (e.g. houses, flats and apartments).
Non-Residential	Preparation, clearing and development of land; and the construction, installation, alteration, repair and deconstruction of commercial or other non-residential purposes buildings (e.g. warehouses, offices, factories, schools).
Infrastructure	Construction, installation, alteration, repair and deconstruction of built infrastructure (e.g. roads, rail, bridges, water, wastewater, power, telecommunications).

The construction sector is a vital component of Auckland's economy. In 2019 it employed over 86,000 people in 24,192 businesses accounting for almost 7 per cent of Auckland's Gross Domestic Product (Huang and Wilson, 2020). The construction sector was also the second largest sector in Auckland as measured by employment (10 per cent of the Auckland total). More than one in five (22 per cent) of the sector's employees and one in three (34 per cent) businesses were in Residential Building Construction (Huang and Wilson, 2020).

Residential and non-residential construction is funded by a mix of public and private businesses. In 2019, over half of the total value of building work (residential and non-residential) in Auckland was new residential buildings (\$5.7 billion in 2019 dollars), and the rest was new non-residential buildings (\$3.3 billion) and alterations (\$1.8 billion) (Huang and Wilson, 2020). This work is driven by Auckland's population growth and demand for housing. Auckland Council's development strategy

influences the location of new residential and non-residential construction through development controls and signalling the location of future growth areas and nodes (Auckland Council Unitary Plan, 2016; Auckland Council Auckland Future Urban Land supply strategy, 2017 Auckland Plan 2050, 2018).

Auckland's infrastructure is provided by a combination of central government, local government and the private sector through a mix of operational and capital budgets. Auckland Council and associated council-controlled organisations (CCOs), along with central government agencies, fund the majority of infrastructure projects in Auckland. The delivery of horizontal infrastructure is characterized by large amounts of unavoidable risk as a function of both its intimate relationship with the physical environment (i.e. ground conditions, and the inclusion of large-scale highly complex projects). This risk drives the need for high levels of technical expertise and specialization in fields such as tunnelling, bridging, roading and rail (Entwine, 2018).

5.3.2 Characteristics of Auckland's construction sector

Key components of the construction sector are land, labour costs, materials costs, compliance costs and profit. Materials consumed by the construction sector are diverse and include: brick, concrete, aggregates, aluminium, glass, plasterboard, timber, sand, steel, and weather board. Several key materials are manufactured in Auckland including steel, aggregate, plasterboard and concrete. Imported materials, particularly from China and Australia are a significant component of the construction supply chain. The sector utilises the outputs of the manufacturing sector, and turns them into usable infrastructure, extending the capital stock, adding significant value as part of this process (PWC, 2016).

Compared to most other sectors, Auckland's construction sector generally has smaller businesses (fewer employees per business unit). Notwithstanding, people in the construction sector are still more likely to be in self-employment compared to other sectors. The rate of self-employment in the sector (35 per cent) was more than twice the rate in the total Auckland economy (16 per cent) (Huang and Wilson, 2020). The cyclical nature of the sector means that many small businesses in the construction sector have little incentive or resources to invest in business growth and capacity building (PWC, 2016). This lack of capacity building may mean they are less prepared to weather climate related shocks such as disrupted supply changes and may take longer to adapt to changes in regulations.

The construction sector is labour intensive and is not highly automated (PWC, 2016). The sector has also been facing difficulties in finding labour. A report by Rider Levett Bucknall (2019) forecasts that New Zealand's construction sector would require 57,600 more skilled workers by 2026. Profit margins rise and fall with economic cycles and can also be indicative of the ability of firms to raise prices in response to cost pressures. The ability of SMEs to absorb costs or raise prices will likely reflect a number of internal and external variables such as demand, competition, consumer expectations, and operating costs.

5.3.3 Overview of most significant risks and consequences for the construction sector

All construction sub sectors will likely become increasingly exposed to heatwaves, floods and storms resulting in delays, rework, reduced productivity, increased costs, and an increased insurance burden. There is likely to be increasing time and money lost to non-work days, damaged materials and equipment, disrupted supply chains and increased litigation associated with weather related construction disruption. Water scarcity leading to increased cost of water could result in increased costs for water intensive construction activities or products such as concrete curing, dust suppression and steel.

There may be increasing demand for emergency maintenance and repairs, deconstruction, and hazard protection works, as more existing built assets and infrastructure are exposed to sea level rise and flooding. This is a potential opportunity for the construction sector. There is a risk that the residential and commercial construction sectors construct buildings that may not perform effectively under future climatic conditions with respect to cooling, durability and drainage. This risk is in part addressed through evolving building code and design specifications which are increasingly considering climate change.

The three most significant physical climate change risks to the construction sector have been identified as:

- Partially constructed buildings and infrastructure, construction sites and equipment are damaged or destroyed. This risk was rated minor in 2040 for all subsectors rising to moderate/major in 2110.
- Maritime infrastructure and maritime transportation assets are damaged or destroyed disrupting the construction sector supply chain. This risk was rated minor in 2040 rising to moderate in 2110.
- Changes to seasonality and average climatic conditions which result in failure of buildings and infrastructure to meet or maintain the level of service expected by owners or end users. This was rated minor in 2040 rising to moderate in 2110 for the residential and non-residential subsectors.

5.3.4 Maritime infrastructure and maritime transportation assets are damaged or destroyed

Maritime transportation assets for this sector include ports and port assets associated with sea freighting construction materials. Auckland is a significant import port and imported materials to service the construction sector arrive in Auckland, therefore damage or destruction of key import infrastructure such as port assets could disrupt construction supply chains.

Imports by the construction sector, as a percentage of output generated are on par with the New Zealand average (PWC, 2016). However, imports by the construction sector have been increasing over the last decade. In particular, the volume of imported steel used in structures has increased. There has been a trend in the residential construction subsector to import non-traditional building materials, such as wall boards and insulation, especially where imports can meet the same quality standards required of New Zealand-made products as there is potential to use these products to reduce the cost of construction of homes, buildings and infrastructure (PwC, 2016).

Long-term shortages of imported materials may have a significant effect on the construction sector. For example, according to the Australian Construction Industry Forum (ACIF), Australia imports approximately 60 per cent of its annual \$6bn spend on construction materials from China. Delays are expected on constructions of building projects, as sourcing of these materials are anticipated to be difficult for up to six months (as a result of COVID-19) (RSM, 2020). However COVID-19 has highlighted the risk of depending heavily on supplies from one locality (China). Julien Leys, Chief Executive, Building Industry Federation of New Zealand, suggests the building supply chain is already mitigating this risk by working again with local manufacturers of components and materials, providing certainty and business continuity for these local businesses (Leys, 2018). This suggests that if disruptions to imports as a result of maritime transportation assets being damaged or destroyed were long lasting, the construction sector would shift to a more local supply chain.

The construction supply chain also utilises trans-shipping between the North and South Island for bulky or heavy products such as cement (Samarasinghe, 2014). While concrete suppliers are located in Auckland, most cement is transported by ship (Deloitte, 2018b). Bringing in cement by road from another port would likely increase the cost of this input to the production of concrete due to the increased cost of transportation. This transport cost increase is likely true for a range of inputs and materials that may need to be transported further than usual to reach the Auckland market if port assets were damaged or destroyed. Similarly, if maritime infrastructure is damaged, additional pressure on the roading network could cause delays also increasing the cost of transport of inputs and outputs.³⁸

Disruption to the supply of internationally supplied inputs and projects may present opportunities for local suppliers to address supply shortages.³⁹

Subsector	Risk rating			Confidence
	Present	2040	2110	

³⁸ Self-reported from Construction sector workshop attendees.

³⁹ Self-reported from Construction sector workshop attendees.

Maritime transportation assets are damaged or destroyed				
Residential	Insignificant	Minor	Moderate	Medium agreement Limited evidence
Non-Residential	Insignificant	Minor	Moderate	
Infrastructure	Insignificant	Minor	Moderate	

5.3.5 Information and Communication Technology systems are disrupted

The construction sector, like other New Zealand's businesses rely on information and communications technology (ICT), such as the internet and telephone networks to connect to customers, communicate, manage operations and improve productivity. For the construction sector this includes the use of digital tools to manage workflows, manage logistics and supply of goods and services; quality control data and communications. Specific tools such as Building Information Modelling (BIM) are becoming more widely adopted. Disruption to these systems has the potential to decrease productivity and or cause potential delays.⁴⁰

Subsector	Risk rating			Confidence
	Present	2040	2110	
Information and Communication Technology systems are disrupted				
Residential	Insignificant	Minor	Minor	Medium agreement Limited evidence
Non-residential	Insignificant	Minor	Minor	
Infrastructure	Insignificant	Minor	Minor	

5.3.6 Road networks are damaged or destroyed

The roading network is required to transport labour and materials for the construction sector. The Auckland Plan identifies a number of motorways and major roads at risk from sea level rise and flooding. Transport costs are a significant portion of building materials costs in New Zealand (Ying and Robertii, 2013). For this reason, supplies are often sourced from the closest available merchant (Samarasing, 2014).

Damage or destruction to road networks has the potential to escalate transportation costs and or contribute to delays in construction. The wider construction supply chain may also be negatively affected by disruptions to roading network as 70 per cent of New Zealand's freight is transported by road (Ministry of Transport, 2014).

Consequences to individual businesses in the sector will depend on access to alternative suppliers, contractual arrangements, and the response from the supply chain to disruptions. The existence of alternative routes and suppliers ensure that construction processes can continue, albeit with some delays or increased transportation costs.

Businesses who collaborate with their suppliers can have positive wider effects through building capacity and increasing the resilience of supply distribution partners. Damages to roading infrastructure from storm events may be a catalyst for the industry to plan for supply disruptions, seek alternative less exposed supply networks and create a more resilient supply chain.⁴¹

Subsector	Risk rating			Confidence
	Present	2040	2110	

⁴⁰ Self-reported from Construction sector workshop attendees.

⁴¹ Self-reported from Construction sector workshop attendees.

Road networks are damaged or destroyed				
Residential	Insignificant	Minor	Minor	Medium agreement
Non-residential	Insignificant	Minor	Minor	Medium evidence
Infrastructure	Insignificant	Insignificant	Minor	

5.3.7 Water supplies are reduced, disrupted or contaminated

Due to an increasing incidence of drought and increasing rainfall variability, water supplies across the Auckland region are likely to reduce (Pearce et al, 2018). Water is used on construction sites for a range of activities including dust suppression and concrete curing and cutting (WRAP, 2012). The amount of water used on construction sites is largely unknown, in part because the majority of on-site sources are not paid for and are therefore not metered. Therefore, it is difficult to deduce whether drought and increased rainfall variability will impact upon the construction sector in a material way.

The construction sector, like all sectors in Auckland, may face increased costs for water due to increased water scarcity. Within Auckland, water sources for construction projects across the subsectors would typically be provided from Watercare's municipal supply network. As discussed at 4.6, for construction sites attached to Auckland's municipal supply, whether the cost of water increases due to projected water scarcity would really depend on Watercare's policies.

Not all construction sites will be connected to Watercare's municipal supply. If the construction sites are adjacent to natural water sources sites may also apply for water consent takes from bores and streams. These currently cost at least \$7,000 per site (Auckland Council, 2020). Water scarcity may result in an increase in the price of water consent applications or increased difficulty in obtaining a consent application.

There may be upstream supply chain costs for the construction sector due to the increased cost of materials as a result of water scarcity. For example, steel manufacturing is a water-intensive process. At the Glenbrook Steel Mill in South Auckland; approximately one million tonnes of water is circulated around the site daily to produce steel outputs (New Zealand Steel, 2020). The Steel Mill has its own water supply that it takes from the Waikato River and larger industrial facilities and is therefore has some capacity to self-manage their supply (New Zealand Steel, 2020). However decreasing rainfall variability and increasing drought may impact upon the amount of water New Zealand Steel is able to extract from the Waikato River. This may result in local authorities placing a cap on overall water takes from the Waikato River (Pacific Institute, 2009). These consequences would require New Zealand Steel to purchase additional water, which in turn increases their production costs. These costs are likely to be passed onto consumers, although they are dependent on the market and it is very difficult to predict where costs will fall.

More drought conditions may increase levels of dust on construction sites. This has severe health issues both on onsite workers and the surrounding community.⁴² As well as dust control, water is used to ensure spoil is not distributed beyond work sites to local roads, polluting waterways. Water is used for a number of construction processes, therefore when shortages occur, workarounds must be found, or water bought in from alternative locations, which adds cost to the business.

⁴² Self-reported from Construction sector workshop attendees.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Water supplies are reduced, disrupted or contaminated				
Residential	Insignificant	Minor	Minor	Medium agreement Limited evidence
Non-residential	Insignificant	Minor	Minor	
Infrastructure	Insignificant	Minor	Minor	

5.3.8 Built assets that are necessary for service provision are damaged or destroyed

This consequences of this risk to the construction sector fall into two areas:

1. Disruption to Auckland based construction supply chain
2. Increased frequency of emergency maintenance and repairs; deconstruction/demolition services; and hazard protection works resulting from assets becoming increasingly vulnerable to flood, coastal inundation and storms (opportunity).

Disruption to Auckland-based building supply chain

The construction sector relies on built assets where products used in construction are extracted, manufactured, stored and sold. Key construction materials produced in the Auckland Region include: steel, aggregates, sand, plasterboard, and concrete. Disruption of local production due to production assets being damaged or destroyed could result in a shortage of these materials in the short term, leading to cost increases due to decreased supply. The impact will depend on which type of material production is disrupted and whether there are readily available alternative sources from outside Auckland.

Building supply merchants and wholesalers store and sell construction materials from multiple locations across Auckland. Damage to a materials storage or sales facility may require additional transport of materials to site as construction companies seek alternative suppliers in turn increasing input costs. However, the duplication of providers likely means damage to one wholesaler/retail merchant would not have a significant impact on the construction sector.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Disruption to Auckland-based construction supply chain				
Residential	Insignificant	Minor	Minor	Medium agreement Low evidence
Non-residential	Insignificant	Minor	Minor	
Infrastructure	Insignificant	Insignificant	Minor	

Opportunity: Increased frequency of emergency maintenance and repairs; deconstruction/demolition services; and hazard protection works

When buildings and infrastructure are damaged as a result of extreme weather events, flooding, and coastal inundation, they are either repaired or disassembled/demolished. Increasing vulnerability of buildings and infrastructure may result in increased damage or destruction of built infrastructure and therefore an increase in demand for repair and disassembly services from the construction sector. These services may be required during recovery from a hazard event or while the event is still ongoing, such as a storm or a flood. This work may present additional health and safety challenges. In addition, the skills required for reparation of buildings and infrastructure repair may be different from what is currently present in the market and presents an opportunity for the construction sector.

An analysis by Paulik, et al (2020) revealed that 1,790 buildings in Auckland are in 2020, exposed to a 100-year extreme sea-level flood event. By 2110, at 1.2 m of sea level rise, the number of buildings exposed more than quadruples to 7,296. To avoid damage or destruction, these buildings are likely to be either need to be deconstructed and removed or provided flood protection. An increasing number of properties being exposed to extreme sea-level flood events may lead to an increasing demand for these services from the construction sector.

Subsector	Opportunity rating			Confidence
	Present	2040	2110	
Increased frequency of emergency maintenance and repairs and planned hazard protection works				
Residential	Insignificant	Insignificant	Minor	Medium agreement Low evidence
Non-residential	Insignificant	Insignificant	Minor	
Infrastructure	Insignificant	Insignificant	Minor	

5.3.9 Construction sites, crops and livestock are damaged or destroyed

Both construction activities (particularly those in the early phases of constructing new buildings and infrastructure) and demolition activities are exposed to the elements. Weather is consistently rated as one of the most frequent and harmful causes of construction project delays (Assaf and Al-Hejji 2006, AlSehaimi and Koskela 2008, Orangi et al. 2011, Mentis 2015 as cited in Cooke, 2018) by ruining partially constructed, unprotected and exposed constructed elements (El-Rayes and Moselhi 2001 as cited in Cooke). Increased frequency or severity of extreme weather events could increase damages to partially constructed infrastructure and buildings, construction sites and equipment.

The construction sector is accustomed to working in inclement weather. Notwithstanding this, extreme weather events are currently a source of delays and disputes (Moselhi and El-Rayes 2002, Nguyen et al. 2010 as cited in Cooke 2018). Increasing frequency and severity of extreme weather may exacerbate impacts increasing construction delays, damage to equipment, increased construction costs associated with additional site flood mitigation measures, increased insurance cost, and damage to property and assets (Smith, 2013). These consequences could converge to affect the viability of some businesses.⁴³ More intense and less predictable rainfall events could cause costly delays to construction, as well as damage to assets through increased rain and moisture penetration, increased ground and foundation movement; and degradation and failure of pipe and waterway structures (Smith, 2013). There is likely to be increased costs associated with construction to mitigate against these impacts (Hurlimann, 2019). Increasing damage caused by extreme weather events are a key factor in insurers refusal to insure extremely vulnerable regions of Australia and increasing insurance premiums over the last few years (Insurance Council of Australia, 2015). Higher insurance premiums may be absorbed by profitable businesses, and wealthy infrastructure asset owners, however lower income asset owners, and small businesses will likely be sensitive to changes in insurance premiums. However, unlike existing assets, construction works insurance for residential work is often site based and relevant for the duration of the construction process. This means the insurance cost can be incorporated as a direct cost of the project and passed on to the consumer rather than become an escalating cost of doing business for the sector.

Delays and damage due to extreme events combine to result in decreased productivity for the construction sector and increasing cost of delivering built infrastructure. It is difficult to predict how the costs will be spread across the construction sector and wider economy.

In a paper which explored the climate change preparedness of the Australian construction sector by conducting stakeholder interviews, respondents expected the sector to continue to respond to extreme weather through innovation of existing processes. However, respondents also acknowledged there was a high financial risk to pricing projects to allow for potential costs of weather-related impacts and

⁴³ Self-reported from Construction sector workshop attendees.

construction disruptions. The difficulty for smaller businesses to respond to changing risks was also acknowledged by those interviewed (Hurlimann, 2019).

Subsector	Risk rating			Confidence
	Present	2040	2110	
Damage to partially constructed infrastructure and buildings, construction sites and equipment				
Residential	Insignificant	Minor	Major	High agreement
Non-residential	Insignificant	Minor	Moderate	Medium evidence
Infrastructure	Insignificant	Minor	Moderate	

5.3.10 Disruptions to systems that are sensitive to seasonality and changes in climatic parameters

Changes to average climatic parameters in Auckland could result in failure of buildings and infrastructure to meet or maintain the level of service expected by owners or end users. Hurlimann (2019) found that building sector climate adaptation actions consist more of activities which benefit the organisation and less of activities related to changing the constructed products so they are less sensitive to climate change. Actions which benefit the organisation include processes such as prefabrication in a controlled environment to avoid extreme weather, whereas an action to adapt the end product would be exceeding design standards to meet changing climates (Hurlimann, 2019).

Building materials may not have been tested to understand whether they are able to withstand the expected climate of the future. There are examples of imported building materials failing in New Zealand due to Ultraviolet radiation and salt effects (BIFNZ, 2013; Samarasinghe, 2014) and the New Zealand building sector suffered from the 'leaky homes' crisis, where a number of buildings using monolithic cladding systems were not watertight. Liability for leaky homes was reported to be a contributing factor in construction company Mainzeal going into receivership (National Business Review, 2018). Cases were also brought against suppliers of the cladding.

Negative reputation is another potential consequence for architects, engineers, and building suppliers if buildings and infrastructure fail to perform adequately under changing climatic conditions e.g. overheating of recently constructed buildings. As building regulations change, properties are becoming more airtight, which although effective at retaining heat in winter can lead to overheating in summer when adequate ventilation is not also fitted (Gupta & Greggs, 2012; White, 2017, as cited in Joynt and Golubiewski, 2019). This effect may become more prevalent as hot days increase.

The industry self-reported that increasing pests could affect the construction supply chain in term of wood supply: An increased tree mortality has been observed due to the increasing number of bark beetles. Pine trees are one of the materials that are very important for the construction sector. Reduced availability would require the construction sector to find other sources. Participants noted that climate change affects bark beetles but did not offer details on how.⁴⁴

Permanent changes in rainfall patterns such as autumns becoming wetter may result in restricted earthworks seasons, impacting businesses who specialize in this area.⁴⁵ Earthworks are activities which disturb soils, earth or land surfaces. This disturbance can leave earth susceptible to erosion, particularly as a result of rainfall, hence why these types of activities are currently restricted to the dryer months.

⁴⁴ Self-reported from Construction sector workshop attendees.

⁴⁵ Self-reported from Construction sector workshop attendees.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Available infrastructure components, building materials and design fail to meet functional requirements				
Residential	Insignificant	Minor	Moderate	Medium agreement Limited evidence
Non-residential	Insignificant	Minor	Moderate	
Infrastructure	Insignificant	Minor	Minor	

5.3.11 People are exposed to environmental hazards

Climate projections for Auckland, including warming temperatures and an increasing incidence of hot days indicates that the most significant environmental hazard to construction workers is exposure to extreme heat (NIWA, 2018a; Orlov et al, 2020). Workers may also be exposed to stormy conditions or flooded areas, particularly if involved in response and repair following an event. This will lead to increased health and safety mitigation measures and a reduction in working hours.

Many employees in the construction sector work outdoors and engage in physical activity as part of their routine tasks. Construction workers who fall into these two categories will be at increased risk of heat stress and other heat-related illnesses (Orlov, et al 2020; Parsons, 2014). Research on how heat stress may affect worker productivity is still in its infancy (Orlov et al, 2020). However, in extreme heat environments workers will need additional rest breaks and during heatwaves there will likely be periods where employees are unable to work outside, which will affect subsector productivity by reducing the number of working hours on-site.

Aside from reduced working hours, there are additional impacts that hot weather has on workers cognitive functions, which further reduces worker productivity and can lead to an increase in workplace accidents (Zander et al, 2015). Although these consequences lie across a spectrum of severity, they may as a whole result in delays to construction projects.

Under New Zealand law, a 'person conducting a business or undertaking' (PCBU) has a duty of care to identify any hazard, and to eliminate such risks as far as is reasonably practicable (Worksafe, 2019). PCBUs that are managing construction sites across the infrastructure residential and non-residential sub-sectors are legally be required to mitigate risks such as extreme heat. Increasing extreme heat will add additional costs to businesses' health and safety requirements.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Increased health and safety mitigation and reduction in working hours				
Residential	Insignificant	Insignificant	Minor	Medium agreement Medium evidence
Non-residential	Insignificant	Insignificant	Minor	
Infrastructure	Insignificant	Insignificant	Minor	

5.4 Screen

5.4.1 Sector overview

Screen sector	<p>The industries that produce film and television content for domestic and international audiences and service international productions coming to New Zealand.</p> <p>The screen and creative sector includes the following subsectors:</p>
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	<ul style="list-style-type: none"> • Film industry infrastructure • Filming locations
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Over the past four decades, Auckland's screen sector has expanded, and plays a major role in Auckland's economy and culture. It generates significant direct economic benefits, supports tourism, and connects global and domestic audiences to New Zealand's locations, stories, way of life and character in a way that is powerful and authentic. This sector also supports activity in other creative industries such as advertising, marketing and public relations, publishing, music, performing arts and digital. The production of screen content creates indirect employment through the need for provision of ancillary services such as accommodation, corporate catering, security providers, cafes near studios, and equipment rentals.

5.4.2 Characteristics of Auckland's screen sector

In Auckland the screen sector has 1800 businesses, employing 7,400 people, and contributing \$900 M to Auckland's GDP. More than half of all jobs are highly-skilled and are well-paid. The workforce skews younger, and the sector is dynamic and leverages technological innovations to produce content for domestic and international audiences.

The sector however, is not without its challenges. Although a multi-billion-dollar sector, it remains, in many respects, a cottage industry. It is often considered to have three tiers: bottom-tier films that are low-budget with no offshore investment; middle-tier productions that generally have medium-budgets and some offshore investment; and top-tier features that have high-budgets and mainly or entirely offshore investment (Ferrer-Roca, 2017). Within each tier, many individuals, contractors and businesses operate on a small scale, on temporary projects, and they have little capacity to withstand unforeseen shocks.⁴⁶ Screen production is a highly expensive and risky undertaking (Oslberg, 2019), and the sector, despite its success, is reliant at every level on some form of government support.

5.4.3 Overview of most significant risks and consequences for the screen sector

Climate change poses a risk to the screen sector by impacting film sector infrastructure or the critical lifeline infrastructures that the sector needs to produce content, and by impacting the availability, safety, and accessibility of filming locations. Together, these climate change risks, if not adapted to, may restrict growth in the sector. However, with appropriate adaptation, the sector will be able to continue to thrive, and will be able to benefit from its highly skilled workforce, innovativeness, and the growing demand for screen content.

The three most significant physical climate change risks to the screen sector have been identified as:

- Information and Communication Technology systems are disrupted. This risk was rated minor in 2040, rising to moderate in 2110.
- Electricity supplies are disrupted. This risk was rated minor in 2040, rising to moderate in 2110.
- Large scale ecosystem change. This risk was rated minor in 2040, rising to moderate in 2110.

5.4.4 Information and Communication Technology systems are disrupted

Communications infrastructure, such as superfast broadband, is critical for contemporary film-making purposes where large files need to be transmitted at high speed. Ongoing availability of mobile services is also essential in a sector heavily dependent on people working on unique projects, across locations and in tight timeframes (Olsberg, 2019). Any disruptions to ICT systems have the potential to delay production or post-productions, which may impact production schedules and increase overall production costs. If disruptions to ICT infrastructure in Auckland become more frequent and more prolonged than in other production destinations such as Australia, the United States and the United Kingdom, the sector will be at a competitive disadvantage. If, due to consistent, repeated electricity

⁴⁶ ATEED, draft screen strategy. 2020 in press

outages, the sector has to revert to analogue delivery, this will pose major challenges resulting in delays in delivery.⁴⁷

Disruptions to ICT infrastructures may constrain the opportunities that the sectors have to use new digital infrastructures to maximise audience reach.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Information and Communication Technology systems are disrupted				
Film Sector Infrastructure	Insignificant	Minor	Moderate	Medium agreement, medium evidence
Filming locations	-	-	-	-

5.4.5 Electricity supplies are disrupted

The production of screen content depends on a reliable supply of electricity. Without power it is not possible to operate lighting, cameras, communications infrastructure, or regulate the temperature of workplaces. Temporary filming locations, in general, run on power generated onsite, and are thus unlikely to be impacted by disruption to mains electricity supplies.

Permanent facilities, including temporary warehouses are dependent upon the continued functioning of the electricity grid. Disruption to power supplies will impede the ability to shoot scenes, engage in pre and post-production, build sets, refrigerate food for staff and cool or heat accommodation and production facilities. Protracted disruptions may have negative implications for the safety and comfort of employees, and on production schedules and production costs, in addition to an inability for the sector to engage in funding and advertising media.⁴⁸ The sector may also experience reduced demand if there is continued, prolonged electricity disruption.⁴⁹

Subsector	Risk rating			Confidence
	Present	2040	2110	
Electricity supplies are disrupted				
Film Sector Infrastructure	Insignificant	Minor	Moderate	Medium agreement, medium evidence
Filming locations	Insignificant	Minor	Moderate	Medium agreement, limited evidence

5.4.6 Road networks are damaged or destroyed

The filming locations that have contributed to the development of Auckland's screen sectors are dispersed throughout the region. Roads are the primary means of transportation to most mainland locations. Any inundation, damage, or destruction of roads may therefore reduce the ability to access filming locations and film sector infrastructure. Fortunately, most locations on mainland Auckland can be accessed by multiple routes. Certain remote areas may have fewer access points, and roads to these locations may be older, and less frequently maintained, increasing their sensitivity to climate hazards. Rerouting may cause inconvenience and increases costs, and complete loss of access to sites may require rescheduling, or the utilisation of an alternative location.

⁴⁷ Self-reported from Screen sector workshop attendees.

⁴⁸ Self-reported from Screen sector workshop attendees.

⁴⁹ Self-reported from Screen sector workshop attendees.

Damage to road networks across New Zealand may also reduce access to locations, which may decrease the desirability of New Zealand, and Auckland as a filming location.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Road networks are damaged or destroyed				
Film Sector Infrastructure	Insignificant	Insignificant	Insignificant	Medium agreement, limited evidence
Filming locations	Insignificant	Insignificant	Minor	Medium agreement, limited evidence

5.4.7 Flights to and from Auckland International Airport are disrupted

The majority of personnel associated with international productions that make use of Auckland’s screen sector capabilities arrive via Auckland International Airport. Delays or grounding of airplanes may cause inconvenience and reputational damage for the sector, impact production scheduling, or increase costs. It may also limit the ability for international and domestic production crews to move to other regions of New Zealand. Because ease of mobility is an important factor in the selection of destination for international productions (Olsberg, 2019) disruption to Auckland airport has the potential to materially impact the competitiveness and desirability of Auckland as an international production hub. The domestic sector is less sensitive to this risk, as these productions use Auckland airport’s services less frequently. Furthermore, flight shaming internationally due to carbon miles may discourage talent from flying to New Zealand.⁵⁰

Subsector	Risk rating			Confidence
	Present	2040	2110	
Flights to and from Auckland International Airport are disrupted				
Film Sector Infrastructure	-	-	-	-
Filming locations	Insignificant	Insignificant	Minor	Medium agreement, limited evidence

⁵⁰ Self-reported from Screen sector workshop attendees.

5.4.8 Water supplies are reduced, disrupted or contaminated

Sector engagement indicated the cruciality of having clean, reliable drinking water on film sites. Due to an increasing incidence of drought and increasing rainfall variability, water supplies across the Auckland region are likely to reduce (Pearce et al, 2018). On film sets, water can be taken from a bore or purchased and shipped in on a truck, however due to projected reductions in water supplies, the cost of water is likely to increase which will likely increase the expenditure of filming on location where purchased water supplies are needed.⁵¹

Subsector	Risk rating			Confidence
	Present	2040	2110	
Water supplies are reduced, disrupted or contaminated				
Film Sector Infrastructure	-	-	-	-
Filming locations	Insignificant	Minor	Minor	Medium agreement, limited evidence

5.4.9 Built assets that are necessary for service provision are damaged or destroyed

Climate change-related hazards have the potential to constrain the ability of the sector to produce content. The availability of high-quality physical infrastructure is a key factor in the attractiveness of a screen production destination (Olsberg, 2019). This infrastructure includes studios, sound stages, tanks, green screens, workshops, standing sets / scene docs, warehouses, as well as post and pre-production facilities. Many of these assets, necessary to production, are highly specialised. Auckland's screen sector is enabled by several fully-resourced production studios, including the Kumeu Film Studios, Kelly Park Film Studio, Auckland Film Studios, Studio West, X3 Studio, and a brand-new augmented reality and virtual reality hub, AR/VR Garage. Approximately 50 per cent of the sector utilises these specialised assets. The other 50 per cent of the sector uses low-quality warehouse stock which is leased on a temporary basis. This is because growth in screen sector infrastructure has not been able to keep abreast of demand for content driven by major streaming services and the cyclical nature of productions which creates a challenging investment environment for permanent specialised infrastructure.

These assets are distributed across the central Auckland region. This distribution reduces the likelihood of a single hazard event causing simultaneous damage or disruption to multiple facilities. However, due to the scarcity of production space, a single protracted disruption could have moderate consequences for the sector. The scarcity of studio space has meant that Auckland "has, and will continue to, lose significant international productions potentially worth hundreds of millions to competing cities around the world because Auckland's current studios are at capacity, and we can only offer empty industrial warehouses which are far from ideal" (AU, 2016, para 19).

In addition to being "far from ideal", these warehouses are often low quality, and are at risk of water ingress and flooding, which may damage electrical equipment and staging. Specialist facilities, in general, are less sensitive to hazards as they are recently built to higher construction standards, they are well maintained. There is a strong incentive to adapt specialised assets – the services a high-value sector, and the assets are constantly used for film specific purposes. The adaptive capacity of low-quality industrial warehouses is lower, and productions are disinclined to invest in increasing climate resilience in a space that is leased on a temporary basis.

⁵¹ Self-reported from Screen sector workshop attendees.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Built assets that are necessary for service provision are damaged or destroyed				
Film Sector Infrastructure	Insignificant	Insignificant	Minor	Medium agreement, medium evidence
Filming locations	-	-	-	-

Disruptions to systems that are sensitive to seasonality and changes in climatic parameters
Sector engagement identified that changes in seasonality may disrupt filming and production as a result of changing climates. The unpredictability of climate in general may affect scheduling and make it more difficult to stick to a filming schedule, especially when a significant number of outdoor scenes need to be filmed.⁵² It is likely going to be more challenging to obtain key shoot conditions, especially when productions will expect sunshine for light/shoot and edit continuity.⁵³

Subsector	Risk rating			Confidence
	Present	2040	2110	
Disruptions to systems that are sensitive to seasonality and changes in climatic parameters				
Film Sector Infrastructure	-	-	-	
Filming locations	Insignificant	Minor	Minor	Limited agreement, limited evidence

5.4.10 Large scale ecosystem change

Changes to New Zealand's ecosystems and landscapes may have adverse consequences for the screen sector. The sector, including Auckland-based businesses, relies heavily upon New Zealand's pristine and stunning landscapes to attract international productions. Loss or degradation of Auckland's beaches, or loss or degradation in other parts of country (for example the Franz Joseph glacier, or snow-cover in alpine regions) could reduce the attractiveness of New Zealand as a key destination. Domestic productions may suffer from the loss of these ecosystems, and the Auckland industry may suffer due to reduced international interest in New Zealand as a filming location. It is unlikely that domestic content producers will be able to seek alternative locations, thus attenuating the impacts to the sector.

Many of the landscapes that are important locations are also vulnerable to the spread of pests and diseases. The screen sector is highly mobile – it may move from a farm to a studio to a regional park within a number of days – and may face restrictions on entering some landscapes, to avoid the spread of pests and diseases that can be transported on shoes, clothes or equipment, or vehicles. AU has recently advised the screen sector on steps to reduce the spread of *phytophthora agathidicida*, which can infect and kill Kauri, a national taonga (Auckland Council, 2017). In the future, as pests and diseases have wider ranges, it is possible that additional restrictions are imposed, which may limit access to sites, or increase the admirative burden and activities required to be undertaken to access sites.

⁵² Self-reported from Screen sector workshop attendees.

⁵³ Self-reported from Screen sector workshop attendees.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Large scale ecosystem change				
Film Sector Infrastructure	-	-	-	-
Filming locations	Insignificant	Minor	Moderate	Medium agreement, limited evidence

5.4.11 People are exposed to environmental hazards

The production of screen content often requires people to work in areas that are exposed to the weather. The increasing frequency of hazards such as wildfire, extreme heat, storms, and heavy rainfall increase may pose risks to the health and safety of the workforce. The sector has the capability to reduce the exposure of workers to these hazards, through rescheduling when severe or dangerous weather is forecasted, however this may slightly constrain the number of days available for filming. The reduction of days is likely to be minor.

Employees may also be exposed to some hazards while working in indoor spaces. Heat build-up in studios is already significant due to lighting and equipment, higher outdoor temperatures may exacerbate warm temperatures, or increase the costs of cooling.

Subsector	Risk rating			Confidence
	Present	2040	2110	
People are exposed to environmental hazards				
Film Sector Infrastructure	Insignificant	Insignificant	Minor	Medium agreement, medium evidence
Filming locations	Insignificant	Insignificant	Minor	Medium agreement, limited evidence

5.5 Visitor Economy

5.5.1 Sector Overview

Visitor Economy	<p>The production of goods and services for consumption by visitors.</p> <p>The visitor economy includes the following subsectors:</p> <ul style="list-style-type: none"> • Tourism • International Education • Business and Major Events
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Auckland is the gateway to New Zealand, and a major destination in its own right. Millions of people visit on an annual basis, bringing vibrancy to the region, and supporting its economy. The region welcomes more than 2.6 million international visitors each year and nearly as many domestic visitors. These visitors spend more than \$8 billion annually (ATEED, 2018a). The majority of international visitors to Auckland visit for holiday reasons, while the majority of domestic visitors to Auckland visit friends and relatives. Business and major events and international education also attract many people to the Auckland region.

5.5.2 Characteristics of Auckland's Visitor Economy

Auckland's tourism subsector has diverse offerings, from nature-based experiences to shopping, dining and cultural experiences and major events. Across the sector, the majority of businesses are small and medium enterprises, who serve domestic and international markets. The sector is also an

important economic sector for Māori, generating revenue and employment opportunities. The tourism subsector is heavily reliant upon Auckland's natural assets, and natural assets across New Zealand that draw visitors to the region.

The friendliness of Auckland's residents, and high service standards of accommodation, high quality food and wine, and the smoothness of logistics attract thousands of high-value business visitors to Auckland. Across New Zealand, convention and conference delegates spend approximately twice as much per night as international leisure visitors (Tourism New Zealand, nd). Business visitors are also high-value in terms of the knowledge benefits and business networking opportunities they bring with them.

The international education subsector adds diversity to Auckland's export industries while contributing significantly to economic and cultural life. International students come to Auckland to learn and experience New Zealand's culture, and lead to increased economic activity in other sectors, build skills in the labour force and attract talent, and supports business links.

5.5.3 Overview of most significant risks and consequences for the visitor economy

Climate change poses a number of risks to the visitor economy. Impacts to critical lifeline infrastructure can disrupt service provision and reduce mobility, and other built assets can be damaged by hazards such as floods, fires and sea level rise. Changes to landscapes and ecosystems across New Zealand and the region are likely to impact the viability of certain tourism offerings, and changes to weather might impact the enjoyment people derive from their stays.

The three most significant physical climate change risks to the visitor economy have been identified as:

- Information and Communication Technology systems are disrupted. This risk was rated moderate in 2040 and major in 2110.
- Flights to and from Auckland International Airport are disrupted. This risk is rated minor in 2040, rising to major in 2110.
- Large scale ecosystem change. This risk was rated minor in 2040, rising to moderate in 2110.

5.5.4 Maritime infrastructure and maritime transport assets are damaged or destroyed

Damage to, or destruction of, ports, ferry terminals, and marinas and moorings has the potential to constrain growth in the cruise industry, reduce access to islands, and impact upon pleasure craft-related tourism.

Auckland derives significant economic benefits from the cruise industry. Although most cruises in New Zealand typically visit multiple locations, Auckland as New Zealand's key exchange port, captures the largest value add (Market Economics Limited, 2014). In 2013-2014 cruises contributed \$159 million to Auckland's economy. Damage to port infrastructure may reduce the capacity of Auckland's ports to sustain or accommodate growth in the cruise sector.

The consequence of ferry disruption, and the associated reduction in access to Auckland's Islands will most likely be felt by businesses located on, or associated with, the Auckland region's islands. In addition to reducing revenue for affected businesses, disruption of access to these islands may have adverse consequences for the broader tourism sector, as the Hauraki Gulf & Islands activities and attractions received the highest satisfaction rating of all regions from the international market and strengthen Auckland's reputation as a destination (AU, 2020).⁵⁴ Access issues would prevent conservation work on these islands, which may cause degradation of these valuable environments.⁵⁵

The tourism industry also relies on maritime transport and infrastructure to bring in crucial inputs to visitor economy businesses; one business self-reported that they rely on bungy cords from Malaysia. Damage to this infrastructure may make such supplies inaccessible.⁵⁶ Items for shows and exhibitions also enter New Zealand via ship and any damage and corresponding delays on port infrastructure

⁵⁴ Visitor insights report.

⁵⁵ Self-reported from Visitor Economy sector workshop attendees.

⁵⁶ Self-reported from Visitor Economy sector workshop attendees.

would impact Auckland's ability to host such events.⁵⁷ Damage to marina berths or recreational boats may also impact Auckland's tourism sector. Auckland is known as the "city of sails" and has more boats per capita than anywhere else in the world (New Zealand Tourism, n.d.). Boating holidays in New Zealand are common, and key destinations include Auckland's Hauraki Gulf and offshore islands.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Coastal transport assets are damaged or destroyed				
Tourism	Insignificant	Minor	Moderate	Medium agreement, medium evidence
Business and Major Events	-	-	-	-
International Education	-	-	-	-

5.5.5 Information and Communication Technology systems are disrupted

Many tourism activities, particularly nature-based activities, are not highly dependent on ICT infrastructure, although ICT systems are increasingly required to engage with customers, and for routine business practices such as invoicing and payments, booking and reservations. From a health and safety perspective, ICT is crucial to know where customers are, especially in terms of natural disasters.⁵⁸

Disruptions to ICT infrastructures will interfere with the subsectors ability to undertake these essential tasks, however, many of these tasks are not highly sensitive to short-term disruption.

Many of Auckland's major events are highly dependent upon ICT technologies, for the organisation and delivery of events, and for participants, who are often reliant on mobile phones and social media to locate friends and family and share their experiences of the event. ICT technologies are necessary to deliver most business events, and for attendees use at such events. At present, disruptions are rare and relatively inconsequential, however disruptions to ICT could be increasingly consequential over time as demand for hybrid conferences – the combination of face-to-face and virtual conferences/meetings – grows (Business Events New Zealand, 2020).

The international education sector is increasingly utilising ICT infrastructures such as video and audio-conferencing, and online or E-learning in pedagogical practices. Many international students also rely on ICT infrastructure to retain contact with family and friends living in other countries. At present universities have been faster to adopt e-Learning practices (Ministry of Education, 2011), but greater uptake of e-Learning, and the corollary reliance on ICT services, is likely to increase over the next few decades.

⁵⁷ Self-reported from Visitor Economy sector workshop attendees.

⁵⁸ Self-reported from Visitor Economy sector workshop attendees.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Characteristics of Auckland's Visitor Economy				
Tourism	Insignificant	Moderate	Major	Medium agreement, limited evidence
Business and Major Events	Insignificant	Moderate	Major	Medium agreement, medium evidence
International Education	Insignificant	Moderate	Major	Medium agreement, medium evidence

5.5.6 Electricity supplies are disrupted

Disruption of electricity supplies will impact almost all businesses across the subsectors. Without electricity, many services will be unable to function, and visitor experience will be severely compromised. For example, disruptions of electricity supplies will interfere with the ability to meet the needs of business events and major events visitors, particularly with regard to accommodation, dining, and the hosting of events. Workshop attendees highlighted the risks to accommodation facilities and the impact on their ability to function, based on the disruption on electricity supplies.⁵⁹ Disruptions of electricity supplies will interfere with the ability of education institutions to deliver lectures, seminars and engage in research. Protracted disruptions may have negative implications for the safety and comfort of employees. For example, if there are frequent outages, there is a risk the Museum will not be able to hold collections due to risk of collection damage, as the Auckland Museum relies on electricity to regulate the temperature of collections (Auckland Museum, n.d).

Subsector	Risk rating			Confidence
	Present	2040	2110	
Electricity supplies are disrupted				
Tourism	Insignificant	Insignificant	Minor	Medium agreement, medium evidence
Business and Major Events	Insignificant	Insignificant	Minor	Medium agreement, medium evidence
International Education	Insignificant	Insignificant	Minor	Medium agreement, medium evidence

5.5.7 Road networks are damaged or destroyed

Many of the Auckland's tourism destinations are peripheral to central Auckland, requiring access by road-based transportation for both visitors and employees. For the year ending December 2019, three quarters of domestic visitors, and almost half of international visitors used a private or rented vehicle (AU, 2020). Most locations in Auckland can be accessed by multiple routes, although rerouting may cause inconvenience and dissatisfaction with the tourism experience. Some coastal locations however may be particularly affected.

The business and major events and international education subsectors are unlikely to be materially affected by damage to road networks. These visitors are generally not as mobile as tourists, and their movements are primarily within urban areas of Auckland, where there is a dense concentration of roads and many alternative routes to reach destinations. However, disruptions in the city could

⁵⁹ Self-reported from Visitor Economy sector workshop attendees.

compound frustrations domestic and international visitors already have with congestion and parking (AU, 2020). While many events are clustered in central Auckland, the *Auckland Major Events Strategy 2018-2025* aims to spread major events throughout the Auckland region to disperse visitors and spread the benefits of these events (AU, 2018b). This may increase the consequences of disruption to road networks in regional areas, but decrease the consequences of disruption to road networks in central Auckland. However, the disruption of road networks may disrupt the transportation of goods (including food, beverages, clean linens and other essential supplies) that are used for the daily operations of the businesses, meaning they are unable to function.⁶⁰

Subsector	Risk rating			Confidence
	Present	2040	2110	
Road networks are damaged or destroyed				
Tourism	Insignificant	Insignificant	Moderate	Medium agreement, limited evidence
Business and Major Events	Insignificant	Insignificant	Insignificant	Medium agreement, limited evidence
International Education	Insignificant	Insignificant	Insignificant	Medium agreement, limited evidence

5.5.8 Flights to and from Auckland International Airport are disrupted

Most tourism businesses depend upon the international and domestic flights into Auckland Airport. Auckland is a key destination point for international tourists. Using pre-Covid data, in the year ending March 2019 there were 2.74 million international tourists visiting Auckland, an increase in 0.7% from previous years. In the year to February 2018, there was an increase of 2.9% on international guest nights spent in Auckland (Auckland Unlimited, 2019).⁶¹ Disruptions to airport services can delay travel, disrupt itineraries, and cancellations may lead to loss of business. The consequences across subsectors differs based upon the sensitivity of customers to delays and disruption. Attendees of business events and major events, which are generally quite short, are highly sensitive to disruption. It is not just attendees that may be affected: If airport infrastructure is damaged which disrupts flight schedules, this may prevent event talent such as international artists from entering New Zealand, which will cause such events to be cancelled.⁶² Conversely, the international education sector, where trips are significantly longer, sometimes lasting up to several years, is much less sensitive to delays, or rerouting. The tourism sector splits the difference, and depends upon the intended duration of the trip, and the flexibility of the itinerary. Businesses have limited capacity to reduce this risk, and they are reliant upon action been taken by Auckland Airport. Frequent inundation of airport by 2110 would significantly reduce tourist mobility.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Flights to and from Auckland International Airport are disrupted				
Tourism	Insignificant	Minor	Major	Medium agreement, limited evidence
Business and Major Events	Insignificant	Minor	Major	Medium agreement, limited evidence

⁶⁰ Self-reported from Visitor Economy sector workshop attendees.

⁶¹ Self-reported from Visitor Economy sector workshop attendees.

⁶² Self-reported from Visitor Economy sector workshop attendees.

International Education	Insignificant	Insignificant	Moderate	Medium agreement, limited evidence
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5.5.9 Water supplies are reduced, disrupted or contaminated

Anecdotal evidence indicates that increasingly polluted or contaminated water could pose a risk to the reputation of the tourism sector. The Tourism Export Council has expressed concern that worsening pollution problems could conflict with tourist expectations of a 100% Pure New Zealand promise if freshwater resources are not appropriately managed (Cropp, 2017). Climate change is but one pressure on New Zealand's water sources, however the significance will increase over the century, and compound degradation.

There is no municipal water supply system on Great Barrier Island and many households (including visitor accommodation) may source drinking water from rainwater (Sustainable Aotea, 2019). These households are very dependent on weather for their water supply system and are more vulnerable to drought, especially as there are no companies on the island that distribute water (as there are no Waiheke Island).⁶³ If there is not an adequate water supply on Great Barrier Island, the Island will be unable to host visitors.⁶⁴

The contamination of freshwater sources may also affect native flora and fauna that contributes to the natural beauty (and tourism appeal) of New Zealand. For example, Pāteke (Brown Teal) are an endangered endemic species that are highly dependent on well vegetated freshwater wetland systems (Walls, 1999). There is a population on Great Barrier Island (Walls, 1999). Severe water contamination may disrupt the habitat of this species and other birds that rely on wetlands for survival.⁶⁵

A severe reduction in water supplies would make the overall visitor experience offering untenable as it would pose severe health issues for visitors. Restaurants, hotels and attractions would be unable to operate.⁶⁶

Subsector	Risk rating			Confidence
	Present	2040	2110	
Water supplies are reduced, disrupted or contaminated				
Tourism	Insignificant	Insignificant	Minor	Medium agreement, limited evidence
Business and Major Events	-	-	-	-
International Education	-	-	-	-

5.5.10 Built assets that are necessary for service provision are damaged or destroyed

This consequences of this risk to the visitor economy fall into two areas:

1. Damage to essential tourism assets
2. Loss of and damage to Māori cultural landscapes and heritage sites

Damage to essential tourism assets

The tourism sector depends on a range of assets, including accommodation facilities, huts and trails. These assets are distributed across the entire region and are exposed and vulnerable to a range of

⁶³ Self-reported from Visitor Economy sector workshop attendees.

⁶⁴ Self-reported from Visitor Economy sector workshop attendees.

⁶⁵ Self-reported from Visitor Economy sector workshop attendees.

⁶⁶ Self-reported from Visitor Economy sector workshop attendees.

hazards. Damage to these assets may lead to increased costs for reconstruction, or increased insurance premiums, which may limit opportunities for reinvestment in business growth, and constrain profits. Severe damage to key public assets, such as trails and huts, is likely to reduce the viability of tourism businesses that rely on these assets.

The business events and major events sub-sector is exposed to a similar array of hazards, and assets necessary for these events - event and convention centres, stadium or showgrounds, hotels, other accommodations (motels and motor parks), and other establishments such as vineyards, restaurants and theatres (MBIE, 2018) – are generally located in the Auckland CBD, South Auckland, and near Auckland International Airport. Single hazard events may impact a greater percentage of the subsector simultaneously. Hazards may lead to increased costs for asset owners, due to direct damage, or from increased insurance premiums. Severe damage to key assets – Auckland’s few large conference centres and stadiums – have the potential to flow through to reduce demand for ancillary accommodation, tourism and food and beverage businesses. Severe damage to built assets may cause a loss of the city’s vibrancy.⁶⁷

International education sector built assets are even more geographically clustered in central Auckland. The larger proportion of large businesses involved in international education enhances the subsector’s ability to absorb disruptions to and costs associated with damage to university and polytechnic campuses, research facilities and student accommodation.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Built assets that are necessary for service provision are damaged or destroyed				
Tourism	Insignificant	Minor	Moderate	Medium agreement, medium evidence
Business and Major Events	Insignificant	Insignificant	Minor	Medium agreement, medium evidence
International Education	Insignificant	Insignificant	Minor	Medium agreement, medium evidence

Loss of and damage to Māori cultural landscapes and heritage sites

Promoting Māori cultural visitor experiences is a key element of *Destination AKL 2025*, because it will support the broader tourism sector, and is a source of continued potential for the Māori economy. Yet Māori cultural heritage and places of significance, including archaeological sites, historical buildings and structures, and cultural landscapes are under threat from sea level rise and changes to climatic means. In addition to the severe implications for Māori cultural wellbeing and spiritual health, identity, and capacity to sustain livelihoods, damage to and loss of, Māori cultural heritage will impact upon Auckland’s tourism sector (ATEED. (2018a).

⁶⁷ Self-reported from Visitor Economy sector workshop attendees.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Loss of and damage to Māori cultural landscapes and heritage sites				
Tourism	Insignificant	Minor	Moderate	Medium agreement, limited evidence
Business and major Events	-	-	-	-
International Education	-	-	-	-

5.5.11 Disruptions to systems that are sensitive to seasonality and changes in climatic parameters

The weather influences overall demand for tourism activities, what activities tourists want to do, how much money they spend, and how much satisfaction they derive from tourism experiences (Gössling and Hall, 2006). The degree to which it does so depends upon the activity. In a survey of tourist perceptions about optimal weather conditions for beach, mountain and urban environments, Scott, Gössling & de Freitas (2008) found that sunshine was the most important variable for beach environment activities, while the absence of rain was the most important climate parameter for activities in mountain areas. Unsurprisingly, weather conditions are less important for tourism in urban environments as tourists spend significant periods of time indoors and can easily avoid undesirable conditions such as rain. Auckland is the only location in New Zealand with a population and visitor mass large enough to support a variety of all-weather built attractions and experiences (ATEED, 2018a, p. 30). The Auckland region boasts a wide array of tourist offerings, from restaurants and wineries and shopping, to nature-based activities and cultural experiences. Changes to the weather will inevitably impact upon people's preference for, and enjoyment of some of these activities. Evidence about the impacts of changing weather to the visitor economy is limited, however some key trends are apparent. In aggregate, Auckland's tourism sector is likely to be relatively resilient to changes in 'weather' due to climate change, and certain activities may even benefit.

However, the weather also influences whether particular visitor experiences can operate, and an increasing incidence of extreme weather events may pose short-term disruptions to outdoor visitor activities, reducing business profitability. Outdoor activities are very exposed to extreme weather events.⁶⁸ Some activities are unable to operate in high wind and storm events, due to the danger such activities pose to both staff and visitors.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Disruptions to systems that are sensitive to seasonality and changes in climatic parameters				
Tourism	Insignificant	Minor	Minor	Medium agreement, medium evidence
Business and Major Events	-	-	-	-
International Education	-	-	-	-

⁶⁸ Self-reported from Visitor Economy sector workshop attendees.

Opportunity: Grow business event and major event activity in shoulder and off-peak periods

Auckland's mild climate is a factor that influences demand for, and enjoyment of major events and business events. However, it is one of many factors, and unlikely to be a significant driver of demand. Tourism New Zealand (2018) notes that the factors most considered by prospective business event visitors relate to the quality, availability and cost of accommodation, venues, and transport. Warmer winter weather does have the potential to support the aspirations of the business events and major events sector to grow event activity in the shoulder and off-peak periods (ATEED, 2013; ATEED, 2018b). Growing major event and business event activity in the shoulder and off-peak periods helps to increase visitor demand across the year, supporting businesses across Auckland.

Subsector	Opportunity rating			Confidence
	Present	2040	2110	
Grow business event activity in shoulder and off-peak periods				
Tourism	-	-	-	-
Business and Major Events	Insignificant	Insignificant	Minor	Medium agreement, limited evidence
International Education	-	-	-	-

5.5.12 Large scale ecosystem change

Many international visitors come to New Zealand to experience its stunning and unique landscapes. Many of these landscapes, including Auckland's Hauraki Gulf islands, Waitakere Ranges, and New Zealand's alpine, freshwater, coastal ecosystems and indigenous forests are vulnerable to changes in temperature, wind, rainfall, coastal inundation, and wildfires (MfE, 2020). Degradation and destruction of these landscapes are likely to reduce tourism demand, and the viability of businesses reliant on visitors to these areas. The impacts to other destinations in New Zealand, such as the alpine regions and the Franz Joseph glacier may flow through to an overall reduction in demand for Auckland's tourism sector.

Limitations may be placed on visitor numbers in certain areas to protect at-risk landscapes from additional degradation, or the introduction of pests and diseases. Historically, many biodiversity incursions have been linked to tourists, and several kauri forests have recently been closed due to fears that visitors could be transporting kauri dieback (*Phytophthora agathidicida*) on their shoes (Parliamentary Commissioner for the Environment, 2019).

Climatic changes in precipitation patterns and atmospheric temperature will influence animal and insect populations and their migratory patterns. Extended spring and summers may also lead to an increase in mosquito populations, increasing human/vector contact (Swiss RE, 2016). Due to increasing temperatures, there are concerns that both dengue and Ross River fevers may enter New Zealand from the Pacific (Wilson et al, 2011). Any heightened risks of a pest/disease outbreak may discourage visitor activity in the region.⁶⁹

⁶⁹ Self-reported from Visitor Economy sector workshop attendees.

Subsector	Risk rating			Confidence
	Present	2040	2110	
Large scale ecosystem change				
Tourism	Insignificant	Minor	Major	Medium agreement, limited evidence
Business and Major Events	-	-	-	-
International Education	-	-	-	-

5.5.13 People are exposed to environmental hazards

Tourists are increasingly likely to be exposed to multiple hazards, including floods, storms, extreme heat, wildfire, or smoke from wildfire (Becken, Wilson and Resisinger, 2010; Scott and Lemieux, 2010). Death and severe harm are likely to remain infrequent even for nature-based tourism activities, however, the reputation of a region, or tourism offering may be compromised if an event is amplified in national and international media (Rosselló, Becken and Santana-Gallego, 2020). Risks to safety across New Zealand in general may influence perceptions of safety in Auckland. Businesses may also need to invest in additional risk reduction measures.

The business events and international education subsectors are much less vulnerable to this risk, as attendees and students are primarily indoors, and are therefore less exposed to adverse weather events. These subsectors may face additional costs associated with cooling demand on hot days, to ensure the comfort and safety of employees and visitors. Major events, which often draw large volumes of people to a single, and sometimes outdoor location may require additional mitigation measures to reduce risks associated with extreme heat and crowding.

Subsector	Risk rating			Confidence
	Present	2040	2110	
People are exposed to environmental hazards				
Tourism	Insignificant	Minor	Moderate	Medium agreement, limited evidence
Business and Major Events	Insignificant	Insignificant	Minor	Medium agreement, limited evidence
International Education	Insignificant	Insignificant	Insignificant	Medium agreement, limited evidence

6.0 Risk Screen of the Technology and Advanced Manufacturing Sector

The climate risk screen was a component of Phase 2 of this Assessment, it assessed, at a high level, whether the Advanced Manufacturing and Technology sector was exposed to the physical climate change risks identified in Phase 1 of the ECCRA. This assessment was predominately qualitative. As outlined in 1.3.2, AECOM assessed the industry against pre-identified criteria to assess whether the industries are exposed to climate change risks. Both literature and engagement material were used to populate the screen.

Light engagement was undertaken, where an online workshop was held with stakeholders specific to both this industry and all other key sectors.

Workshop data and industry data was used to conduct an initial climate change screen. The climate risk screen considered, at a high level, whether the Advanced Manufacturing and Technology sector is exposed to the physical climate change risks identified in Phase 1 of the ECCRA. There were limited documents available to identify exposure and estimate significance of risks. The limited literature review was supplemented with data from the virtual workshop, where 7 sector participants attended. The results from the screen can be found in this new section - 6.0.

This sector includes both the inputs to advanced manufacturing, the advanced manufacturing process itself and any outputs exported domestically or internationally. The sector focuses on business processes, technology, materials and capabilities used across a value chain, including in the design, manufacture, or handling of a product or service.

A 2017 report on Advanced Manufacturing: Diversifying New Zealand's exports highlights the growth the sector has recently experienced in export earnings. Unlimited. Export earnings have risen from \$1.4 billion in 2012 to over \$6.9 billion in 2017 (The sector is classified as including both ICT and high-technology manufacturing, which is consistent with the classification used by Auckland (Deloitte, 2017). Advanced Manufacturing as a sector is highly valuable to New Zealand's economy: it is New Zealand's third biggest export revenue earner (Deloitte, 2017). New Zealand (and Auckland) has further opportunities to grow this sector due to strong trade connections with Asia and the United States (Deloitte, 2017). Shifting towards products more focused on service delivery, whereby manufacturers are delivering both products and services as one competitive offering, will help grow this industry even further (Deloitte, 2017). However, to ensure the sectors continued growth, further investment in research and design is needed (Deloitte, 2017).

Given the complexity of this industry, key climate change risks will be those associated with the major infrastructure risks identified through the assessment, such as ICT and electricity risks, where the consequences of these risks are digital failure and power outages respectively. There was very limited data available from both literature and workshop content, therefore findings are preliminary. Workshop participants from the Advanced Manufacturing and Technology sector were asked to identify what the top physical climate change risk was for their sector. All respondents were unanimous in that international supply chain risks were crucial. It is unclear whether this industry relies predominantly on sea or air freight, therefore it has been determined that both the "*Maritime infrastructure and maritime transport assets are damaged or destroyed*" risk (Risk 1) and "*Flights to and from Auckland International Airport are disrupted*" risk (Risk 5), are relevant physical climate change risks for this sector.

The table below summarizes the results of the risk screen undertaken for the technology and advanced manufacturing sector.

Table 13: Summary of Advanced Manufacturing and Technology Screen.

Risks derived from hazard projections	Has this risk occurred for this sector?	General description of the consequences that resulted from the historical past event	Is this risk relevant in the present?	Is this likely to be a risk in the medium-term (2030)?	What is the future trajectory of this risk? (from now until 2040)	Consequences that may arise due to projected risk
Risk 1: Maritime infrastructure and maritime transport assets are damaged or destroyed	No	N/A	Yes	Yes	Increase	Disrupted exports and inputs - most significant risk for industry. Difficult to source components locally, delay in logistics in terms of finished goods.

Risks derived from hazard projections	Has this risk occurred for this sector?	General description of the consequences that resulted from the historical past event	Is this risk relevant in the present?	Is this likely to be a risk in the medium-term (2030)?	What is the future trajectory of this risk? (from now until 2040)	Consequences that may arise due to projected risk
Risk 2: Information and Communication Technology systems are disrupted	No	N/A	No	Yes	Increase	Unable to export software to customers; Difficult to deliver browser-based experiences for clients; Remote learning unavailable, if no internet; International collaborations become difficult or impossible
Risk 3: Electricity supplies are disrupted	No	N/A	No	Yes		Difficult to deliver AR/VR experiences in museums and businesses; Reduced lighting and power for tools to undertake critical repairs; Can no longer assume net access which is an issue for browser-based experiences; unable
Risk 4: Road networks are damaged or destroyed	No	N/A	No	Yes	Increase	Reduced revenue for key clients resulting in reduced budget for our services.
Risk 5: Flights to and from Auckland International Airport are disrupted	Yes - but not due to climate change, due to COVID	Supply chain disruptions	No	No	Increase	Issues with acquiring components for physical installations

Risks derived from hazard projections	Has this risk occurred for this sector?	General description of the consequences that resulted from the historical past event	Is this risk relevant in the present?	Is this likely to be a risk in the medium-term (2030)?	What is the future trajectory of this risk? (from now until 2040)	Consequences that may arise due to projected risk
Risk 6: Water supplies are reduced, disrupted or contaminated	No	N/A	Yes	Yes	Increase	Would encourage companies to relocate out of Auckland or out of the country
Risk 7: Built assets that are necessary for service provision are damaged or destroyed	No	N/A	Yes	Yes	Increase	High risk and liability on manufacturing machines; Loss of AR/VR clients if museums affected; Increasing insurance costs lowers ROI, decreasing investment appetite; Possible move from installations to browser-based experiences. Data storage centers may be at risk.
Risk 8: Assets such as construction sites, crops and livestock, are damaged or destroyed	<i>Not relevant</i>					
Risk 9: Disruptions to systems that are sensitive to						
Risk 10: Large scale ecosystem change						

Risks derived from hazard projections	Has this risk occurred for this sector?	General description of the consequences that resulted from the historical past event	Is this risk relevant in the present?	Is this likely to be a risk in the medium-term (2030)?	What is the future trajectory of this risk? (from now until 2040)	Consequences that may arise due to projected risk
Risk 11: People are exposed to environmental hazards	No - low exposure as most workers are indoors in climate-controlled environments	N/A	Only if workplaces do not have appropriate cooling equipment - most likely to be advanced manufacturing factories where workers are at risk rather than tech offices	Yes	Increase	Workers may experience heat stress and may be less productive/make an increased number of errors due to heat stress

It was concluded that the risks to this sector are not sufficient enough to warrant a detailed sectoral risk analysis that has been provided above at Section 5.0. This is primarily because this sector is less vulnerable as it operates indoors and is less reliant on natural processes and environments than the food and beverage, screen, visitor economy and construction sector. However, this conclusion may not be relevant for advanced manufacturing businesses that rely on key primary inputs to their production processes.

7.0 Industry-identified Adaptation Actions

During the Phase 2 workshops workshop participants were asked to identify current and planned adaptation actions based on the 11 key physical climate change risks outlined at 3.0. Adaptation actions from the two face-to-face workshops have been summarised and themed into key categories. These key categories are available for Auckland Unlimited to understand what is possible within their remit based on their available resources.

Sector	Industry-identified Adaptation Actions
Food & Beverage:	<ul style="list-style-type: none"> • Further investment needed in technology: <ul style="list-style-type: none"> - 'Data is key for decision-making, particularly specifics from farming systems, and geospatial data - but it's a real roadblock that confidentiality/competitiveness prevents data from being used - block chain technology' • Further investment needed in research and development: <ul style="list-style-type: none"> - '(need more) research and design - not just crop-focused but practices to manage and protect crops which may include (better management of) physical assets, including better refrigeration and packaging technologies for hotter climates' • Requirements for more resilient infrastructure, particularly around energy systems and water storage and harvesting • Resilience planning, including in terms of building more local, resilient food networks, and diversifying the supply chain to increase local resilience • Increasing education, particularly around sustainable agricultural practices such as integrated pest management <ul style="list-style-type: none"> - '(need an) increased use of Integrated Pest Management - Disease management is massive - need to find solutions to increasing incidence of pests and diseases' • *Most numerous comments were around Risk 6: water supplies are reduced, disrupted or contaminated – solutions offered but regulatory barriers were noted: '<i>water storage and water harvesting on farms should become commonplace but currently too difficult to set up water storage on site due to huge compliance costs and regulatory risk - end up in court with DOC and Fish and Game; growers could share water but need support navigating the regulatory environment.</i>' • Supply chain mapping to ensure that disruption risks are at least understood as part of materials selection.
Screen	<ul style="list-style-type: none"> • Use of technology to facilitate an adaptation response to avoid key physical climate change risks, particular in terms of how virtual sets are replacing locations • Increased requirements or support to retrofitting existing studios in terms of both sustainable energy, resilient water storage and cooling systems.
Construction:	<ul style="list-style-type: none"> • Changing existing business practices to increase resilience, including: <ul style="list-style-type: none"> - Ordering earlier rather than relying on just in time purchases and relying more on local supply - Mapping out logistics for projects and planning for any potential network delays • Implementing sustainable design and build options, including: <ul style="list-style-type: none"> - Continuing with adapting to renewable energy, with a focus in the future of increasing the diversity of energy supplies - Designing passive energy homes - Using rating tools (such as Homestar) - Educational training throughout the industry to ensure sustainable changes are implemented e.g. '<i>training to improve resilience of environmental controls on site</i>'

Sector	Industry-identified Adaptation Actions
	<ul style="list-style-type: none"> • Implementing technological advances for resilience, including investing in the communications network to enhance both communications and range.
Visitor Economy	<ul style="list-style-type: none"> • Planning and regulation changes/wider infrastructure changes <ul style="list-style-type: none"> - Build more resilient port infrastructure - Build a sea wall for Auckland airport to reduce inundation risk - Lobbying for improved IT infrastructure as a sector - Develop short, local supply chains - Allocate land for carbon sequestration and offsetting. • Changing existing businesses practises to increase resilience <ul style="list-style-type: none"> - Adding water tanks onsite to increase water resiliency - Generating electricity onsite/develop standby ecofriendly power generation - Have asset management plans to make sure existing onsite infrastructure is upgraded and/or maintained - Use a climate change risk assessment and mitigation plan of all key assets and new infrastructure developments - Retrofit existing buildings and infrastructure - Developing a pest management plan to protect museum collection items - Ensure tourism marketing messages align with the changing seasons. • Broader sector education <ul style="list-style-type: none"> - Educate people about climate change risk and behaviour change.

8.0 Transitional climate change risks

There is increased recognition that the best way to reduce physical climate risks and create opportunities is to decarbonise the global economy as soon as possible. New Zealand, as a signatory to the Paris Climate Agreement, has committed to reaching net zero emissions nationally on all greenhouse gas (GHG) emissions excluding biogenic methane emissions (methane emissions from the agricultural and waste sectors) by 2050. The target for biogenic methane emissions is a 24-47 per cent reduction by 2050 compared with a 2017 baseline. Auckland has committed to achieving net zero emissions by 2050 and has an interim target to reduce GHG emissions by 50 per cent by 2030, relative to a 2016 baseline.

Transitional climate change risks and opportunities are those that may result from the process of adjustment towards a low-carbon economy. In contrast to the physical climate change risks posed by climate change, climate-related transitional climate change risks and opportunities are highest in the next few decades (as action is taken to reduce emissions), are broader in scope, and are dependent on the speed and scale of transition. Transitional climate change risks and opportunities arise from:

- Policy and Litigation:
 - Policy actions that support mitigation or promote adaptation, and the potential costs involved.
 - Climate-related litigation claims being brought before the courts.
- Technology:
 - Improvements or innovations that support the transition to a low-carbon economy.
- Markets:
 - Shifts in supply and demand for certain commodities, products, and services.
- Reputation:
 - Perceptions of an organization's contribution to the transition to a low-carbon economy.

As discussed at 1.1, Westpac's Climate Change Impacts report modelled two distinct transition scenarios, both central and shock. With the shock scenario, the transition to a net zero economy is delayed by over a decade. This delay means that when the transition does happen, it needs to happen quickly, hence the moniker 'shock.' In contrast, the central scenario involves early and planned transition action.

Findings from Westpac's Climate Change Impacts report demonstrate that New Zealand can transition to a net zero greenhouse gas emissions economy under both a central and shock scenario by 2050. However, taking earlier, planned action is modelled to increase GDP by \$30 billion cumulatively over the period to 2050 because GDP is on average 0.4% lower after 2030 in the shock scenario than in the central scenario. Furthermore, pressure of a faster transition under a shock scenario will reduce GDP growth to below 2% after the 2030 shock event. The emissions price is also projected to be 32% lower by 2050 if the central transition scenario is used as opposed to the shock scenario.

The Climate Change Commission's Chapter 12 advice *How we earn our way in the world*, has similar findings to the Westpac report in that it recommends an early, planned transition. The Climate Change Commission developed one reference scenario (a base to compare the actual reality) and four modelling scenarios/pathways which are as follows:

- Target Pathway 1; sets out central assumptions across the energy and land system.

The three other pathways test policy and technological uncertainties:

- Target Pathway 2: Methane technology. Combines quicker uptake of methane reduction technologies with tighter methane targets for biogenic methane.
- Target Pathway 3: Less removals. Constrains forestry removals, to identify costs of relying more heavily on emissions reductions.

- Target pathway 4: Faster reductions. Tests the impacts of adopting more ambitious near-term emissions reduction targets for non-biogenic methane.⁷⁰

Results from the modelling show that under the reference scenario GDP is projected to grow to \$512 billion by 2050 (although this doesn't take into account the physical impacts of climate change). Under Target Pathways 3 and Target Pathways 4 (the pathways preferred by the Commission as they are most in line with the Commission's proposed emissions budgets and key assumptions) GDP at 2050 is projected to grow to \$508 billion. Under TP3 and TP4 it is estimated that the transition will cost less than 1% of GDP.

8.1 Transitional climate change risks and opportunities

Key risks to the four sectors of the economy⁷¹ identified in this assessment are presented in Table 14 and Table 15. Risks were derived from a transition scenario developed for this assessment. For more information on the scenario, refer to **Appendix A**. In general, the level of risk depends upon the ability of the economic entities within the sector/subsector to absorb costs or to pass costs on to consumers, and the sensitivity of consumers to changes in products and prices. Transitional climate change risks were not rated as part of this study. Key opportunities identified are presented in Table 11.

Table 14: Transitional climate change risks applying to all sectors

Transition risk	Commentary
Increased costs of transporting input materials across the sectors due to increasing fuel costs	Risk depends upon the distance inputs to production must travel, the distance to consumer markets, and the mode of transportation. This risk applies to land-based transportation, aviation and shipping
Higher electricity costs causing reductions in demand, or reductions in profit margins	Risk depends upon the energy intensity of the production of a good or service, the ability of the business to absorb costs or to pass costs on to consumers, and the sensitivity of consumers to changes in price
Increased costs of inputs to production due to price on carbon	Risk depends upon the volume of material inputs, the emissions intensity of the material, and the technological viability of decarbonising the relevant production and supply chains.
Additional capital outlays required for fuel switching and energy efficiency retrofits in response to policy, regulation, consumer demand or market signals, stressing balance sheets and cash flows.	Risk depends upon the magnitude of the capital outlays required, and the ability of the business to access necessary capital.
Stranded assets: Investments see their economic life curtailed due to technological, regulatory and/or market changes, stressing balance sheets	Risk depends on current or likely future existence of substitutes for production processes or goods and services, the emissions intensity of assets, asset adaptability, asset useful life, and the capital intensity of sector outputs.
New costs of compliance associated with carbon-related regulation such as the TCFD causing reductions in profit margins via increased operating costs	Risk depends on the size of the business (i.e. employees, market capitalisation) and ownership structure (i.e. public, private), and emissions intensity of sector.

⁷⁰ We've interpreted this as all other gases excluding non-biogenic methane.

Transition risk	Commentary
Reputational risk if skills required to the transition, or prosper from the transition, are not present in the labour market	Risk depends on the need for new skills (i.e. is the transition driven through changes to labour, or capital, the adaptability of the labour-force, the ability to attract appropriately skills workers from outside the Auckland region).
Increased risks from wildfires due to afforestation efforts	Risk depends upon locations of assets and workforce exposure to smoke. Risk may also flow through transport networks and other linear infrastructures.
Reduction in the competitiveness of exports if other markets do not take action to reduce emissions.	Risk depends on importance of exports to the sector
Increased Directors and Officers (D&O) liability insurance costs	Risk depends on size of the business and likely liability under transition scenarios

Table 15: Transitional climate change risks applying to specific sectors

Visitor Economy	<ul style="list-style-type: none"> Reduction in demand due to increased price of air travel. Risk depends upon distance travelled Reduction in demand due to the increasing awareness of the significance of aviation sector emissions. Risk depends upon distance travelled Increase in urban and environmental amenity due to reduction in noise, air and water pollution (from switch to EVs). Risk depends on other factors influencing urban and environmental amenity such as land use changes, ecological protection.
Screen	<ul style="list-style-type: none"> Reduction in the number of filming locations due to landscape change relating to afforestation, wind turbines, urban densification and changes to agricultural landscapes.
Food and Beverage	<ul style="list-style-type: none"> Lack of producer knowledge and support to transition to low carbon food and beverage production systems Reduction in animal product consumption (e.g. milk and meat) due to increasing consumer awareness about the carbon-intensive nature of livestock production systems
Construction	<ul style="list-style-type: none"> Increased costs of materials used in construction e.g. fuel, steel and cement as a result of the increasing cost of carbon Rising compliance costs from net zero carbon building regulations and policies Increase in capital outlays required to build new assets to higher energy and water efficiency standards, and to upgrade existing assets (for example, with insulation, solar panels) Lack of workforce capability and capacity to build net zero buildings and infrastructure.

Table 16: Transition opportunities

All	<ul style="list-style-type: none"> Increasing demand for locally produced goods and services as imports increase in relative price due to higher transportation costs Onsite electricity generation / microgrids may increase resilience to disruption to external energy network shocks Ability to expand into new markets through the provision of low-carbon goods and services Access to new financial products (e.g. green bonds, sustainability linked loans, sustainability linked bonds) to support business growth
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Visitor Economy	<ul style="list-style-type: none"> Increased opportunities for recreation, tourism and conservation due to afforestation Higher education institutions may benefit from funding made available for low-carbon research Higher education institutions may be able to develop new service offerings to equip students for professions likely to prosper in a low-carbon economy
Screen	<ul style="list-style-type: none"> A higher percentage of the workforce sourced from Auckland to minimise aviation emissions and costs Increase investment in technologies such as landscape scanning, augmented reality, virtual reality, animation to reduce the need to travel to sites during production
Food and Beverage	<ul style="list-style-type: none"> Improved catchment hydrology as a result of afforestation Both the aquaculture and fisheries subsectors may experience changing consumer preferences. There is projected to be strong consumer demand for safe and sustainable protein, particularly into the future as seafood supplies become less reliable due to changing climatic conditions. China and the USA are New Zealand's top two export seafood markets by value (Seafood New Zealand, 2019). China in particular is projected to have increasing demand for New Zealand's seafood (Coriolis, 2019a) and businesses that are able to deliver safe, sustainable seafood consistently to Chinese markets have an opportunity to prosper (KPMG, 2020c). Both large scale ecosystem change and disruptions to climatic parameters may make it difficult to keep fish healthy in marine waters (KPMG, 2020c). Due to these constraints, aquaculture is projected to become the fastest-growing food sector in late 2020 (Poppick, 2019).
Construction	<ul style="list-style-type: none"> Additional opportunities from demand for low-carbon buildings and infrastructure Increased energy efficiency of houses and other buildings leading to reduced operational energy costs Strengthened local supply chains

8.2 Industry identified transitional climate change risks and opportunities – Phase 2

During the Phase 2 workshops participants identified current and planned transition actions in addition to future transition actions. Participants were asked to identify actions that related to the following preidentified transitional climate change risks from Phase 1:

- Reduction in the competitiveness of exports
- Increased costs of inputs to production due to price on carbon
- New costs of compliance associated with carbon-related regulation
- Increased costs of transporting input materials
- Additional capital outlays required for fuel switching and energy efficiency retrofits
- Reputational risk if business fails to transition
- Higher electricity costs
- Stranded assets.

This section of the report involves synthesizing these actions identified by industry stakeholders. With regards to the current and planned transition actions, no verification has been carried out with respect to whether these actions are underway in their respective industries. These workshop outputs essentially read as a wish list but do capture the genuine concerns of each industry sector. Detailed outputs from all workshops (both face to face and online) have been captured in

Table 17 below. We have captured written contributions and in some cases further follow up would be needed to more closely define what action/recommendation is being requested. Key findings based on information from the face to face workshops are as follows:⁷²

- All sectors identified the need for financial support, whether that be with regards to compliance costs or managing increasing costs within the supply chain. There were multiple references to the need to support a just transition, to ensure a fair and equitable transition for all.
- All sectors identified the need for technical guidance and/or clearer guidance from local and central government, whether that be creating additional policy or support to comply with pre-existing policy. Many participants understood the climate change risks identified but struggled with how to translate that knowledge into tangible action for their business/industry.
- It was suggested that having industry action plans to translate knowledge into tangible and plausible actions for businesses to implement would be a useful first step in preparing industries to implement changes

Table 17: Summary of adaptation and transition actions from workshop participants

Current & Planned transition actions	Future transition actions
Food and Beverage	
<p>Currently investigating the use of certification schemes such as Global Good Agricultural Practice (Global GAP) and New Zealand Good Agricultural Practice (NZ GAP) (farm assurance program ensuring safe and sustainable agricultural production) – international markets are expecting these certification schemes now</p> <ul style="list-style-type: none"> • Data plays a crucial role; need to measure the impact farming has on the environment and data is important for this. 	<p>Sector requires financial and technical support to transition:</p> <ul style="list-style-type: none"> • Financial support is needed for SMEs to deal with compliance costs • Technical support is need to help SMEs with using carbon measurement tools (even the development of simple calculators to understand energy and water usage would be helpful); specific research for what New Zealand horticulture needs for regenerative agriculture would be useful – horticulturally rather than pastorally-focused • Business access to trusted advisors would be valuable to businesses to implement technical support; would have a secondary aim of removing regulatory distrust • Industry believes there is a need to invest in research and design to develop better technology and not assume what is currently available is the best possible option. <p>Enhanced district/regional planning processes and policy needed to support the transition across the sector:</p> <ul style="list-style-type: none"> • Protect productive land for food growing rather than urban development - incorporate access to food in urban land use planning • Increase food markets across the region to reduce consumer transport costs

	<p>Clearer communication with consumers needed:</p> <ul style="list-style-type: none"> • Publicise the narrative of carbon reduction efforts to counter the increased costs to build more resilience into our organization • Food miles pressure/shaming is a risk but businesses need to advertise the reality of this e.g. onions exported from NZ have a lower carbon footprint than those grown locally in overseas markets due to our low emissions methods of production • Need to make sure both consumers and markets support businesses as they transition to more climate resistant varieties. <p>Investigate innovative approaches/actions. For example:</p> <ul style="list-style-type: none"> • Utilize market ready soil carbon sequestration models that are recognised and operational • Investigate the native reforestation market - repopulating unused farmland • Focus on large scale innovation spending instead of spending on remedial risks • The internet of things and block chain can be used to provide provenance and value add from custom production for overseas markets <p>Implement regenerative farming and circular economy actions:</p> <ul style="list-style-type: none"> • Transition to regenerative growing practices needs more research as soon as possible – e.g. cost benefit analysis • Find ways to empower Māori landowners to become more involved in food production - using mātauranga Māori and kaupapa around food production and food sovereignty could be a community solution • Use nitrate leaching technology to measure and manage leaching and emissions • Leverage New Zealand’s opportunity to produce ‘green food’ (i.e. low carbon food) using regenerative and carbon zero farm management as an opportunity for export competitiveness • Robust monitoring of new pests and diseases and best management practices; herbicide resistance is an issue, so finding regenerative methods to assist is key • Find a substitute for fertiliser imports - these are finite resources too and often from unethical international sources, so good alternatives needed in future • Opportunity to investigate the use of waste or outputs from other local companies as inputs to production processes e.g. citizen beer (made from surplus bread).
Screen	

<p>Currently using emissions measuring tools.</p>	<p>Sector requires financial and technical support to transition:</p> <ul style="list-style-type: none"> • Including a mental health fund for sector due to climate change impacts • Technical support - compliance costs and increased carbon offset costs may make Auckland a more expensive film destination; resourcing a sustainability manager for compliance would help the screen sector reduce these costs • Expand screen production grant criteria to allow for climate change funding for transition – a percentage of this grant should go towards sustainable retrofits • Align with sponsors/partners and set higher expectations for sustainable production, with a focus on attracting low-carbon or green screen clients around Auckland • Invest in industry startups to take advantage of the changing sector, including AR/VR. <p>Clearer communication with consumers needed:</p> <ul style="list-style-type: none"> • Advertise cancellation fees - expectation management and contingencies around advertising for shoot schedule disruption. <p>A key transition focus is on energy upgrades and retrofits</p> <ul style="list-style-type: none"> • Including installing solar power; adapting generators to move away from diesel; electric boilers to water tanks.
<p>Construction</p>	
<p>Moving towards more sustainable methods of construction:</p> <ul style="list-style-type: none"> • Transitioning fuel and fleet • Developing new technology • Understanding baseline carbon + building performance • Offsite manufacturing of modular housing • Installing electric rather than gas into state houses • Reducing carbon intensity of building materials such as cement • Intensifying the built environment. <p>Changing operational behaviour to facilitate sustainability:</p> <ul style="list-style-type: none"> • Moving to TOTEX (total capital expenditure and operational expenditure approach) model instead of capital expenditure and operating expenditure because it allows for energy efficiency 	<p>Sector requires financial support to transition:</p> <ul style="list-style-type: none"> • Increased costs within supply chain – erosion of margin within long-term contractors, clients may not be in a position to fund cost of services • Green infrastructure needs to be cost accessible for all communities. <p>Sector needs to move towards more sustainable methods of construction, including:</p> <ul style="list-style-type: none"> • Decarbonisation of heavy fleet to biofuel and hydrogen fuel • Large scale prefabrication • Offsite manufacturing • Modular housing • Automation • Work with the supply chain to reduce embedded carbon in products • Plant climate resilient plants in landscaping and recycled materials in streetscapes.

<ul style="list-style-type: none"> • Socialising climate change within organisations. <p>Developing technical skills in carbon measurement and risk reporting:</p> <ul style="list-style-type: none"> • Setting science-based targets and decarbonisation plans out to 2030 • Improved measurement and report of carbon footprint and climate risk under CDP (Carbon Disclosure Project), DJSI (Dow Jones Sustainability Indices) TCFD (Taskforce on climate-related financial disclosures). <p>Increasing awareness and understanding about climate change</p>	<ul style="list-style-type: none"> • Support the growth of local sector to be able to supply alternative materials (reducing reliance on overseas products) • Transition current plants and fleet to renewable energy e.g. electricity/hydrogen/biofuel • Produce concrete using more sustainable methods. <p>Policy/regulatory changes needed to support the transition:</p> <ul style="list-style-type: none"> • Support changes to building code • Account for scope 3 emissions in all projects - both reporting and target-setting • Facilitate reuse of materials - don't necessarily need competition in the market for materials production, could have one supplier and regulate price • Higher density, lower footprint developments primarily in brownfield sites. <p>Educate and train to foster innovation within the sector:</p> <ul style="list-style-type: none"> • Education and training of industry creates a bed of innovation; innovation reduces costs and carbon emissions; there is a need to invest early to be an early adapter • Clearer guidance needed (reputational risk for being a slow adopter versus early adopter and increased exposure to risks) • Need to educate horizons return on investment vs. cost. <p>Planning and regulation changes/wider infrastructure changes:</p> <ul style="list-style-type: none"> • Decentralised energy trails for housing developments • Processes to identify future at risk sites where construction should be avoided • Planning for end of life policy alterations to drive action • Minimise the use of agricultural land in new building developments (to safeguard food production) • Upgrading port infrastructure and diversifying port usage – looking at using alternative ports such as Whangarei and Tauranga that have a resilient rail connection.
Visitor Economy	

<ul style="list-style-type: none"> • Visitors can currently offset flights. • Current and planned future fleet program; transitioning fleet to biofuel and EVs; planning to expand to hydrogen EVs. 	<p>Sector requires financial support to transition, especially as very heavily impacted financially by COVID-19:</p> <ul style="list-style-type: none"> • Need an increase in visitor numbers and revenue to ensure there are funds for visitor economy businesses to transition • Need to prioritise capital investment and adaptation in education and training on sustainable practices in the sector (e.g. working from home and incentivizing public transport use) • There were also multiple comments around financing (e.g. regional micro-financing) and ensuring a just transition for businesses and society, including ensuring the transition is equitable, allowing for a culturally sensitive transition (which considers indigenous wisdom) and receiving financial support from the government. <p>Clear guidance needed from government bodies around a plan for the industry:</p> <ul style="list-style-type: none"> • Multiple comments also exist around the need for the government to provide clear governance for business in terms of adapting and transitioning • Multiple comments around the value in the government providing high level recommendations for the sector, for example a list of recommendations/actions businesses can implement to increase their resilience/facilitate their transition • Better dialogue needed between regulators and business to understand capital constraints and business cycle - effects of policies may take time to emerge • National policies needed to lessen impact on visitor experience - cannot have patchwork of regional responses. <p>Businesses also require technical support, particularly in terms of climate accreditation and/or training programmes.</p>
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9.0 Implications for recovery from COVID-19

9.1 COVID-19 impacts to date

The global response to COVID-19 has had profound economic and social implications. Physical distancing measures and enforced lockdowns were a common mitigation strategy used by many

countries to curb the impacts of the pandemic which have resulted in severe social and economic implications (Treasury, 2020a).

There have been wide reaching impacts both nationally and regionally. Nationally, key economic indicators such as GDP, unemployment and seasonally adjusted labour force participation have decreased from the previous December 2019 quarter. Senior economists at both ANZ Bank and ASB Bank have predicted New Zealand will experience a deep but short-lived contraction in GDP growth as a result of the pandemic. (Gray, 2020).

Various economic packages have been developed in an attempt to reduce the economic impacts of the pandemic. On 9 March 2020 the government announced the Business Continuity Package. As part of the New Zealand budget announced on 14 May 2020, an additional \$50 billion was put towards establishment of the COVID-19 Response and Recovery Fund (Treasury, 2020b). Within this Fund, the Government has offered specific support for small to medium-sized enterprises including interest free loans, tax relief to SMEs. The government also offered specific support to regional businesses, including webinars and business mentoring support (Treasury, 2020c).

As at 14 May 2021, New Zealand has weathered the economic storm of COVID-19 remarkably well, largely due to the successful management and eradication of COVID-19 within our domestic borders. The seasonally adjusted unemployment rate fell to 4.7% in the March 2021 quarter, which was a 0.2% decrease from the December 2020 quarter (Stats NZ, 2021). The market has demonstrated strong employment trends in sectors such as healthcare, construction and public administration (Infometrics, 2021). However, the rate of underutilization, which is just as important as the unemployment rate, has risen since last quarter by 0.4% (Stats NZ, 2021).⁷³ In Auckland, there was an increase of 31,600 underutilised people; this has risen from 9.5% to 12.4% since February to March 2021 (Stats NZ, 2021). Furthermore, the 2020 summer affected regional economies that rely on tourism (including Auckland), with the season having a 10% decline in tourism spending compared to the same period in 2020 (Infometrics, 2021). The opening of the trans-Tasman bubble will provide an economic boost to tourist regions, although it is unlikely to be as much of an economic boost as anticipated (Infometrics, 2021).

9.2 Sector-specific impacts

The Food and Beverage, Construction, Tourism and Screen sectors all face unique challenges as a result of COVID-19. Key challenges to the food and beverage sector include labour shortages and a contracted market for premium food and beverage distribution channels (due to contraction of the hospitality sector) (KPMG, 2020a). Exporters reliant on airfreight may need to find additional avenues of transport due to the contraction of this industry (KPMG, 2020a). The challenges to this sector are exacerbated by the impacts of a severe drought faced by the upper half of the North Island for the first half of this 2020 (KPMG, 2020a).

The COVID-19 outbreak has demonstrated that international consumers will pay a premium price for food that they consider is safe (KPMG, 2020a). Ensuring New Zealand remains free from pests and diseases that overseas primary produce markets are exposed to is key to ensuring New Zealand retains this competitive advantage.

Lockdowns have highlighted the vulnerability of food and beverage supply chains and the risks around food security (KPMG, 2020a). While part of the government's response has been to invest in shovel-ready projects, investing in stimulus packages to support rural resilience such as rural connectivity and water storage and distribution will increase food security (KPMG, 2020a).

For the construction sector, site shut-down resulted in increased delays to construction projects and significant losses for major construction companies (KPMG, 2020b). Although construction sites are now open, construction companies have faced increased health and safety costs from additional requirements needed to comply with level 3 and 2 restrictions. At present, these restrictions have eased now that the country is at level 1. However, border restrictions continue to limit the ability to

⁷³ The underutilisation rate incorporates the following categories: those who don't have a job but are able to work and either are or are not actively seeking employment; those who are underemployed as they work part-time and want to increase their working hours per week; those who are unavailable to start work but are looking for a job and will be available to start work within the next month (Statistics New Zealand, 2021).

import labour and either limit or increase the complexity required to import specialised construction skills from overseas. The sector is vulnerable to labour shortages if overseas workers cannot be sourced, which may impact on the sectors overall ability to deliver major infrastructure works (both private and public) (KPMG, 2020b).

In the short-term, the construction sector may experience either late or default payment from built assets in the residential sector, which will have flow-on effects for developers and construction companies (KPMG, 2020b). In the long-term, there may be reduced/deferred funding for private developments and capital projects depending on how much the sector contracts (KPMG, 2020b).

The screen sector faced major impacts when lockdown hit, as production houses were unable to film/rehearse and artists were unable to publicly perform. Approximately 55 projects were affected by the lockdown period; 47 domestic productions and 8 international productions (Hunt, 2020).

However, as New Zealand maintains a low number of COVID-19 cases, the country has a competitive advantage as a relatively safe area for filming productions. Annabelle Sheehan, Chief Executive of the New Zealand Film Commission, has indicated that many international studios have expressed interests filming productions in New Zealand (Hunt, 2020).

Although New Zealand has strict border controls in place, they demonstrated support to the sector by allowing international filming crews to enter New Zealand to film Avatar 2 in June 2020 (Roy, 2020). This provides confidence to other international film studios that the government is willing to be flexible around immigration to support growth in the domestic film sector.

9.3 Recovering from COVID

9.3.1 The COVID-19 recovery context

Across the world, emergency COVID-19 economic rescue packages have been designed and implemented to ensure the continued solvency of businesses and the livelihoods of citizens. These packages have focused on prevention of immediate harm. In the coming months longer term COVID-19 economic recovery packages will be introduced by governments around the world, including New Zealand. New Zealand's recovery package will have a significant impact on the ability of Auckland and New Zealand to achieve emissions reduction targets. With this in mind, we suggested in our Phase 1 Technical Report that Auckland should focus on increasing employment and economic growth, while accelerating the transition to a low-carbon economy and adapting to physical climate change risks.

To meet these goals AU could advocate for and implement projects and policies:

- with **high economic multipliers** to create jobs
- that can be **rapidly implemented** to reduce the time people spend out of work
- that **accelerate progress towards net-zero emissions** by 2050 to reduce greenhouse gas emissions and attendant physical climate change risks
- which increase the **climate resilience** of Auckland's communities and economies.

9.3.2 Auckland Council COVID-19 recovery response

Operating cash income across Auckland Council is \$250 million less than the previous year due to COVID-19). The impacts of the COVID-19 pandemic on Auckland has been substantial over the 2020/2021 year.

During 2020 Auckland Council noted the need to manage the financial impacts of COVID-19 in ways that are sustainable and aid a quick financial recovery while also upholding key principles important to the Auckland region.

In June 2019, Auckland Council declared a climate emergency, signaling its intention to put climate change at the forefront of decision making. During, and post the first COVID-19 lockdown, Auckland Council continued finalising Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan with formal adoption on 21 July 2020.

Through conversations and workshops with Auckland Council and AU, AECOM recognises that Auckland Council's desired response to post COVID-19 economic recovery identifies the need to invest in a future-focused and ecologically sustainable economy, building greater resilience to a variety of shocks. This response also drives Auckland Council to examine its economic and social roles to support the Auckland community, both presently and into the future. The desired response supports actions that guide Auckland towards a low-carbon and resilient future, aligning with the principles and outcomes of Auckland Plan 2050 and Te Tāruke-ā-Tāwhiri. For example: Auckland Council and AU need to continue climate-positive ways of working and living; prioritise infrastructure that supports climate-positive behaviours; reinforce the connection between climate action and post-COVID-19 recovery; prioritise implementation of the climate plan on key opportunities that support long-term, resilient recovery; advocate for climate focus in government recovery, future-ready industries; and reinforce the equity dimension of climate action and ensure interventions help the most vulnerable to be more prepared for the next shocks.

During the Phase 1: Review workshops with ATEED (now AUL) and Auckland Council we covered potential desired responses (provided by ATEED for the Development, Tourism, Tertiary Education and Food System subsectors. Note that these subsectors do not accurately align with the sectors and subsectors that form part of this CCRA. The desired responses for these subsectors have been outlined below. We have also included additional subsector responses that we believe are relevant to the four key sectors which are the subject of this CCRA. Potential response actions for each area have been tabulated and then themed according to whether such actions accelerate the low-carbon transition and enhance climate resilience.

In general, the desired responses outlined below will support the transition to a low carbon economy, and will enhance climate resilience. However, these subsector responses may lead to adverse outcomes if the effects of climate change are not fully considered. Auckland Council needs to consider all their economic recovery activities and programmes with a climate lens to ensure that they reduce risk.

Visitor Economy

The two tables below analyse the potential response of two relevant subsectors to the Visitor Economy: the tourism subsector and the tertiary education subsector.

Tourism

Potential response action to recovery	Accelerates the low-carbon transition	Enhances climate resilience
Showcase Māori tourism	No significant effect	May increase sensitivity to loss or damage or Māori cultural heritage sites.
Develop local small scale and environmentally sustainable tourism	Potential to reduce transport related GHG emissions	No significant effect
Use technology to provide events and experiences	Potential to reduce transport related GHG emissions and consumption-based GHG emissions.	Potential to reduce dependence on natural environments, and exposure to environmental hazards. Potential to increase sensitivity to risks associated with ICT and electricity system disruptions.
Emphasise and celebrate Auckland's cultural diversity	No significant effect	No significant effect
Retrain and redeploy labour into other sectors	Potential to build labour force capacity in low-carbon growth sectors. Potential to build labour force capacity in high-carbon sectors.	Potential to reduce sensitivity to all visitor economy related risks.

Potential response action to recovery	Accelerates the low-carbon transition	Enhances climate resilience
Repurpose accommodation stock into rental stock or apartments	No significant effect	No significant effect
Repurpose facilities to other uses	No significant effect	May increase adaptive capacity to respond to climate risks if other venues are available.
Repurpose the visitor offer to a new sustainable model	Potential to reduce transport related GHG emissions and consumption-based GHG emissions.	May reduce degradation of the natural environment

Tertiary Education Sector

Potential response action to recovery	Accelerates the low-carbon transition	Enhances climate resilience
The multiple tertiary training providers to look at alternative ways of teaching and offering	No significant effect	No significant effect
Assessment the strengths and vulnerabilities of the international student model across the whole sector	No significant effect	Increasing awareness of strengths and vulnerability may encourage risk reduction efforts
Invest in remote /distance learning	Potential to reduce transport related GHG emissions and consumption-based GHG emissions.	Potential to increase sensitivity to risks associated with ICT and electricity system disruptions.
Vocational training alongside taught courses	Potential to build labour force capacity in low-carbon growth sectors. Potential to build labour force capacity in high-carbon sectors.	No significant effect
AU's Study Auckland team to support this direction	No significant effect	No significant effect
Provide students alternatives to upskilling and practical employment opportunities in council	No significant effect	No significant effect
Increase existing career and education services for rangatahi Māori to support upskilling for a post COVID-19 world.	Potential to build labour force capacity in low-carbon growth sectors.	Potential to reduce sensitivity of Māori visitor economy related risks if they are employed in a less-risky sector.
AU to work with sector on alternatives to attract students	No significant effect	No significant effect

Construction Sector

The two tables below analyse the potential response of two relevant subsectors to the Construction sector: development and waste and recycling.

Development

Potential response action to recovery	Accelerates the low-carbon transition	Enhances climate resilience
Recovery stimulus = ideal opportunity towards meeting NZ emission targets	Acknowledging the opportunity provided by COVID-19 is a pre-requisite for targeted emissions reduction efforts	Can enhance climate resilience if investment does not increase exposure to physical climate change risks.
Right investments contribute to greater resilience and adaptation	No significant effect	Acknowledging the need to invest in climate resilience and adaptation is a pre-requisite for efforts to build climate resilience
Invest towards emission reduction by 2030 and achieving greater resilience	Direct investment in emissions reduction efforts will support the transition to a low carbon economy	Direct investment in adaptation and planning will support climate resilience
Increase investment in long term sustainable projects	Direct investment in emissions reduction efforts will support the transition to a low carbon economy	Sustainable projects will likely support climate resilience
Capitalise on likely lower project costs due to competition and sharper pricing	Lower project costs are common to all projects, including non-transition aligned projects.	Lower project costs may support the delivery of climate resilience building efforts that would otherwise be economically unviable
Mix and spread stimulus projects to benefit SMEs and Māori enterprise	May help reduce transitional climate change risks	Benefits to SME's and Māori enterprises has the potential to increase adaptive capacity.

Waste and Recycling

Potential response action to recovery	Accelerates the low-carbon transition	Enhances climate resilience
Invest in recycling and refuse infrastructure	<p>Potential to reduce transport related GHG emissions and GHG emissions embedded in supply chains.</p> <p>Potential to develop new skills that are required for the low-carbon transition.</p> <p>Potential to support consumer choice to reduce consumption related GHG emissions.</p>	Potential to reduce the risk of disruption to supply chains
Explore options to design waste out of the system		
Support the waste and recycling market		
Work with the construction sector as it recovers, to reduce waste to landfill		
Turn waste into wealth (innovative and productive uses of waste)		
Advocate to central government for onshore processing		
Advocate for product stewardship (e.g. national container deposit scheme)		
Lead by example, improve waste diversion from our own activities	No significant effect	No significant effect

Potential response action to recovery	Accelerates the low-carbon transition	Enhances climate resilience
Integrate waste minimisation into design, manufacturing, retailing and consumer choices	Potential to reduce transport related GHG emissions and GHG emissions embedded in supply chains.	Potential to reduce the risk of disruption to supply chains and to ensure products are fit for purpose
Increase resilience by exploring onshore processing solutions and align with Te Ao Māori worldview	Potential to reduce emissions through adoption of Māori knowledge that leads to more sustainable design and construction practices	
Advocate for ongoing central government stimulus funding for waste minimisation	Potential to reduce GHG emissions embedded in supply chains.	No significant effect
Accelerate investigation into the future options for paper and cardboard processing	Potential to reduce GHG emissions associated with land-use change	No significant effect

Food and Beverage

The table below analyses the potential response for the Food and Beverage sector using: the Food System.

Potential response action to recovery	Accelerates the low-carbon transition	Enhances climate resilience
Develop an urban agriculture sector, also helping unemployment	Potential to reduce transport related GHG emissions	Diverse systems, in different locations, easily accessible to the population may enhance climate resilience Increased urban green space can help with urban heat island effects and may reduce flooding
Low-carbon diets	Has significant potential to reduce diet-based greenhouse gas emissions	No significant effect
Support local business through a local, sustainable food procurement policy	May increase capacity for sector to engage in lower carbon production practices	No significant effect
Develop long-term supplier contracts that build capacity and provide business security to council suppliers	May increase capacity for sector to engage in lower carbon production practices	May increase adaptive capacity by providing certainty to allow investments and planning over longer timeframes
Support community groups, not for profits and marae to play a greater role in a sustainable food system and food security	Potential to reduce transport related GHG emissions	Can increase community resilience through job creation and increasing equitable access to low carbon healthy food.
Support transition to regenerative urban and rural food production	Reduce carbon emissions associated with extraction and manufacture of farm inputs such as fertilisers, reduce carbon loss from soils and increase soil carbon sequestration.	Reduce reliance on depleting finite mineral resources and imports from overseas; financial advantage in converting waste to resource (e.g. compost); increased resilience to drought through increased soil organic matter; improved soil health leads to healthier, more pest resilient

Potential response action to recovery	Accelerates the low-carbon transition	Enhances climate resilience
		plants requiring fewer inputs, improved biodiversity; reduced soil leaching and improved water quality.
Support community led local food movements and low-carbon diet behaviour	Potential to reduce transport related GHG emissions Potential to reduce diet-based greenhouse gas emissions	No significant effect

10.0 Conclusion

AECOM has undertaken this economic CCRA across five key Auckland economic sectors to support AU in developing their potential responses to COVID-19 economic recovery. AECOM analysed climate drivers at both the present, 2040 and 2110 timescales to identify both physical climate change risks and opportunities for each of the sectors. AECOM also developed a transition scenario (detailed in **Appendix A**) to highlight potential transitional climate change risks and opportunities for the respective sectors. Results from both the physical and transition risk assessments provide AU with an understanding of the implications of climate change related risks and opportunities.

Each of the key sectors has different priority risks, based on their individual sector attributes. Understanding the climate change risks, their associated consequences and potential adaptation actions is crucial to increase the economic resilience of Auckland. Understanding these priority climate change risks, their associated consequences and potential adaptation actions can assist AU to incorporate relevant measures into economic recovery planning in light of COVID-19. It can also assist AU with resilience planning for each sector, ultimately increasing the economic resilience of Auckland.

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Appendix A

Assessment Methodology Statement

Auckland Economy Climate
Change Risk Assessment

Auckland Tourism, Events and
Economic Development

09-Aug-2021

AECOM

Assessment Methodology Statement

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Client: Auckland Tourism, Events and Economic Development

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Quality Information

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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 (Intergovernmental Panel on Climate Change [IPCC], 2014).
Adaptive capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2014).
Biodiversity	The variability among living organisms from terrestrial, marine and other ecosystems. Biodiversity includes variability at the genetic, species and ecosystem levels (IPCC, 2014).
Climate	Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (IPCC, 2014).
Climate change	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes or trends in the mean and/or the variability of its properties, and that persists for an extended period, typically decades to centuries. Climate change includes natural internal climate processes or external climate forcings such as variations in solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014).
Climate projection	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which is in turn based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realized (IPCC, 2014).
Confidence	A qualitative measure of the validity of a finding, based on the type, amount, quality and consistency of evidence (e.g., data, mechanistic understanding, theory, models, expert judgment) and the degree of agreement (MfE, 2019).
Consequence	The outcome of an event that may result from a hazard. It can be expressed quantitatively (e.g., units of damage or loss, disruption period, monetary value of impacts or environmental effect), semi-quantitatively by category (e.g., high, medium, low level of impact) or qualitatively (a description of the impacts) (adapted from Ministry of Civil Defence and Emergency Management [MCDEM], 2019).
COVID-19	COVID-19 is a disease caused by a new strain of coronavirus. 'CO' stands for corona, 'VI' for virus, and 'D' for disease.
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 by a change in external stresses that a system is exposed to. In the context of climate change these are normally specific climate and other biophysical variables (IPCC, 2007).

Extreme weather event	An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season) (IPCC, 2014).
Forest Fire Danger	Fire danger in New Zealand is assessed via a Fire Danger six class system, which uses fire intensity to indicate the difficulty of fire suppression (New Zealand Forest Owners Association, 2018). There are six ratings, which range from low (green) to very extreme (purple).
Greenhouse gas	Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and clouds. This property causes the greenhouse effect. Water vapour (H ₂ O), carbon dioxide (CO ₂), nitrous oxide (N ₂ O), methane (CH ₄) and ozone (O ₃) are the primary greenhouse gases in the Earth's atmosphere.
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources (IPCC, 2014).
Kaupapa Māori	Kaupapa Māori theory is based on a number of key principles: Tino Rangatiratanga - The Principle of Self-determination Taonga Tuku Iho - The Principle of Cultural Aspiration Ako Māori - The Principle of Culturally Preferred Pedagogy Kia piki ake i ngā raruraru o te kainga - The Principle of Socio-Economic Mediation Whānau - The Principle of Extended Family Structure Kaupapa - The Principle of Collective Philosophy Te Tiriti o Waitangi - The Principle of the Treaty of Waitangi Ata - The Principle of Growing Respectful Relationships
Likelihood	The chance of a specific outcome occurring, where this might be estimated probabilistically (IPCC, 2014).
Lockdown	Refers to the period of time New Zealand spent at Alert System Level 4, which was from 25 March to 27 April 2020.
Mitigation	A human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2014).
Potential evapotranspiration deficit (PED)	As the growing season progresses, the amount of water that is lost from the soil can exceed the amount of rainfall which creates a deficit. The difference between this demand and the actual evapotranspiration is defined as the 'potential evapotranspiration deficit', or PED (Pearce et al, 2018).
Primary production	The production processes associated with agriculture, horticulture and viticulture production. Forestry is excluded.
Representative Concentration Pathway (RCP)	A suite of representative future scenarios of additional radiative heat forcing at the Earth's surface by 2100 (in Watts per square metre), which is the net change in the balance between incoming solar radiation and outgoing energy radiated back up in the atmosphere. Each RCP can be expressed as a

	greenhouse gas concentration (not emissions) trajectory adopted by the IPCC for its Fifth Assessment Report (AR5) in 2014 (IPCC, 2014).
Physical risks	Physical risks relate to the physical impacts of climate change. Physical risks resulting from climate change can be event driven (acute) or gradual longer-term shifts (chronic) in climate patterns.
Resilience	The capacity of social, economic, and environmental systems to cope with a hazardous event, trend or disturbance by responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (IPCC, 2014).
Risk	The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. The term risk is used to refer to the potential, when the outcome is uncertain, for adverse consequences on lives, livelihoods, health, ecosystems and species, economic, social and cultural assets, services (including environmental services) and infrastructure. Risk results from the interaction of vulnerability, exposure and hazard. To address the evolving impacts of climate change, risk can also be defined as the interplay between hazards, exposure and vulnerability (IPCC, 2014).
Risk Assessment	The overall qualitative and/or quantitative process of risk identification, risk analysis and risk evaluation, with multiple entry points for communication and engagement and monitoring and reviews (AS/NZS ISO 31000:2009, Risk Management Standard).
Seasonal Severity Rating	Seasonal Severity Rating (SSR) is a seasonal average of the Daily Severity Rating (DSR), which captures the effects of both wind and fuel dryness on potential fire intensity, and therefore control difficulty and the amount of work required to suppress a fire. It allows for comparison of the severity of fire weather from one year to another (NRFA, n.d, as cited in Pearce et al, 2018).
Te Ao Māori	The Māori world view (te ao Māori) acknowledges the interconnectedness and interrelationship of all living & non-living things. There is no 'one' Māori worldview.
Transition risks	Transition risks are risks-related to the transition to a lower-carbon economy. Transitioning to a lower-carbon economy may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputational risk or opportunities to organizations (TCFD 2018).
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).

1.0 Introduction

1.1 Purpose of the Assessment Methodology Statement

This Assessment Methodology Statement (AMS) was developed to guide the delivery of the Auckland Economy Climate Change Risk Assessment (CCRA). It documents the methodology used to identify and assess climate risks and opportunities to the construction, food and beverage, visitor economy, and screen and creative sectors.

The AMS accompanied the Project Plan as a key project document for the Auckland Economy CCRA. The AMS was updated as required throughout the life of the project to reflect agreed changes in methodology and scope and provide an accurate record of the method applied.

2.0 Setting the context

2.1 Scope and objectives

The CCRA was undertaken in two distinct phases. The first Phase was undertaken between April and June 2020. The second Phase is currently underway and will span January – May 2021.

2.1.1 Phase 1

Climate change is already affecting Auckland. The Auckland Economy CCRA will add to the knowledge of climate change risks already identified through the Climate Change Risk Assessment technical report series. The CCRA is focused on climate change risks and opportunities to the construction, food and beverage, visitor economy, and screen and creative sectors of Auckland's economy. The CCRA will identify and evaluate risks and opportunities that may arise from hazards that are caused, exacerbated or influenced by climate change. The CCRA will also identify risks and opportunities that may arise from a transition to a low-carbon economy.

The objectives of the Auckland Economy CCRA are to:

- Identify and evaluate physical climate change risks, and identify opportunities that may result from physical climate changes;
- Identify risks and opportunities that may result from a transition to a low-carbon economy;
- Explore potential interactions between physical and transition risks;
- Enhance ATEED's understanding of how Small and Medium-sized Enterprises (SMEs) within each sector may be impacted differently by both the physical and transition risks of climate change compared with larger businesses; and
- Explore the implications of climate change related risks and opportunities for economic recovery from Covid-19 to enable the incorporation of relevant measures into support packages as part of economic recovery.

This project was limited to risks and opportunities that arise to the specified sectors in the Auckland region.

2.1.2 Phase 2

Phase 2 of this Economy CCRA will involve more targeted stakeholder engagement than was undertaken in the previous Phase, expansion to consider risks to additional sectors (namely advanced industries) and specific consideration of risks and opportunities to Māori businesses. The project will also consider the current state of adaptation actions through stakeholder engagement only.

Key objectives for Phase 2 are as follows:

- Extending the Assessment to cover key economic sectors not included in Phase 1
- Understanding how identified risks and opportunities may be different for Māori businesses.
- Conducting broader engagement with business on climate risks and adaptation, including engagement specifically targeted at Māori businesses.
- Exploring literature available on financial costs of not transitioning; and
- Synthesizing adaptation actions (both planned and underway) identified through engagement.

In consistency with Task 1 this assessment is limited to risks and opportunities that arise to the specified sectors in the Auckland region. For geographically diverse sectors (such as aquaculture and fisheries), we have considered aquaculture and commercial fishing that is occurring within the geographical location of Auckland (12 nautical miles from land, outside of the exclusive economic zone).

2.2 Sectors and subsectors at risk

2.2.1 Phase 1

Phase 1 of the Auckland Economy CCRA assessed risks and opportunities to four sectors. Description of the sectors, and a list of the subsectors to be assessed within each sector are contained in **Table 1**.

Table 1 Description of economic sectors assessed in Phase 1

Sector	Description
Construction ¹	<p>Preparation, clearing (including demolition) and development of land, and the construction, installation, alteration, repair and deconstruction of buildings, structures and infrastructure.</p> <p>The construction sector includes the following subsectors:</p> <ul style="list-style-type: none"> • Residential construction • Non-residential construction • Infrastructure construction
Food and Beverage	<p>Growing and producing, processing, transporting and distributing fresh, prepared and packaged food, and alcoholic and non-alcoholic beverages.</p> <p>The food and beverage sector includes the following subsectors:</p> <ul style="list-style-type: none"> • Manufacturing • Wholesale • Food Technology • Supply Chain • Agriculture • Viticulture • Horticulture
Visitor Economy	<p>The production of goods and services for consumption by visitors.</p> <p>The visitor economy includes the following subsectors:</p> <ul style="list-style-type: none"> • Tourism • International Education • Business Events
Screen	<p>The industries that produce film and television content for domestic and international audiences and service international productions coming to New Zealand.</p> <p>The screen and creative sector includes the following subsectors:</p> <ul style="list-style-type: none"> • Film industry infrastructure • Filming locations

¹ This assessment will only consider the physical impacts of climate change to the built environment as they relate to the characteristics and level of demand for construction services.

2.2.2 Phase 2

Phase 2 completed the Phase 1 assessment by adding Fisheries and Aquaculture to the Food and Beverage sector. Phase 2 also involved a high-level screen of the Advanced Manufacturing and Technology sectors. This will differ to the more in-depth risk assessment of the four sectors listed above. The climate risk screen will consider, at a high level, whether any of the Advanced Manufacturing and Technology sub sectors are exposed to the physical climate change risks identified in Phase 1 of the ECCRA.

Table 2: high level

Sector	Description
Advanced Manufacturing and Technology	<p>High level screen of both the Advanced Manufacturing and Technology sectors. Auckland’s Advanced Manufacturing sector can be defined as business processes, technology, materials and capabilities used across a value chain in the design, manufacture or handling of a product or service.² It includes high-value industries that process and fabricate advanced materials.³</p> <p>Auckland’s Technology sector includes the following subsectors:</p> <ul style="list-style-type: none"> • ICT • High-Tech manufacturing; and • Biotech.⁴ <p>We are focusing on those businesses that meet the following criteria:</p> <ul style="list-style-type: none"> • Originate in New Zealand • Retain a meaningful presence in New Zealand • Operate in the high-tech manufacturing, ICT or biotech sectors • Generate at least 10% of their revenue offshore.
Food and Beverage	Added aquaculture and fisheries as one subsector to food and beverage.

In meeting the objectives for Phase 2 in relation to:

- Understanding how identified risks and opportunities may be different for Māori businesses and;
- Conducting broader engagement with business on climate risks and adaptation, including engagement specifically targeted at Māori businesses.

We have adapted our conceptual framework below under 2.3.1 to ensure an appropriate Te Ao Māori perspective is considered throughout the project. A review of Phase 1 work completed, as well as all work completed during Phase 2, will be undertaken, where we will apply a kaupapa Māori approach to determine how the risks and opportunities and adaptation actions identified in Phase 1 and Phase 2 might be different for Māori Businesses.

2.3 Physical risks

2.3.1 Conceptual framework

The assessment used a risk-based conceptual framework, consistent with that which was adopted by the Intergovernmental Panel on Climate Change (IPCC) for the Fifth Assessment Report (AR5) and the National Climate Change Risk Assessment for New Zealand. As shown in **Figure 1**, risk is a function of

² Sourced from email from Auckland Unlimited staff.

³ Auckland Unlimited (2021). Advanced Materials. Retrieved from <https://www.aucklandnz.com/business/economy-and-sectors/sectors-of-importance/advanced-materials>.

⁴ Definition for this sector provided via mail communication with Lit Wei Chin dated 26 March 2021.

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hazards, exposure and vulnerability. Vulnerability in AR5 is understood as a function of sensitivity and adaptive capacity.



Figure 1 Schematic of the functional relationships between the elements of risk: hazards, exposure and vulnerability with a te Ao Māori approach. Adapted from IPCC (2014).

Considering Te Ao Māori in the context of this framework ensures consideration is given to how each component might change for Māori businesses, whether on its own or as an interconnected component. Māori perspectives of the world are based on the proposition that the environment is an interacting network of related elements, each having a relationship to the other and to earlier origins⁵. This framework is adapted to reflect, recognise and apply this perspective within the outcomes of the report.

2.3.1.1 Hazards

The term 'hazard' describes "the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources" (IPCC, 2014, p.5).

2.3.1.1.1 Climate change projections

Climate change projections depend strongly on our estimates of future greenhouse gas concentrations. Future greenhouse gas concentrations are uncertain; they depend on greenhouse gas emissions, which are driven by policy and factors such as economic activity, population changes and technological advances. This uncertainty is addressed by the IPCC through the use of Representative Concentration Scenarios (RCPs), four scenarios of future concentrations of greenhouse gases and climate warming by 2100.

This assessment used climate projections based on RCP8.5, a high emissions scenario characterised by increasing greenhouse gas emissions driven by population growth, increased use of land for agriculture, a heavy reliance on fossil fuels and a high energy intensity and low rates of technology development.

⁵ Durie, M. (1998). *Te Mana, Te Kāwanatanga: The Politics of Self Determination*. Oxford University Press: Wellington. At page 21.

This assessment used projections prepared for the Auckland region by Pearce (et al., 2018). The assessment adopted the six-model average (the ensemble-mean) unless otherwise noted.

2.3.1.2 Exposure

Exposure is “the presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected” (IPCC, 2014, p.5). The project team assessed the potential exposure of sectors and sub-sectors to hazards based upon GIS data provided by ATEED, and the Pearce (et al., 2018) climate change projections. In considering where exposure may differ for Māori businesses particularly, we have considered where the levels of exposure may be compounded due to multiple areas of affectedness being present. Further, this has also been considered where opportunities exist.

2.3.1.3 Vulnerability

Vulnerability is “the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt” (IPCC, 2014, p.5). It is a function of adaptive capacity - the ability of people, institutions, organizations, and systems, using available skills, values, beliefs, resources, and opportunities, to address, manage, and overcome adverse conditions in the short to medium term – and sensitivity - the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. This definition of adaptive capacity enables the application of kaupapa Māori concepts and principals within our analysis.

2.3.2 Timeframes

The assessment identified and rated physical climate change risks for the periods outlined in Table 3. The timeframes align with climate change projections outlined in *Auckland Region climate change projections and impacts* (Pearce et al., 2018).

Table 3 Risk assessment timeframes

Timeframe	Description
Present	Risks occurring in the present day, and those that have been observed over the past 10 – 20 years.
Medium-term (2040)	20-year average for the period 2031-2050
Long-term (2110)	20-year average for the period 2101-2120

2.3.3 Consequence criteria

2.3.4 Phase 1 Consequence Criteria

For the four key sectors listed in Table 1 above the project rated risks in accordance with the risk framework below. The framework was developed to allow the project team to rate risks across subsectors in a uniform way. The framework accounts for both the likelihood of the occurrence of a hazard, or series of hazards that give rise to the risk, and the scale and intensity of the impact of the risk. In this framework, risks are a function of the number of businesses exposed within a subsector, or the percentage of economic activity exposed within the subsector, and the severity of the consequences that stem from the exposure.

Put simply: Risk = exposure x consequence, where exposure and consequence are each scored 1-5. This exposure and consequence criteria is contained within Table 4.

Table 4 Exposure and consequence criteria

	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Extreme (5)
Scale	Few businesses affected	Limited number of businesses affected	A small number of businesses affected	Many businesses affected	More businesses in the subsector are affected than those that are not affected
	OR	OR	OR	OR	OR
	Insignificant percentage of economic activity within the subsector affected	Limited percentage of economic activity within the subsector affected	Some percentage of economic activity within the subsector affected	A large proportion of economic activity within the subsector is affected	More economic activity within the subsector is affected than that which is not affected
Indicative % subsector affected (logarithmic scale)	0-5	6-10	16-30	31-50	51-100
Risk Impact	Insignificant financial losses	Minimal financial losses. No business failure	Moderate financial losses. Losses can be absorbed by almost all businesses. Minor business failure	Large financial losses. Losses can be absorbed by most businesses. Some business failure	Large financial losses leading to widespread business failure
	AND	OR	OR	OR	OR
	No reduction in trust and consumer confidence. No media attention.	Limited reduction in trust and consumer confidence. Some national media attention.	Some reduction in trust and consumer confidence. Short term negative international or national media attention. Short term political attention.	Major reduction in trust and consumer confidence. Sustained negative international or national media attention. Sustained political attention.	Substantial reduction in trust and consumer confidence. Sustained negative international or national media attention. Sustained political attention. Loss of social license to operate.
Opportunity Impact	Insignificant financial benefits.	Minimal financial benefits.	Moderate financial benefits	Large financial benefits	Major financial benefits
	AND	OR	OR	OR	OR
	No increase in trust and consumer confidence. No positive media attention.	Limited increase in trust and consumer confidence. Some short term positive national media attention.	Some increase in trust and consumer confidence. Short term positive international or national media attention.	Major increase in trust and consumer confidence. Sustained positive international or national media attention	Substantial increase in trust and consumer confidence. Sustained positive international or national

					media attention. Expanded social license to operate.

Overall consequence rating (risk)	Score	Correlation to impacts on subsector - risk
Insignificant	1-5	Limited impacts to subsector
Minor	6-10	Some impacts to subsector. Potential for growth in subsector is not significantly constrained.
Moderate	11-15	Subsector able to cope with consequence of risk, but growth in subsector may be constrained
Major	16-20	Subsector may be viable in a diminished or substantially changed form
Extreme	21-25	Subsector may no longer be viable

Overall consequence rating (opportunity)	Score	Correlation to impacts on subsector - opportunity
Insignificant	1-5	Limited impacts to subsector
Minor	6-10	Minor additional potential for growth in subsector
Moderate	11-15	Some additional potential for moderate growth in subsector
Major	16-20	Some additional potential for major growth in subsector
Extreme	21-25	Potential for significant growth in and increase in value-add of subsector

2.3.5 Phase 2 Consequence Criteria

Phase 2 will complete the food and beverage assessment by adding in an additional subsector of analysis, aquaculture and fisheries, as this subsector was not covered in Phase 1. We will apply the above consequence criteria to the aquaculture and fisheries subsectors to complete this assessment (see Table 4).

For Phase 2 we will undertake a high-level screen of the Advanced Manufacturing and Technology sectors. This is predominantly a qualitative exercise. We will assess whether the subsectors are exposed to the risks identified in Phase 1 of the ECCRA based on literature (20-30 documents). This process will help us assess the broad risk spectrum using available information. We will use the same projections and timeframes as used in Phase 1 for the physical climate change risks (RCP8.5 at present day, 2040 and 2110 – see Table 3).

Once exposure is identified, we will use additional high-level criteria to indicate the significance of these risks. The first pass screen will provide a high-level overview of exposure to climate change risks. The goal is to identify sectors that might be at risk and establish whether the risk is large enough to warrant a more detailed risk assessment following this study. Table 5 below contains criteria will allow us to rank the potential consequences of the preidentified risks.

Table 5 Example of screen criteria to be applied to the Advanced Manufacturing and Technology sectors (DRAFT).

Risks derived from hazard projections	Has this risk occurred for this sector?	General description of the consequences that resulted from the historical past event	Is this risk relevant in the present?	Is this likely to be a risk in the medium-term (2030)?	What is the future trajectory of this risk? (from now until 2040)	Consequences that may arise due to projected risk
Maritime infrastructure and maritime transport assets are damaged or destroyed	Yes	e.g. damage to Auckland's Port in X year		e.g. increasing amount of exports sent by sea freight	Increase	Disrupted exports
Information and Communication Technology systems are disrupted						
Electricity supplies are disrupted						
Road networks are damaged or destroyed						
Flights to and from Auckland International Airport are disrupted						
Water supplies are reduced, disrupted or contaminated						
Built assets that are necessary for service provision are damaged or destroyed						

2.4 Transition Risks

Transition risks have been identified for all sectors assessed in Phase 1. For Phase 2, transition risks have been identified the aquaculture and fisheries sector only. The high-level screen undertaken for the Advanced Manufacturing and Technology sectors is not detailed enough to investigate transition risks.

New Zealand’s and Auckland’s emissions reduction targets are indicative of the scale and pace at which decarbonisation efforts must occur, however they provide limited guidance as to what a low carbon future may look like and how the economy will decarbonise. It has been suggested that New Zealand lacks strong policies required to meet its 2030 and 2050 targets (Climate Action Tracker, 2020).

The project team reviewed peer reviewed literature, reports, plans and strategies to develop one possible future scenario that connects present policies and greenhouse gas emissions to the net zero emissions targets. The scenario outlines in brief several trends that are likely to materialise during a transition to a low carbon economy. The purpose of the scenario was to facilitate a discussion on climate-related transition risks and opportunities to the four sectors. No modelling was undertaken. The scenario is presented below.

2.4.1 New Zealand and Auckland at present

New Zealand Policy and Targets

As a signatory to the Paris Agreement, New Zealand has committed to the global transition to net zero emissions, and to reaching net zero emissions sometime in the second half of this century. The transition to a low carbon economy in New Zealand will mean dramatic change across all industries, particularly the Agriculture and Energy sectors, which contribute at 48 per cent and 41 per cent of gross emissions respectively, as shown in **Figure 2**.

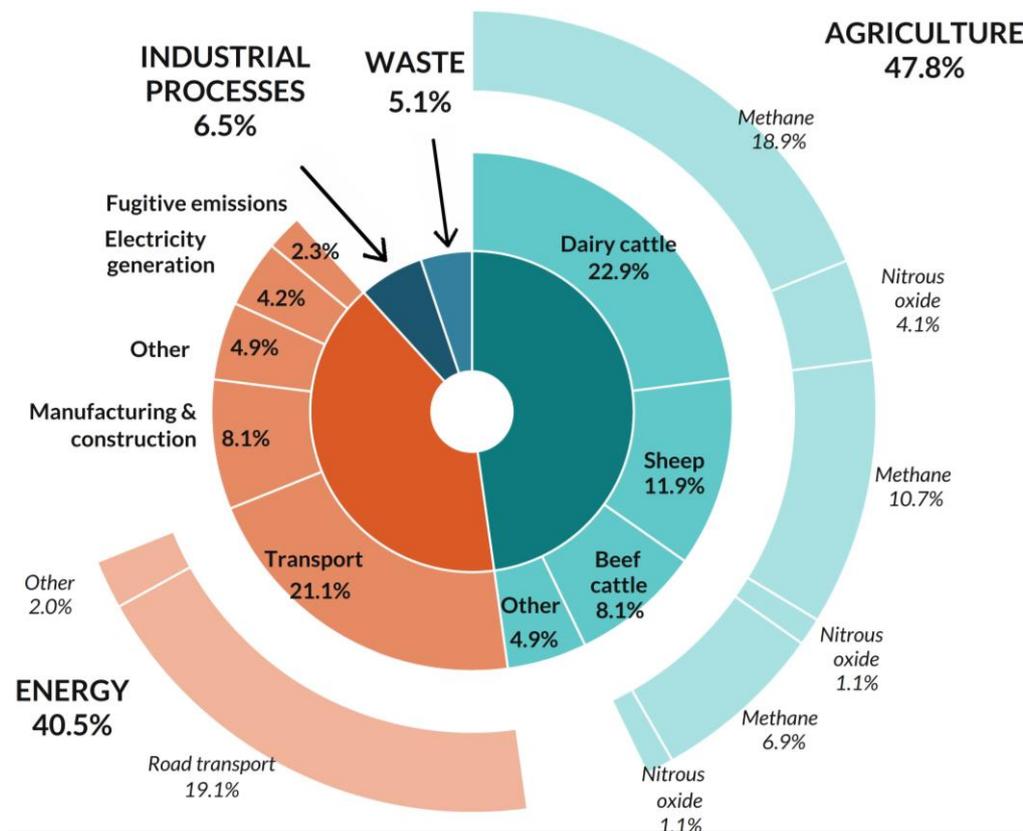


Figure 2 New Zealand's gross GHG emissions – 2018 (MfE, 2020a)

New Zealand has shown leadership by passing the Climate Change Response (Zero Carbon) Amendment Act 2019, the world's second-ever Zero Carbon Act, which aims to achieve net zero emissions of all greenhouse gases, except for methane emissions from agriculture and waste, by 2050. The Climate Change Response Act strengthens former targets to reduce GHG emissions by 50 per cent by 2050, however the Act, sets a framework, and does not introduce any new policies to reduce emissions.

At present, New Zealand's main instrument to reduce greenhouse gas emissions is an Emissions Trading Scheme (NZ-ETS). The NZ-ETS incorporates forestry, liquid fossil fuels, stationary energy and industrial processes, and waste and synthetic greenhouse gas sectors. A slow but steady increase in the price on carbon has occurred since the NZ-ETS has transitioned into a domestic-only scheme (MfE, 2016). The government is in the process of amending the NZ-ETS (New Zealand Parliament, 2019).

A green investment bank – New Zealand Green Investment Finance (NZGIF) – was established by the Crown in December 2018 to catalyse investment in low-emissions initiatives. NZGIF was set up with capital of NZD\$100 million and is targeting the transport, process heat, agriculture, energy efficiency and distributed energy resources sectors for investment (New Zealand Green Investment Finance, 2019).

The New Zealand government is also pursuing initiatives to reduce agricultural emissions, such as the Productive and Sustainable Land Use Package, the New Zealand Agricultural Greenhouse Gas Research Centre, and the He Waka Eke Noa agreement, and to offset emissions through forestry (MfE, 2020b).

Auckland Policy and Targets

Auckland, like the rest of New Zealand, aims to deliver on the Paris Agreement commitments and limit warming to 1.5°C. Auckland has targets to reduce GHG emissions by 50 per cent by 2030 and reaching net zero GHG emissions by 2050 (Auckland Council, 2019a). As shown in Table 6 and Figure 3, Auckland's primary sources of GHG emissions are related to Energy and Industrial processes and product use, which accounts for approximately 70 per cent and 20 per cent of GHG emissions respectively.

Table 6 GHG emissions produced in Auckland in 2016 broken down in to five key sectors. Adapted from Auckland Council (2019a).

Sector		Description	Contribution to Auckland's 2016 GHG emissions (%)
Energy	Transport	Emissions from private and light commercial vehicles, trucks, buses, trains, ferries and other ships and aviation.	43.6
	Stationary energy	Emissions from energy consumption in buildings, including electricity and natural gas, and energy use in manufacturing and construction.	26.6
Industrial processes and product use		Non-energy related greenhouse gases from industrial processes, mainly steel production, and GHG emissions from industrial product, mainly associated with the use of hydrofluorocarbons (HFC's) and perfluorocarbons (PFCs) in air conditioning units and refrigerators.	20.2
Agriculture		Emissions include methane and nitrous oxide from livestock, animal wastes and fertiliser use.	6.4
Waste		Emissions from landfilled waste and wastewater treatment	3.1

In 2016, Auckland’s net GHG emissions were 10.1 million tonnes of carbon dioxide equivalent (MtCO₂e).⁶ Under business-as-usual, Auckland’s net GHG emissions are projected to increase by around 17 per cent by 2050.

To reach Auckland’s goal, emissions need to peak and then rapidly decline. According to the Intergovernmental Panel on Climate Change “*pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems*” (IPCC, 2018, p. 17).

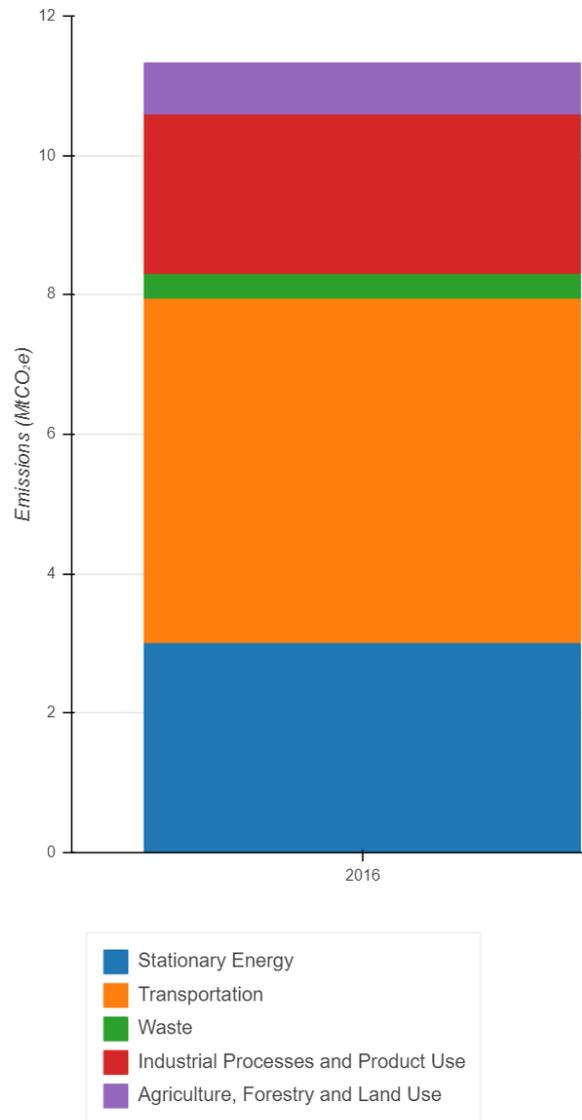


Figure 3: Auckland's Gross GHG emissions

⁶ Gross GHG emissions were 11.3 MtCO₂e. Carbon sequestration from forestry reduced emissions by approximately 10.5 per cent (Auckland Council, 2019b).
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2.4.2 Transitioning to a low-carbon economy by 2050

Climate change has been described by Lazarus (2009) and Levin et al., (2012) as a ‘super wicked problem’ that requires successive governments to commit to policy reform, and to take actions now to avoid future harms (Boston, 2016). The Productivity Commission (2018) identifies key aspects of New Zealand’s political and governance architecture that will need to come in to place to support an efficient and equitable transition to a low-carbon economy. These aspects, and their effects are summarised in Table 7.

Table 7 Key aspects of the political and governance architecture underpinning New Zealand’s transition to a low carbon economy.

Key Development		Mechanism	Effect
Emissions pricing ⁷	Pricing of long-lived greenhouse gases	NZ ETS	Encourages lower greenhouse gas emitting behaviour in all sectors covered by the price on carbon.
	Pricing of short-lived greenhouse gases ⁸	Dual-cap NZ ETS or an alternative methane quota system (MQS)	
Stable policy, regulations and institutions	Legislated and quantified long-term GHG emissions reduction targets	Climate Change Response (Zero Carbon) Amendment Act (2019)	Provides a strong signal about future policy intentions and helps drive the development and implementation of a long-term policy response.
	Successive “emissions budgets”	Emissions budgets developed for 5-year periods	Translates long-term targets into clear short to medium-term emissions reduction goals.
	An independent expert advisory body	Climate Change Commission established under the Climate Change Response (Zero Carbon) Amendment Act (2019) ⁹	De-politicises climate change action and reduces the likelihood of a weakening of emissions reduction ambition.
Innovation	Investment in research and development	Making available significant resources for low-emissions innovation	Supports cost-effective decarbonisation in carbon intensive sectors including agriculture, transport, buildings, and industrial processes. May create economic opportunities and other co-benefits.
	Deployment of offshore technologies	Building capabilities and resources to identify, absorb and adapt technologies	
Mobilising capital	Withdrawing investment from emissions-intensive activities	Green bonds, commercial equity, enabled by emissions pricing	Minimises risk of stranded assets. Ensures businesses can obtain capital to invest in actions that support a transition to a low carbon economy.

⁷ According to the Productivity Commission (2018), the price of carbon dioxide equivalent may need to rise to over \$200 a tonne to achieve the domestic emissions reductions needed to meet New Zealand’s international commitments.

⁸ Greenhouse gases have different atmospheric lifetimes. Methane is relatively short lived, with the bulk of warming caused by atmospheric methane occurring in a 20 year period. Carbon dioxide remains in the atmosphere, leading to effectively irreversible warming. New Zealand is unique in its high proportion of short-lived gases relative to long-lived gases. This proportion should, and does, influence New Zealand’s mitigation targets, emission-reduction trajectories, and policy frameworks. The Productivity Commission (2018) recommends that New Zealand “establish separate long-term emissions-reduction targets for short- and long-lived gases, as well as separate emissions “budgets” for short- and long-lived gases” (p. 4).

⁹ The Climate Change Commission provides independent evidence-based advice to government to help Aotearoa New Zealand transition to a low emissions and climate resilient economy.

Key Development		Mechanism	Effect
	Investing in low-emissions activities	Mandatory climate-related financial disclosures ¹⁰	
		Targeted grants and loans	
		New Zealand Green Investment Fund	

These developments in policy and governance may result in three key shifts in New Zealand's economy (New Zealand Productivity Commission, 2018):

1. A transition from fossil fuels to electricity and other low-emission fuels across the economy;
2. Substantial afforestation; and
3. Changes to the structure and methods of agricultural production as shown in **Table 7**.

The shifts summarised relate to the entirety of New Zealand. They have been included because changes across New Zealand will flow through supply chains, the labour market, and the financial sector to the Auckland region.

¹⁰ The Government is proposing to require financial firms and listed companies to report on the impacts for their business and investments in a consistent way. In 2019 the Ministry for the Environment undertook a consultation last year on a regime regarding the financial impacts of climate change on businesses, how they are valued and reported on within financial markets in New Zealand. This may lead to new regulation.

Table 8 Shifts underpinning New Zealand's transition to a low carbon economy

Key shifts	Component of the shift	Detailed changes
A transition from fossil fuels to electricity and other low-emission fuels across the economy.	Increase in total electricity generation, with generation met by low-carbon energy.	Overall electricity demand increases from 44 TWh in 2019 to 57 TWh in 2035. 92% of electricity is from renewable sources by 2035 (Interim Climate Change Committee, 2019).
	Fuel switching in process heat. ¹¹	Switching approximately one third of fossil fuel used for food manufacturing to electricity. Replacing fossil fuel heating with heat pumps in schools, hospitals and businesses (for example in hot houses for indoor cropping). ¹²
	Fuel switching in transport, i.e. rapid and comprehensive switch of the light vehicle fleet to electric vehicles and other very low-emissions vehicles.	EVs make up 80 per cent of new and used imports into New Zealand by the late 2020s, reaching 85% of new and used imports by 2035. ¹³
Substantial afforestation	Large-scale afforestation.	Land planted in forests increases by between 1.3 million and 2.8 million hectares. ¹⁴ This land is mostly converted from marginally profitable beef and sheep land.
Changes to the structure and methods of agricultural production	Expansion in horticulture and cropping.	Rapid expansion in horticulture, from a small base, to between 500,000 and 1,500,000 ha. Regions such as Bay of Plenty, the West Coast and Auckland experience modest change in land-use. ¹⁵
	Adoption of low-emissions practice on farms.	Practices include, use of genetic grains, reducing stocking rates, reducing nitrogen inputs, milking once a day, and using stand-off pads. Research into new technologies has the potential to further reduce agricultural emissions in the medium to long term.
	Reducing dairying emissions	
Changes to international transport ¹⁶	It is assumed that international transport will be incorporated into carbon markets. Concept Consulting (2017) have estimated that an emissions price of \$100 per tonne of CO ₂ e could reduce domestic air travel demand by up to 12%. It is assumed that international air travel will decrease as the price on carbon increases.	

¹¹ Data and assumptions are derived from Interim Climate Change Committee (2019). It is assumed that the government will not pursue the 100% renewable electricity generation target due to the high marginal emissions abatement cost associated with greater than 98% renewable energy generation. This marginal abatement cost would require overbuilding of renewable energy infrastructure, and the high costs would hinder the electrification of the transport and industrial sectors.

¹² Modelling by the Interim Climate Change Committee (2019) was limited to low and medium-temperature heat, as users of high-temperature process heat have more limited fuel switching opportunities. It is estimated that switching away from coal to electricity or biomass will become economic in the range of \$60-\$120/t CO₂e. Switching away from natural gas starts to become economic only above \$120/t CO₂e (Productivity Commission, 2018).

¹³ This rate of EV uptake is comparable to that of ambitious countries such as the UK and Norway. It is assumed that uptake will be supported through the introduction of fees and rebates linked to the emissions intensity of imported vehicles, government procurement of EV's and investment in EV infrastructure projects to fill gaps in the charging network that are commercially unviable for the private sector.

¹⁴ This will require a planting rate similar to the highest ever recorded in New Zealand to be sustained over the next thirty years (New Zealand Productivity Commission, 2018).

¹⁵ The Productivity Commission (2018) notes that the scale of future change in land use up to 2050 is likely to vary considerably by region, with regions mentioned above likely to experience the most modest levels of change.

¹⁶ International transport did not feature prominently in the Productivity Commission report, as emissions from international aviation and shipping lie outside national GHG emission obligations and emissions pricing schemes. At present, international commitments exclude international aviation emissions. However, these emissions are material. New Zealand's international transport emissions in 2015 were the equivalent of about 5% of New Zealand's total emissions (Ministry of Business, Innovation and Employment, 2017).

Auckland's transition to a low-carbon economy.

Auckland Council has identified one combination of climate actions that could reduce GHG emissions by 50 per cent by 2030 (against a 2016 baseline) and transition Auckland towards net zero emissions by 2050. The actions to the five sectors outlined in Table 9, have informed the Draft Auckland Climate Action Plan (2020).

Table 9 Key developments underpinning Auckland's transition to a low carbon economy

Sector		Actions that will result in emissions reductions
Energy	Transport	<ul style="list-style-type: none"> • Changing work practices change to reduce the need to travel. • Mode shift to public transport and active transport. • Switch to electric and zero emissions passenger, commercial and freight vehicles • Increase in fuel efficiency of vehicles. • Increase in Transport Orientated Developments.
	Stationary energy	<ul style="list-style-type: none"> • Switching from gas to electricity in process heat and adopting best practice technology and energy efficiency measures. • Energy efficient retrofits and replacement of natural gas boilers with heat pumps. • New residential and commercial buildings to operate at net zero emissions from 2030. • Percentage of grid electricity that is renewable increases to 94%.
Industrial processes and product use		<ul style="list-style-type: none"> • Increase energy efficiency and adopt best practice technology.
Agriculture		<ul style="list-style-type: none"> • Afforestation
Waste		<ul style="list-style-type: none"> • N/A

2.4.3 Timeframe

We will identify transition risks that may arise between the present and 2050. Transition risks are not identified beyond 2050 as it is assumed that the domestic 2050 net zero emissions target will be met.

3.0 Phase 1: Identify and evaluate physical and transition risks and opportunities

3.1 Purpose of Phase 1

The purpose of this Phase was to:

- Identify the physical climate change risks and opportunities to the four priority sectors;
- Analyse and evaluate physical risks using an agreed risk framework;
- Identify transition related risks and opportunities to these sectors; and
- Analyse implications of findings for Auckland’s economic recovery from the impacts of COVID-19.

3.2 Identify physical risks and opportunities

We undertook a desktop review of peer reviewed literature, reports, and plans and strategies to identify climate change related risks and opportunities to the four priority sectors of Auckland’s economy.

All risks were reviewed and validated by the project team and technical reviewers before being documented in a Microsoft Excel workbook.

Each risk is accompanied by an assessment of confidence in the finding, based upon the confidence scale in **Figure 4**.

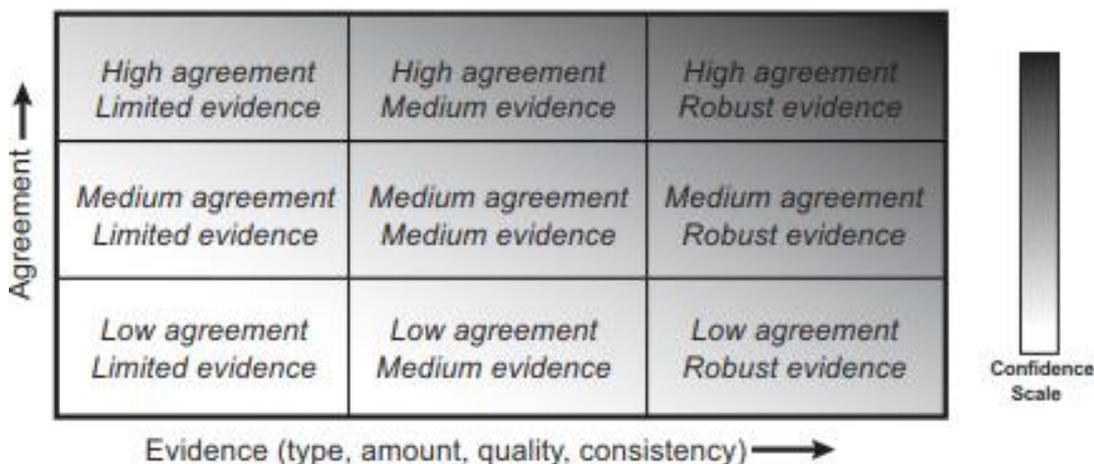


Figure 4: Confidence scale (reproduced from Mastrandrea (et al. 2010))

3.3 Rate physical risks and opportunities

We identified the consequences of physical risks and opportunities across the timeframes specified in Section 2.3.2 using the consequence criteria detailed in Section 2.3.3. Consequences were estimated based upon the project team’s understanding of the functional relationship between a hazard and its magnitude and frequency, exposure and vulnerability.

3.4 Identify transition risks and opportunities

We identified potential implications of the transition to a low carbon economy to the four sectors using a combination of peer reviewed literature, and the transition scenario detailed in 2.4.2. The transition scenario, and a list of potential transition risks and opportunities were validated and explored further in the focus group sessions with ATEED and Auckland Council. During this workshop we assessed the

materiality of the risks and opportunities to each sector and analysed implications of findings for Auckland's economic recovery from the impacts of COVID-19

We reviewed primary literature and preliminary planning that is being undertaken by Auckland Council on the economic recovery from the impacts of COVID-19. We prepared themes for discussion at the focus group sessions regarding the implications of climate change related risks and opportunities to recovery the impacts of COVID-19.

3.5 Stakeholder engagement

During Phase 1, AECOM collaborated with ATEED to facilitate two, two-hour focus group meetings with representatives from across ATEED and Auckland Council who have been working on economic recovery. No external engagement was undertaken as part of this project.

At the first focus group meeting, AECOM:

1. Presented an overview of key trends related to the low carbon transition and risks associated with these trends;
2. Facilitated an activity to identify additional transition risks to the priority sectors; and
3. Facilitated an activity to assess the materiality of transition risks to the priority sectors.

At the second focus group meeting, AECOM:

1. Presented an overview of physical and transition risks identified for priority industries and their risk ratings where relevant; and
2. Facilitated a discussion on the implications of physical and transition risks arising from climate change for Auckland's economic recovery from the impacts of COVID-19.

AECOM developed and provided briefing materials to participants prior to the focus group meetings.

4.0 Phase 2

4.1 Purpose of Phase 2

The purpose of this Phase is to:

- Extend the Assessment to cover key economic sectors not included in Phase 1
- Understand how identified risks and opportunities may be different for Māori businesses.
- Conduct broader engagement with business on climate risks and adaptation, including engagement specifically targeted at Māori businesses.
- Explore literature available on financial costs of not transitioning; and
- Synthesize adaptation actions (both planned and underway) identified through engagement.

4.2 Identify physical risks and opportunities

We used the preidentified physical risks and opportunities from Phase 1 to identify the physical risks and opportunities for the aquaculture and fisheries subsector within the broader food and beverage sector. For this subsector, we developed consequence writeups, risk ratings and confidence statements. For the Advanced Manufacturing and Technology sectors, we also used the preidentified physical risks and opportunities from Phase 1 to undertake the high level risk screen identified at 2.3.5.

4.3 Rate physical risks and opportunities

For the aquaculture and fisheries subsector, we rated physical risks using the same methodology at 3.3. For the Advanced Manufacturing and Technology sectors, we rated preidentified risks using the consequence criteria outlined at 2.3.5.

4.4 Identify transition risks and opportunities

For the aquaculture and fisheries subsector, we identified transition risks using the same methodology applied at 3.4. We also identified transition risks and opportunities for the Advanced Manufacturing and Technology sectors.

4.5 Undertake a risk screen for the Advanced Technology and Manufacturing sector

The climate risk screen considered, at a high level, whether the Advanced Manufacturing and Technology sector is exposed to the physical climate change risks identified in Phase 1 of the ECCRA. This assessment was predominately qualitative. Using literature, AECOM assessed the industry against pre-identified criteria to assess whether the industries are exposed to climate change risks. There were limited documents available to identify exposure and estimate significance of risks. We supplemented our literature review with data from the virtual workshop, which had several participants attend from this sector. The screen criteria we used has been included above (see Table 5).

4.6 Stakeholder engagement

Phase 2 involved more detailed stakeholder engagement. During Phase 2, AECOM collaborated with Auckland Unlimited to deliver a total of 3 workshops, which were grouped as follows:

- 2 sector-specific in-person workshops, led by AECOM.
- 1 online workshop for both the Advanced Manufacturing and Screen sector and for those who could not attend workshops in person led by AECOM.

Each workshop was run in two parts and covered risk and adaptation sequentially. The first part of the workshops involved validating the physical and transition risks identified and their consequence ratings (2 hours). AECOM validated the key risks with stakeholders and captured the consequences from each risk as identified by the sector participants.

The second part of the workshop involved gathering information on what adaptation and transition actions are being undertaken or planned to date (1 hour). This enabled AECOM to harness the institutional and localised knowledge of stakeholders to assist in identifying feasible adaptation pathways for businesses. The outputs from these two workshops have been incorporated into the Final Report.

4.7 Explore literature available on financial costs of not transitioning to a low carbon scenario

We also undertook a literature review of 6-8 readily available pieces of literature. We indicated for each document: key commentary on transition costs, applicability to Auckland, whether the document contains data which could be used to make financial assumptions of the costs of not transitioning. No economic modelling of the costs of not transitioning will be undertaken. The literature review was used to update the context and or 'Climate Change in Auckland' section of the ECCRA report and was summarised in an Appendix.

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Appendix B

Climate change in
Tamaki Makaurau.
Understanding how risks
and opportunities may
be different for Māori
Businesses

Climate change in Tāmaki Makaurau:
Understanding how risks and opportunities may
be different for Māori Businesses

**Summary of Analysis for Auckland Unlimited to support the
Tāmaki Makaurau Economic Climate Change Risk Assessment**



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Executive Summary

The primary aim of this report is to provide insight of how risks and opportunities identified within the **Tāmaki Makaurau Economic Climate Change Risk Assessment (ECCRA)** (AECOM, 2021), may differ in the context of Māori business. The report also considers what drivers may be contributing to these differences. For physical climate change risks, the analysis considers drivers of vulnerability. For physical climate change opportunities, the analysis extends to looking at why Māori businesses may be more poised to take advantage of opportunities.

The ECCRA undertook an in-depth risk assessment across four priority sectors. These sectors have been summarised in Figure 1 below. Figure 2 below outlines pre-identified physical climate change risks and outlines which risks are relevant to each priority sector (AECOM, 2021).

Figure 1: Key sectors of the ECCRA that had an in-depth risk assessment undertaken (AECOM, 2021).

			
<p>Food and Beverage</p> <ul style="list-style-type: none"> Growing and producing, processing, transporting and distributing fresh, prepared and packaged food, and alcoholic and non-alcoholic beverages. 	<p>Construction</p> <ul style="list-style-type: none"> Preparation, clearing (including demolition) and development of land, and the construction, installation, alteration, repair and deconstruction of buildings, structures and infrastructure. 	<p>Screen</p> <ul style="list-style-type: none"> The industries that produce film and television content for domestic and international audiences and service international productions coming to New Zealand. 	<p>Visitor Economy</p> <ul style="list-style-type: none"> Production of goods and services for consumption by visitors. It is an amalgamation of industry sectors including accommodation, transport, attractions, and food and beverage (ATEED, 2018).

Figure 2: Physical climate change risks identified in the ECCRA (AECOM, 2021).

Risk	Food and Beverage	Construction	Screen	Visitor Economy
Maritime infrastructure and maritime transport assets are damaged or destroyed	X		X	X
Information and Communication Technology systems are disrupted	X		X	X
Electricity supplies are disrupted	X		X	X
Road networks are damaged or destroyed	X	X	X	X
Flights to and from Auckland International Airport are disrupted	X		X	X

Water supplies are reduced, disrupted, or contaminated	X	X	X	X
Built assets that are necessary for service provision are damaged or destroyed	X	X	X	X
Assets, such as construction sites, crops and livestock, are damage or destroyed	X	X		
Disruptions to systems that are sensitive to seasonality and changes in climatic parameters	X	X	X	X
Large scale ecosystem change	X		X	X
People are exposed to environmental hazards	X	X	X	X

Physical Climate Change Risks – Non-sector Specific

Māori businesses are likely to be more vulnerable to physical climate change risks. This is because of the following drivers:

- Māori businesses face challenges related to accessing financial capital (including accessing funding) (BDO, 2020).
- In most sectors, Māori businesses also appear to be operating with significantly lower margins than non-Māori businesses (TPK, Te Matapaeroa, 2019), which may also impact their ability to prepare, transition and adapt to physical climate change risks.
- Both small and medium enterprises and larger commercial entities are clearly guided by specific principles and focused on people and te taiao over profit but acknowledge the importance of profit in achieving these purposes (Interviewee(s), 2021). These principles fuel their characteristics of employing significantly more Māori within their businesses than their non-Māori owned industry businesses (TPK, 2019 and Interviewee(s), 2021). These unique ‘business as usual’ approaches influences their decision making and with smaller margins often comes greater vulnerability and fewer options to adapt.
- Resourcing gaps: finding appropriate staff to fill resource gaps is another challenge for Māori businesses (BDO, 2020 and Interviewee(s), 2021).
- Governance remains critical for Māori businesses at all levels and is highlighted as one of the major factors of influence for vulnerability and either increasing or decreasing consequences (MfE, 2019).

These challenges may equate to an increase in vulnerability, impacting upon the adaptive capacity of Māori businesses and their ability to access the resources necessary to achieve their aspirations in all areas, including reducing exposure to climate change risks.

Assessment of Risks for Māori Businesses Against Te Ora ō Tāmaki Makaurau Wellbeing Framework

The Te Ora ō Tāmaki Makaurau Wellbeing Framework (Framework) has been used as a tool to understand whether physical climate change risks may impact Māori Businesses differently from other businesses. This framework was developed in response to Te Tāruke-ā-Tāwhiri: Auckland’s Climate Plan (Auckland Council, 2020). It is therefore regionally specific and was developed with the Mana Whenua Kaitiaki forum, providing insights from mana whenua in the region.

The values and principles that underpin Te Ora ō Tāmaki Makaurau Wellbeing Framework when applied in practice are also categorised as ‘Ngā Mahi a te Ora’ (Wellbeing Activities) in the context of the framework. Considering how the identified physical climate change risks impact on these well-being activities (and particularly on Māori businesses and their owners’ ability to put these principles into practice) is an appropriate way of contextualising and considering the physical climate change risks and their impact for Māori businesses in this context. In most cases the values and principles increase the consequences these risks have on Māori businesses.

The analysis found that each of the identified physical climate change risks clearly impacts on all elements of Ngā Mahi a te Ora (Wellbeing Activities) for Māori business, therefore each risk is not considered in isolation against these principles. A broader assessment using this framework indicates that all risks identified within the ECCRA may in fact impact Māori businesses in additional ways. In most cases this increases the consequences the identified risks have on Māori businesses because these are additional considerations for Māori businesses.

Table 1 below summarises how this Framework has been used to further identify physical climate change risks across the sectors.¹ The following table discusses the ECCRA in *terms of how they relate to the Te Ora ō Tāmaki Makaurau Wellbeing Framework*.

Table 1: Summary of analysis using Te Ora ō Tāmaki Makaurau Wellbeing Framework Principles for Māori Business across the sectors.

Te Ora ō Tāmaki Makaurau Wellbeing Framework Principle	Analysis against ECCRA physical climate change risks
Manaakitanga	The risks may impact on the ability for mana whenua operated businesses to fulfil their responsibilities to care for visitors and the population of Tāmaki Makaurau. This principle also drives mataawaka businesses in the region and will have similar impacts across these sectors. Ensuring manaaki of their staff, clients and consumers will impact all sectors equally, but those who provide services to external customers will be more deeply impacted, such as Māori businesses in the visitor economy and food and beverage sectors. Generally, damaged road networks and contaminated water supplies will impact upon accessing, caring for, hosting and keeping people safe. The principle of manaakitanga means Māori

¹ This table is informed by a combination of te Ao Māori perspectives and based on the research reviewed and undertaken as detailed within the body of this report.

	are innately driven to care for those in their rohe. This culture of looking after each other will mean Māori face increased consequences if they are unable to fulfil these obligations. This culture of manaakitanga has been seen during the recent COVID-19 lockdown and associated impact period. For example, Ngāti Whātua have been distributing food parcels to their constituency.
Kaitiakitanga / tiakitanga	The risks may impact on the ability for mana whenua operated Māori businesses as well as mataawaka to fulfil their responsibilities to care for their natural environment. The consequences of larger scale physical climate change risks include infrastructure and assets being destroyed. Being able to prioritise kaitiakitanga and the environment over people, and repairing damages such as those to physical built assets will be a challenge. Additionally, the whakapapa connection between Māori and their whenua may result in additional emotional and spiritual impact as Māori experience these physical impacts on their whenua. There may also be conflict between Māori and tau iwi approaches: such as wanting areas protected against coastal inundation and allowing natural reclamation by the sea. This issue is particularly relevant to mana whenua.
Whanaungatanga	Impacts on connectivity will impact the physical outworking of whanaungatanga in some cases and the ability for Māori businesses to rely on their existing networks. For example, disruption of ICT systems and road networks will impact physical and digital kanohi-ki-te-kanohi interactions that Māori businesses rely upon. The ability to hold and attend tangi will also be impacted, and in turn this will have a significant negative impact for Māori. This was a challenge that was experienced during the recent COVID-19 lockdowns.
Rangatiratanga	All physical climate change risks identified may impede the ability for Māori businesses to assert their rangatiratanga: to be leaders in their industry and participate in their business communities. With the consequences of larger scale physical climate change risks such as infrastructure and assets being destroyed, and potential emergencies resulting, exercising rangatiratanga will need to be intentional and provide opportunity for Māori businesses to lead across their sector.
Mātauranga	Expressing, educating, and enabling the use of mātauranga in relation to stories, whenua and taonga will be compromised within industries such as visitor economy and food and beverage, where these physical climate change risks typically occur. Damaged road networks will impact upon accessing and engaging with clients and sharing mātauranga, knowledge systems and practices which form part of the experiences Māori businesses offer.
Ōritetanga and Tōnuitanga	Social equity will be further compromised within Māori businesses. While some businesses have both support networks and access to capital, others do not. This inequity will be further entrenched through the identified differences in operational practices and environment of Māori businesses. This will compromise the ability of Māori businesses to enhance the wellbeing of whanau that they both support and serve.

Physical Climate Change Risks – Sector specific

Table 2 below summarises the sector-specific risks for each priority sector.

Table 2: Summarising the risk considerations for Māori Businesses within the ECCRA Sectors

Sector	Summarising the risk considerations for Māori Businesses within the Sectors
Food and Beverage	<ul style="list-style-type: none"> • The presence of fisheries and aquaculture as a subsector within the food and beverage sector lifts the relevance of risks to maritime infrastructure and maritime transport assets being damaged or destroyed, due to significant Māori ownership of assets within this subsector (KPMG, 2020). This is a significant risk for fisheries assets, ports and vessels and may impact directly on supply chain, catch, business continuity and profit. • Large scale ecosystem change increases the risk for Māori with commercially valuable Quota Management System (QMA) species migrating south, out of northern QMAs. This may have a significant impact on Māori fisheries businesses and shareholdings (KPMG, 2020). This is reduced by the fact that 20% of the new species quota will be transferred to Māori, but with close to 50% ownership in current species, this loss has the potential to significantly impact Māori (Te Ohu Kaimoana, 2017).
Construction	<ul style="list-style-type: none"> • On the basis of the more limited diversification of business interests within Māori entities in the Tāmaki Makaurau region (MBIE, 2015, TPK, Te Matapaeroa, 2019) and the resulting consequences of these risks all being highly relevant, the risk for Māori may be increased. With both large numbers of Māori employees in the industry (MBIE, 2015) as well as Māori owned businesses, alongside the significant iwi/hapū asset base in the sector (Interviewees, 2021, Ngāti Whātua ō Ōrakei and Waikato-Tainui Annual Reports), the consequences for Māori business across all relevant physical climate change risks may be significant. • Given the value of the industry to the Māori economy and the factors detailed above the Māori businesses in the sector may have increased vulnerability. • However, the values baseline of operations for most Māori businesses (Interviewees, 2021), often with a key focus on environmental impacts, means that they may be acknowledging, prioritising and planning for the identified risks to the industry.
Screen	<ul style="list-style-type: none"> • The non-sector specific barriers already identified above apply to the screen industry.

Visitor Economy	<ul style="list-style-type: none"> • The tourism sector is heavily reliant on Māori taonga, sites of significance, culture and people in Tāmaki Makaurau and the ability for Māori businesses to be front and centre in telling their own stories and histories. This reliance within the tourism sector may only increase over time. With technological advancements and increases in commercial asset bases, these business opportunities may increase thus increasing their exposure. • The consequences for Māori further increase due to the emotional and cultural connection to these sites over and above the financial impacts of changes to business operations that they are dependent on. • The importance of the industry to Māori business and culture within the region is noted, due to the number of Māori businesses and iwi and hapū commercial entities that exist within the sector and subsectors (TPK, Te Matapaeroa, 2019).
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Physical Climate Change Opportunities – Sector specific

Māori businesses may also be more resilient to physical climate change risks and may in turn be positioned to benefit from opportunities arising from physical climate change risks. Data sourced through both desktop literature reviews and interviews has identified the following sectoral opportunities for Māori business from physical climate change risks (see Table 3). The opportunities identified within the ECCRA all apply (AECOM, 2021), and these opportunities may not be specifically unique to Māori business. The report considers the opportunities identified within the ECCRA alongside the unique contexts, operational nuances and areas where Māori businesses show resilience. In addition, the opportunities have been further highlighted either within the research or during interviews.

Table 3: Physical Climate Change Opportunities.

Sector	Physical Climate Change Opportunity
All	<ul style="list-style-type: none"> • Opportunity for unique Māori provenance stories throughout export markets. • Opportunity for remote Māori businesses to secure more efficient and reliable power supply through increased onsite electricity generation.
Food and Beverage	<ul style="list-style-type: none"> • Creating plant-based alternatives to meat through driving greener production systems aligns well with obligations as kaitiaki.
Construction	<ul style="list-style-type: none"> • Māori have an increased focus on protecting their people and using valuable sources of profit to achieve their aspirations for their people. They are likely to be involved in innovative construction technologies as Māori are keen early adopters of technological advancements. • Opportunity for Māori businesses to work together in sustainable infrastructure ventures, such as green waste and recycling – also opportunities to partner/procure this work to others.

Visitor Economy	<ul style="list-style-type: none"> • Increased opportunity for authentic cultural tourism owned and operated by Māori. • Enhance connections between the Visitor Economy and Māori research institutions, for Māori businesses to benefit from the increased funding for mātauranga Māori or Māori perspectives in climate adaptation/mitigation-based research, as well as these new career pathways being developed. This evolving knowledge economy provides opportunity for enhancing and growing the visitor economy.
Screen	<ul style="list-style-type: none"> • Increased opportunities for Māori artists and creatives both on and behind the screen. • Increased opportunity for advancing the knowledge economy and mātauranga Māori within this, including owning these stories and their presence in the industry. • To strengthen more digital or weightless exports and supporting development of these industries.

Transitional Climate Change Risks and Opportunities

Although this review prioritised physical climate change risks, transitional climate change risks were also considered in a Māori context. For Māori, many of the consequences for transitional climate change risks identified were general rather than sector specific. Often these consequences were related to the vulnerability drivers identified above in terms of financial challenges. With Māori small and medium enterprises experiencing greater financial exclusion (TPK, Microfinance, 2019), their access to additional capital required to transition may be limited. Access to human capital may also be difficult for Māori businesses, especially where knowledge gaps and resources are already stretched. This labour gap may be compounded where Māori have not been supported through the necessary educational pathways to meet the future needs of the market.

The opportunities arising from the transitional climate change risks identified in the ECCRA and from the realities of the changes that climate mitigation will bring are significant for Māori across all of the sectors reviewed.

Opportunities from these Challenges

Facing these challenges provides an opportunity to enable and prioritise further work to resolve these issues in a consistent manner. This will assist future work programmes and kaupapa within Auckland Unlimited to be better aligned to meet the needs of Māori business. It will enable effective planning, policy and projects to specifically reach Māori business for positive impact.

Opportunities to work with Māori advisors already exist within Auckland Unlimited. Using these networks to co-design future projects may ensure clarity and consistency of approach for future work in these areas. Further, working to create specific connections with iwi and hapū in the region to gain insights into their business profiles, needs and aspirations, as well as the development of localised transition plans alongside mana whenua, may improve data availability in addition to increasing Māori businesses resilience. Undertaking the same approach for each industry sector and reaching and connecting with Māori businesses to gain thorough and specific insights into their needs and their contributions to the region, will improve relationships as well as improving current data availability.

A focus on seeking Māori specific data across all industries and clearly defining what a Māori business is to Auckland Unlimited should be prioritised. This definition should be developed collaboratively with internal and external insights. These are by no means new challenges or opportunities, but will when addressed, go a long way to better serving Māori businesses within Tāmaki Makaurau.

Limitations

In this section, we have outlined the challenges that have impacted the assessment of the report. It is important to understand these challenges, and the report to be reviewed with them in mind. These need noting to ensure this report is understood and considered in context.

There was no universal agreement from a range of sources as to what constitutes a Māori business. The differing ways that local and central government and their advisors, Māori organisations and Māori business owners qualify what constitutes a Māori business, differs considerably. We have therefore had to use multiple definitions of what constitutes a Māori business, depending on the source used. This issues has had a significant impact on the way in which this review could be undertaken and on its output. The inability to align these differences with the available data and how it was collected, as well as the lack of this data being regionally specific, compounded this challenge further.

There were also conflicting perspectives around what should constitute a Māori business within the context of this report, mana whenua or mataawaka, within the Auckland region and how these perspectives should be prioritised.

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1. Introduction

1.1 Background

The Economic Climate Change Risk Assessment (ECCRA) was undertaken in two distinct phases. The Phase 1 assessment was undertaken between April and June 2020. The Phase 1 assessment focused on climate change risks and opportunities to four priority sectors: construction, food and beverage, visitor economy, and screen sectors. Phase 1 identified and evaluated risks and opportunities that may arise from hazards that are caused, exacerbated or influenced by climate change. It also identified risks and opportunities that may arise from transition to a low-carbon economy.

Phase 2 has expanded this assessment to include the following activities:

- Undertaking a risk screen of the advanced manufacturing and technology sectors not assessed in Phase 1 of the ECCRA against physical climate change risks identified in Phase 1 of the ECCRA;
- Understanding how identified risks and opportunities may be different for Māori businesses;
- Conducting broader engagement with business on climate risks and adaptation, including engagement specifically targeted at Māori businesses;
- Exploring literature available on financial costs of not transitioning; and
- Synthesising adaptation actions (both planned and underway) identified through engagement.

1.2 Purpose of Report

The key purpose of this review is to assist with understanding whether the risks and opportunities for businesses identified in the ECCRA, are the same for Māori businesses, and if not, how they differ. This summary report delivers the findings from Whetū Consultancy Group (Whetū), including insights gained through interviews with targeted Māori businesses in the rohe.

1.3 Methodology

The ECCRA undertaken by AECOM in 2020 developed a methodology which was guided by both national and international best practice for climate change risk assessments. Refer to the ECCRA Assessment Methodology Statement for details of the methodology utilised within the ECCRA (AECOM, 2021).

This work contributes to the ECCRA undertaken by AECOM in 2020 and builds upon the assessment framework and methodology used. Whetū have worked with AECOM to understand the methodology used and to assess Māori impacts and opportunities within this context. There are multiple methodologies that could have been used in the risk assessment to include a te Ao Māori lens as part of the risk rating process. We considered a number of frameworks from a conceptual viewpoint, rather than as an assessment tool, as the methodology for the overarching risk assessment (ECCRA) had already been undertaken. Frameworks we considered included the He Ara Wairoa used by the Climate Change Commission (previously developed for use by Treasury).

The resulting methodology included a whakaaro Māori baseline, and incorporated an overarching test

or measure of impact through the Te Ora ō Tāmaki Makaurau Wellbeing Framework, developed alongside the Mana Whenua Kaitiaki Forum in response to Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan. Further detail around this framework is noted below. This framework is regionally specific and appropriate as an end point measure of the assessment.

As part of this assessment a range of values, knowledge sets, quantitative and qualitative data (including interview data) have been used. To enable a fuller representation of aspirations and values from a Māori perspective (as best practice suggests) these perspectives and whakaaro should be considered alongside economic modelling (Awatere et al, 2018).

A series of one-on-one interviews were undertaken to:

- connect and gain further insight about business operations; and
- to discuss the findings of the ECCRA with Māori businesses identified within the rohe.

These findings have been incorporated into tables throughout the report. A wide range of stakeholders have been interviewed across the priority sectors. It is important to note that interviewees were those willing to give their time towards this kaupapa, under some constrained circumstances, including timing and an evolving COVID-19 environment. Due to the limited number of interviewees within each sector, it would be inappropriate to claim the interview data as being indicative or to form generalisations around Māori business within any sector or subsector. However, this data has been included as it provides a level of richness and insights into Māori businesses operating within these sectors, or those working alongside Māori businesses within these sectors.

We considered te ao Māori perspectives through all these data sources and then applied Te Ora ō Tāmaki Makaurau Wellbeing Framework as detailed below.

1.3.1 Assessment of Risk, Consequence and Vulnerability for Māori businesses

According to the New Zealand Climate Change Risk Assessment, vulnerability is influenced by socio-economic and cultural processes (including adaptation and mitigation actions and governance), which can increase or decrease the consequences (and therefore the risk) resulting from exposure to a hazard (MfE, 2020). One of the primary inputs into the ECCRA and application of the consequence criteria was in relation to the exposure of a subsector. Identified risks were evaluated as a function of the number of businesses exposed within a subsector, or the percentage of economic activity exposed within the subsector, and the severity of the consequences that stem from the exposure.

Where Māori businesses comprise a disproportionately greater percentage of that economic activity exposed within any subsector, this increases the exposure for Māori businesses in comparison to non-Māori businesses in the subsector. This disproportionate impact has a greater impact on the Māori economy as a whole. This increased exposure for Māori business may not necessarily mean an increase in the consequence rating, but it depends on how the scale and impacts of each risk interact to form the overall risk rating. Given the very minimal amount of data available to qualify this assessment, using the original consequence criteria used in the ECCRA was not the primary input into our assessment. Instead a consideration of contributing information such as employees in the sector, knowledge of iwi and hapū interests in the sector, as well as the importance of the role that Māori play

in the sector (ie cultural inclusion in tourism). This is therefore a qualitative and subjective assessment.

1.3.2 Phase One Assessment

The first phase of our assessment involved considering what differences there were between Māori businesses and non-Māori businesses that might impact the extent or gravity of any of the identified physical or transitional climate change risks from the ECCRA.

This phase was informed by the significant literature and knowledge that exists around Māori perspectives, te Ao Māori, tikanga Māori and kaupapa Māori, in so far as it relates to the contexts of climate change, the environment and te taiao. Detail supporting some of these contributing perspectives is summarised and included as *Appendix A*.

Further, an assessment against the principles of Te Ora ō Tāmaki Makaurau Wellbeing Framework was undertaken, against the identified risks. Te Ora ō Tāmaki Makaurau Wellbeing Framework was developed in response to Te Tāruke-ā-Tāwhiri: Auckland’s Climate Plan (Auckland Council, 2020). It is therefore regionally specific and was developed with the Mana Whenua Kaitiaki forum, providing insights from mana whenua in the region. Key tenets of the framework include:

- Ngā Aho Taiao - The ability and capacity of te taiao to sustain and maintain whole living systems and regenerate its own mauri, while contributing to the mauri of people and land.
- Ngā Aho Whenua - The ability and capacity of the whenua to sustain and maintain whole living systems and regenerate its mauri, while contributing to the mauri of people and nature.
- Ngā Aho Tangata - The ability and capacity of tangata to sustain and maintain their mauri, while contributing to the mauri of the land and nature. For mana whenua, this relates to their ability and capacity to maintain, sustain and regenerate their specific whakapapa relationships with land, nature and people of Tāmaki Makaurau (Auckland Council 2020).

Figure 3: Te Ora ō Tāmaki Makaurau Wellbeing Framework.

Te Ora ō Tāmaki Makaurau Wellbeing Framework



This provides a grounding point for considering and assessing whether the physical climate change risks identified within the ECCRA impact Māori businesses within the region in different ways.

The framework connects directly to the ability and capacity of communities to maintain, sustain and regenerate whānau and community well-being within Tāmaki Makaurau. The business community is a critical component of this community, providing income, employment and social support. The impacts and risks identified for Māori businesses directly impact on their well-being as defined within the framework.

Maintaining the importance of using Māori values and principles when considering the impacts and risks of climate change, as well as in framing our solutions, is critical.

“The framework is structured around core Māori values and principles derived from Māori views of the world. These values and principles provide an insight into Māori concepts and beliefs anchored upon intergenerational symbiotic relationships between people, place, nature and the wider universe (whole living systems) and the reciprocal responsibilities and obligations to care for, protect, activate, maintain and regenerate these whakapapa relationships.” (Auckland Council, 2020).

The values and principles in the well-being framework are:

- manaakitanga
- kaitiakitanga / tiakitanga
- whanaungatanga
- rangatiratanga
- mātauranga
- ōritetanga
- tōnuitanga.

These values and principles when applied in practice, are also categorised as ‘Ngā Mahi a te Ora Wellbeing Activities’ in the context of the framework. Consideration of the impacts of the physical climate change risks identified on these well-being activities (and particularly on Māori businesses and their owners’ ability to put these principles into practice) is an appropriate way of contextualising and considering the physical climate change risks and their impact in this context.

To gain further insight, one-to-one or small group interviews were undertaken with identified and willing Māori businesses within the sectors in the region. These included business owners or representatives of organisations that work alongside Māori businesses within these sectors. A record of key insights from the interviews is included throughout this report.

1.3.3 Phase Two Opportunities

This phase included considerations of how these perspectives and inputs from Phase One may inform and provide strategic opportunity that could mitigate some of the risk and consequences identified for Māori businesses within these sectors. This is an important element of producing research outputs that don’t result in deficit perspectives, but instead provide useable outputs for Māori that help to inform strategy and intend to navigate pathways to success.

In this instance, we included the development of fictional future scenario settings for each sector to connect the sector opportunities and identify how Māori businesses within the sector might look in the future. This phase provides alignment with intergenerational aspirations and endpoints, rather than shorter term business horizons. It includes knowledge of existing aspirations, operations, areas of interest and asset bases, and then considers opportunities that were highlighted either within the

ECCRA, interviews or literature, that might align for Māori businesses within these sectors.

1.4 Limitations

This report does not purport to be the only Māori perspective, nor does it represent the perspectives of any iwi, hapū or whanau in the Tāmaki Makaurau region or across Aotearoa. The assessment was limited by the data available. Further limitations existed with the interview and engagement process taking place during and post the 2021 Auckland COVID lockdowns which threatened to impact on engagement and the ability to easily undertake face-to-face engagement.

The availability of data for Māori businesses within sectors was limited and as a result, assumptions and conclusions had to be drawn from a mixture of qualitative and quantitative data, literature, and desktop research. Data sources used were not all able to align with the same data groupings and data sets used for the ECCRA. The literature review revealed that inconsistencies exist with the way available data collected had been classified, and grouped, which meant that pulling out industry specific data was only possible for two of the sectors analysed. The availability of Māori business data, by sector in addition to location, was negligible.

These factors all impacted the assessment of the report, and the report should be reviewed with them in mind.

In this section, we have outlined the challenges that have impacted the assessment of the report. It is important to understand these challenges, and the report to be reviewed with them in mind. . Further, there were differing or additional methods of classifying Māori businesses. Based on Te Puni Kōkiri's (TPK) Te Matapaeroa 2019 report, Māori businesses in the Tāmaki Makaurau region for example, jumped from 27 identified using Stats NZ data to 1389 using a different definition and data sources (TPK, 2019).

1.5 Defining Māori Business

The issues identified that prevented providing a higher level of confidence in the data analysed included the definitions and way that datasets had been grouped and categorised. For example, defining what constituted a Māori business for the data used was an issue.

There are a number of ways that Māori business is and can be defined. TPK has defined a Māori business as “a business that is 50% or more owned by Māori”. ‘Te Matapaeroa 2019 - Insights into Māori business’, with the most detailed data that we could apply to this review, states their definition for Māori business as being:

- Using ‘Statistics NZ’ identifier (1,300 businesses) – A business is an enterprise and is flagged as Māori by Statistics NZ and used in their Tatauranga Umanga Māori reporting
- Using ‘Majority Shareholders are Māori’ identifier (8,800 businesses) – A business where at least 51% of wages paid to directors, partners or active shareholders are to individuals of Māori ethnicity or descent.

This is the context of most of the data reviewed. For the purpose of our analysis we have included the following groupings in order to provide a Māori lens. Due to the internal and external influences,

particularly for Māori commercial entities, we needed to consider the risks for Māori businesses from a number of perspectives as detailed in

Table 4.

Table 4: Māori Business Classifications

Māori Business			
Iwi or Hapū	Māori Commercial Entities	Whanau Trusts or Collective Landholders	Māori owned Private Businesses
The majority of the businesses owned within this space are known to be Māori businesses within the data and statistics. The two are often seen as interchangeable but they have clearly defined roles and purposes within this space.		These may not feature within Māori business data. They are not operated like traditional businesses unless a business operation is taking place on or connected with the land.	Many of these businesses appear to have been overlooked in traditional data gathering or missed but contribute to a significant and growing part of the Māori economy.
In this context they are the owners of assets impacted by changing climate and also integral decision makers for some commercial entities. They are Māori collectives or natural groupings and for the purpose of Western ownership of land, have been required to established Post Settlement Governance Entities (PSGE's) as organisations that receive and administer land and other assets resulting from Treaty settlements or through directed acquisition.	These are the entities that operate commercial interests on behalf of iwi, hapū or other post settlement governance entities. They are the frontline of business operations and decision making at management level. Some larger entities have their own governance board, others are governed by the board of their PSGE.	These are collective landholders or shareholders of parcels of land mostly held under Te Ture Whenua Māori Act. These entities are normally whanau connected groups that operate outside of iwi or hapū settlement contexts, to utilise their land for the benefit of their greater whanau, albeit within the confines or restrictions of Te Ture Whenua Māori Act.	These are private businesses that will be operating independently of PSGE's and other Māori organisations. Essentially, they are business owners who identify as being Māori.

Iwi and hapū and their PSGE's play a significant role in governance and strategic direction, setting the expectations for the commercial entities, as their work helps to fulfil the aspirations of the iwi or hapū. Many of these aspirations and values baselines, provide additional expectations, reporting

components and KPI's for commercial entities and their business operations. How these two facets of Māori Enterprise operate together is what makes them unique and sets them clearly apart from other mainstream corporates operating in the identified sectors.

2. Review and Analysis

2.1 ECCRA Risks Identified

2.1.1 Physical Climate Change Risks

The physical climate change risks identified within the ECCRA are based on a future emissions scenario which was based on projections prepared for the Tāmaki Makaurau region by Pearce (et al., 2018). The high emissions scenario is characterised by the following, according to the ECCRA:

“...by 2110, the Auckland region is projected to be 3.25-3.75°C warmer than at the beginning of the century. Most of Auckland is projected to experience more than 90 hot days per year (days > 25°C) and there may be approximately 12 more days with very high or extreme fire danger. The volume of annual rainfall is likely largely unchanged, but more rainfall is likely to occur in autumn, and less in spring. When rain falls, it is likely to be more intense. Most of the Auckland region will experience between 12-21 more dry days per year. Oceans will be more acidic, and sea levels will be 1.2 metres higher than the 1990s.”

The resulting risks have been identified in the ECCRA and are summarised in the following diagram.

Figure 4: Summary of identified physical climate change risks for Tāmaki Makaurau.



These identified risks are based on science, projections and modelling, and on this basis these physical climate change risks are assumed to be the same for Māori businesses. As referred to in Section 1.3, the risk identification process has followed the methodology used by the National Climate Change Risk Assessment. Further detail around these risks and what they encompass can be found in the ECCRA at pages 10-16 (AECOM, 2021).

The framework applied within the ECCRA rated risks in accordance with a risk framework which is described in detail in Appendix A of the ECCRA report (AECOM, 2021). The framework accounted for both the likelihood of the occurrence of a hazard, or series of hazards that give rise to the risk. It includes the scale and intensity of the impact of the risk. The identified risks were based on the number of businesses exposed within a subsector, or the percentage of economic activity exposed within the subsector, and the severity of the consequences that stem from the exposure.

The ECCRA provides these risk ratings (intentionally) in isolation and resists leaning into other discussions associated with these timelines. Technology particularly may have a significant influence on all risk ratings in the context of these scenario timelines, due to the possibility of technological advancements that could partially or wholly reduce these risks. For example, innovative construction materials fabricated here so require no importation from China is required, thus supply chain risks eliminated/reduced. Factors such as these are not considered. The table below indicates how or whether these risks were assessed in the ECCRA as being applicable for each sector.

Table 5: The applicability of risks to the four sectors of Tāmaki Makaurau economy assessed (AECOM, 2021).

Risk	Food and Beverage	Construction	Screen	Visitor Economy
Maritime infrastructure and maritime transport assets are damaged or destroyed	X		X	X
Information and Communication Technology systems are disrupted	X		X	X
Electricity supplies are disrupted	X		X	X
Road networks are damaged or destroyed	X	X	X	X
Flights to and from Auckland International Airport are disrupted	X		X	X
Water supplies are reduced, disrupted or contaminated	X	X	X	X
Built assets that are necessary for service provision are damaged or destroyed	X	X	X	X
Assets, such as construction sites, crops and livestock, are damage or destroyed	X	X		
Disruptions to systems that are sensitive to seasonality and changes in climatic parameters	X	X	X	X
Large scale ecosystem change	X		X	X
People are exposed to environmental hazards	X	X	X	X

The following review (in Section 3) has considered how Māori business characteristics, challenges and operating rationale impact in the context of this ECCRA. For further detail on Māori business characteristics, challenges and operating rationale and insights see *Appendix C*.

3. Risk Assessment

3.1 Summary of Assessment of Risks for Māori Businesses Against Te Ora ō Tāmaki Makaurau Wellbeing Framework

Each of the identified physical climate change risks clearly impacts on all elements of Ngā Mahi a te Ora (Wellbeing Activities) for Māori businesses, therefore each risk is not considered in isolation against these principles. A broader assessment using this framework indicates that all risks identified within the ECCRA may in fact impact Māori businesses in additional ways. Because these are additional considerations for Māori businesses, in most cases this increases the consequences the identified risks have on Māori businesses.

Table 6: Summary of assessment of risks for Māori Businesses against Te Ora ō Tāmaki Makaurau Wellbeing Framework Principles.

Risk	Impact on Ngā Mahi a te Ora for Māori Business
<p>Risk 1- Maritime infrastructure and maritime transport assets are damaged or destroyed</p> <p>Risk 2- Information and Communication Technology systems are disrupted</p> <p>Risk 3- Electricity supplies are disrupted</p> <p>Risk 4- Road networks are damaged or destroyed</p> <p>Risk 5- Flights to and from Auckland International Airport are disrupted</p> <p>Risk 6- Water supplies are reduced, disrupted or contaminated</p>	<p>Manaakitanga - These risks may impact on the ability for mana whenua operated businesses to fulfil their responsibilities to care for visitors and the population of Tāmaki Makaurau. These principles also drive mataawaka businesses in the region and will have similar impacts across these sectors. Ensuring manaaki of their staff, clients and consumers will impact all sectors equally, but those who provide services to their customers externally will be more deeply impacted, such as Māori businesses in the visitor economy and food and beverage sectors.</p> <p>Generally, damaged road networks and contaminated water supplies will impact upon accessing, caring for, hosting and keeping people safe. The principle of manaakitanga means Māori are innately driven to care for those in their rohe. This culture of looking after each other will mean Māori face increased consequences if they are unable to fulfil these obligations. This culture of manaakitanga has been seen during the recent COVID-19 lockdown and associated impact period. For example, Ngāti Whātua distributing food parcels to their constituency.</p> <p>Kaitiakitanga / tiakitanga – These risks may impact on the ability for mana whenua operated Māori businesses as well as mataawaka to fulfill their responsibilities to care for their natural environment. The consequences of larger scale physical climate change risks include infrastructure and assets being destroyed. Being able to prioritise kaitiakitanga and the environment over people and repairing damages such as those to physical built assets will be a challenge. Additionally, the whakapapa connection between Māori and their whenua may result in additional emotional and spiritual impact as Māori</p>

<p>Risk 7- Built assets that are necessary for service provision are damaged or destroyed</p> <p>Risk 8 - Assets, such as construction sites, crops and livestock, are damaged or destroyed</p> <p>Risk 9- Disruptions to systems that are sensitive to seasonality and changes in climatic parameters</p> <p>Risk 10- Large scale ecosystem change</p> <p>Risk 11- People are exposed to environmental hazards</p>	<p>experience these physical impacts on their whenua. There may also be conflict between Māori and tau iwi approaches ie: such as wanting areas protected against coastal inundation and allowing natural reclamation by the sea. This issue is particularly relevant to mana whenua.</p> <p>Whanaungatanga – Impacts on connectivity will impact the physical outworking of whanaungatanga in some cases and the ability for Māori businesses to rely on their existing networks. For example, Disruption of ICT systems and road networks will impact physical and digital kanohi-ki-te-kanohi interactions that Māori businesses rely upon. The ability to hold and attend tangi will also be impacted, and in turn this will have a significant negative impact for Māori. This was a challenge that was experienced during the recent COVID-19 lockdowns.</p> <p>Rangatiratanga – All physical climate change risks identified may impede the ability for Māori businesses to assert their rangatiratanga: to be leaders in their industry and participate in their business communities. With the consequences of larger scale physical climate change risks such as infrastructure and assets being destroyed, and potential emergencies resulting, exercising rangatiratanga will need to be intentional and provide opportunity for Māori businesses to lead across their sector.</p> <p>Mātauranga – Expressing, educating, and enabling the use of mātauranga in relation to stories, whenua and taonga will be compromised within industries such as visitor economy and food and beverage, where these physical risks typically occur. Damaged road networks will impact upon accessing and engaging with clients and sharing mātauranga, knowledge systems and practices which form part of the experiences Māori businesses offer.</p> <p>Ōritetanga and Tōnuitanga - Social equity will be further compromised within Māori businesses. While some businesses have both support networks and access to capital, others do not. This inequity will be further entrenched through the identified differences in operational practices and environment of Māori businesses. This will compromise the ability of Māori businesses to enhance the wellbeing of whanau that they both support and serve.</p>
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All physical climate change risks identified within the ECCRA may have additional impacts for Maori businesses, which increases the range of impacts such businesses are likely to face. The wellbeing activities identified through the Te Ora o Tāmaki Makaurau Wellbeing Framework are also the tools of action that will enable and strengthen Māori businesses to overcome and endure through these predicted times of crisis and exposure to these risks, and provide opportunities across the sectors.

3.2 Māori Business Sector Summaries

Each sector below includes a summary of insights gained during the interviews which informs about challenges and opportunities for Māori businesses across these sectors and also notes perspectives on which physical climate change risks identified in the ECCRA are of most significant concern to those

interviewed. Opportunities are identified within each sector through a future scenario and opportunities table (orange). For an overview of the Māori economy in the Tāmaki Makaurau region refer to *Appendix D*.

3.2.1 Food and Beverage

For the purpose of the ECCRA the Food and Beverage sector comprised of the following subsectors: manufacturing, wholesale, food technology, supply chain, horticulture, viticulture and agriculture, including fisheries and aquaculture.

“A realisation that I am just a dot in the whole scheme of things. That’s where non-Māori don’t necessarily connect. With their pepeha and their whakapapa to the whenua.” - Interviewee

3.2.1.1 Manufacturing, Wholesale, Food Technology, Supply Chain

It was difficult to gain insights or identify any detailed existing data in relation to Māori businesses in Auckland in this subsector, although one interviewee operated within this sector and provided solid insights into the risks for them within their business as well as operating context. Targeted research in this area is required. The Māori business context continues to apply to businesses within these sectors.

3.2.1.2 Agriculture and Horticulture

Nationally, more than 12% of Māori-owned SMEs are in the Agriculture, Forestry and Fishing industries with this increasing to 23% for Māori entities (Stats NZ, 2019). Māori play a significant role in this sector, both as producers and landowners. For Māori commercial entities primary production and fisheries generally provide significant income to support iwi and hapū aspirations for post-settlement entities within fisheries quota allocations and through agricultural operations on Māori land. The interests that Māori hold within the agricultural industry are significant nationally.

Overall, the Māori share of primary assets is upwards of \$13 billion (including forestry and fisheries) (KPMG, 2020). Within national level agricultural interests this is significant.

A number of iwi and hapū in the Tāmaki Makaurau region indicate that they operate farming enterprises, including Ngāti Paoa with a \$20mil farming asset base (Ngāti Paoa, 2016). The reality of much of the Tāmaki Makaurau region being more urban means that iwi/hapū in the area are less likely to have agricultural operations. Treaty Settlements and the desire for Māori to work with their whenua mean that ownership of primary production businesses in the future may only increase within the scenario timeframes where land becomes available in the outer Auckland regions.

3.2.1.3 Fisheries

For many iwi and hapū a significant part of their asset base consists of fisheries quota, with the information available around the iwi and hapū in the region indicating that for some, over half of their asset base consists of fisheries quota, alongside direct income from their allocated shares in Aotearoa Fisheries (Ngāti Wai, 2019).

Under two national fisheries settlements in 1989 and 1992, Māori were granted control over one-third of New Zealand's commercial fisheries. After over a decade of debate about how this allocation could be fairly undertaken, in 2004 the Māori Fisheries Act saw a combination of allocation rationale based on percentage of tribal coastline as well as numbers of tribal members in relation to deep-sea fisheries.²

Essentially, the settlement has resulted in quota being owned by all iwi but with most iwi in the Tāmaki Makaurau region not owning enough to viably operate in the industry alone. Instead the quota is leased to other operators in the industry, often competing with the 100% collectively Māori owned Moana New Zealand and the 50% owned Sealord. Over 97 species or groups of species are managed as 633 fish stocks under the QMS (Te Ohu Kaimoana, 2017). This is important to note given the changes predicted for fish stocks with climate impacts as well as the risks around eco-system change.

It is difficult to access a breakdown of who and where these Māori-owned assets operate. It is also difficult to uncover which Auckland-based companies lease quota from Māori, aside from those who publish it in detail in their annual reporting. Ngāti Wai indicate in their Annual Report (2019) that their asset base includes \$24mil of fishing quota as well as \$1mil in Aotearoa Fisheries Income Shares. According to the Companies Office, Ngāti Whātua holds the 15th largest share in the company of 1.54%. In the absence of consolidated regionally specific data, if an analysis is made of the overall value of the asset base owned by Māori collectively it can be assumed that any impacts to the industry may impact Māori Treaty Partners and Commercial entities disproportionately compared to the remainder of the sector.

Annual Revenue of the top 4 fisheries is as follows:

- Sealord - \$450m – 50% Māori Owned
- Sanford - \$460m (a percentage of quota may be leased from Māori)
- Talley's – Estimated \$220m (a percentage of quota may be leased from Māori)
- Aotearoa Fisheries Ltd (Now Moana New Zealand Ltd) - \$154m – 100% Māori Owned (Te Ohu Kaimoana, 2017).

Based on this data, the impacts for Māori businesses operating within the fisheries sector may be considerable. A focus on remaining vocal and influential within the marine governance space may be critical in ensuring a Māori voice when the impacts of climate change become increasingly into the future, ensuring transparency. This will be critical when the time comes to ensure that new commercially valuable species that emerge into New Zealand waters are added to the QMS as other

² In this Settlement, the Crown recognised the full extent of Māori customary rights to fishing and fisheries by:

- Providing funds for Māori to buy a 50 percent stake in Sealord Products Limited (now Sealord Group Limited) which, as one of the largest fishing companies in New Zealand at the time, was a major owner of fisheries quota;
- Undertaking to provide Māori with 20 percent of commercial fishing quota for all new species brought within the QMS;
- Undertaking to ensure the appointment of Māori on statutory fisheries bodies; and
- Agreeing to make regulations to allow self-management of Māori fishing for communal subsistence and cultural purposes (Te Ohu Kaimoana, 2017).

species move out of northern waters (KPMG, 2020). As a result of the fisheries Treaty settlements, Māori are guaranteed 20% of all new species introduced into the QMS.

Table 7: Risk Summary – Food and beverage sector.³

Risk Summary for Māori Business - Food and beverage sector
The addition of fisheries and aquaculture as a subsector lifts the relevance of risks for maritime infrastructure and maritime transport assets being damaged or destroyed, due to significant Māori ownership within this subsector. This is a significant risk for fisheries assets, ports and vessels and may impact directly on supply chain, catch, business continuity and profit.
Large scale ecosystem change increases the risk for Māori with commercially valuable Quota Management System (QMA) species migrating south, out of northern QMAs. This may have a significant impact on Māori fisheries businesses and shareholdings. This is reduced by the fact that 20% of the new species quota will be transferred to Māori, but with close to 50% ownership in current species, this loss has the potential to significantly impact Māori.

Table 8: Insights from interviews – Food and beverage sector.

Key Risks Identified through interviews
<ul style="list-style-type: none"> • The concerns were more limited as the interviewee felt confident that larger players in their industry will have these things planned for and have alternatives available that they would be able to leverage off • Risk 3: Power disrupted- Medium risk, but echoed the fact that they would move to alternatives • Risk 5: Flights disrupted- Pre-covid this was material; post-covid they have adapted to seeing this as low-medium risk • Risk 6: Water is critical for production, but comfortable that things are in place externally so can outsource • Risk 7: Medium risk – as can relocate operations if needed relatively easily • Risk 8 and 9 and 10: Crops are essential for raw product – Ecosystem changes are much higher risk – bio-hazard risks so much bigger. Breakdown of food change and viruses, for example
Sector comments from interviews
<ul style="list-style-type: none"> • Inclusion of Māori practices such as maramataka in agriculture is important • Breakdown of food-chain is integral to operations and connection with te taiao • With environmental change, concerned with impact on insects and bees as pollinators and strained food chain • Focus on operating sustainably, not exploitatively • Maximising outputs, not mass production. It's not about extracting as much as you can out of anything, but 'how can we look beyond, sustain that and achieve win-wins' • 'The more wins I can generate the happier I am'. Producing more product = more need for ingredients and more money can be invested in environmental good. 'More everything... it's the full food chain, more flowers, trees, life' • Recognition that the land has sustained the people for that long. The only way to move ahead is to prepare and be kaitiaki for the next generations

³ Note: Risk summaries are based on literature and data review only, due to limited interview data across sectors.

- European farmer often focuses on generating x amount of profit and then sells, moves on to another space. A different operating rationale.
- Not yet 100% sustainable but the intention is that with time and resources = becoming completely sustainable
- Providing this experience, 'joy, sharing and manaaki is a huge part of what we do'
- Inclusivity is key and manaaki, looking after that approach, less competitive mindset
- Authenticity over growth, and acknowledge that a longer timeframe is ok
- Values baseline, integrity, value alignment

3.2.1.4 A Future Scenario for Māori Businesses in the Food and Beverage Sector

"We operate sustainably, not exploitatively. It's not extracting as much as I can out of anything, but how can we look beyond and sustain and achieve win-wins." – Interviewee

This future scenario sees Māori businesses well-advanced in their water planning in relation to water access and water quality for their businesses within the food and beverage sector. With water rights and interests being resolved, Māori play a critical role in influencing water quality and securing water rights for their businesses into the future. This makes these businesses more resilient and ensures that their businesses have prioritised water security for the future, thus reducing the risk.

Having focused on leadership in regenerative and restorative agriculture, Māori agricultural businesses may have adapted and created sustainable enterprises telling their provenance stories and leading the way in profitability without compromising on protecting te taiao. They may transform their production to include crop species that previously did not flourish in the cooler Tāmaki region but will thrive in the warmer climate of the future. This diversification and changing of practices may mitigate and reduce the potential risks identified and provides opportunity for Māori business to be leaders in both Aotearoa and international export markets, enhancing their provenance story.

All Māori businesses in these subsectors have transitioned to renewable energy sources well in advance and are integral in testing and creating innovative industry solutions which are then pushed out internationally through non-competitive industry relationships.

The interconnectedness of working with their whenua, and farming, fishing, growing and producing kai having such a significant impact on sustainability is the key driver for change in the sector for Māori business.

Pathways to success have been enabled and cemented through Strategic Actions 2 and 4 of Te Tāruke-ā-Tāwhiri: Auckland’s Climate Plan.⁴ This is implemented effectively with synergies between identified actions for Auckland Council and the priorities and operational practices, risks identified and the opportunities for Māori business in the food and beverage sector.

Table 9: Māori Business Opportunities – Food and beverage sector.

Opportunities identified in ECCRA	Opportunity for Māori Business
<ul style="list-style-type: none"> Improved catchment hydrology as a result of afforestation Strong consumer demand for safe and sustainable protein Increasing demand for locally produced goods and services as imports increase in relative price due to higher transportation costs Onsite electricity generation / microgrids may increase resilience to disruption to external energy network shocks Ability to expand into new markets through the provision of low-carbon goods and services Access to new financial products (e.g. green bonds, sustainability linked loans, sustainability linked bonds) to support business growth 	<ul style="list-style-type: none"> Māori dominate fisheries, providing considerable opportunity for these markets Opportunity for remote Māori businesses to secure more efficient and reliable power supply
	<p>Opportunities identified through interviews</p> <ul style="list-style-type: none"> Developing impossible foods – created foods and foods to replace higher emission products AU is working on a project called ‘From the Groundup’ – It is about adaptation and pursuing higher value niche products as well as a sustainable seafood corridor. This is something that would be of interest to Māori and Māori Businesses

⁴ **Strategic action 1** - Support, endorse and resource the establishment of a rōpū that enables us to put the indigenous framework into action. What this means in practice – form an intergenerational collective, that is rangatahi-led, to act as a channel between council and stakeholders. The purpose of the collective is to manage activities to support climate action and resilience.

1. Phase One: Establish trust and rapport through a series of wānanga that facilitates collective consciousness and a common agenda.

2. Phase Two: Develop an indigenous measurement tool to support management, prioritisation, and measurement of the state of progress against the indigenous framework.

3. Phase Three: Using a collective impact model, establish a term of reference for working between the intergenerational collective, council and stakeholders.

4. Phase Four: Establish rangatahi rōpū (group) to create a collective impact movement for change (that supports bringing climate justice and resilience actions to life). Members represent key Atua māori that are most impacted by climate change.

Strategic action 4 - Support, endorse and resource food sovereignty in accordance with our indigenous measurement tool. What this means in practice – reconnecting people of all ages to where our sustenance comes from - how it grows and how we can be more resilient when we understand this. Sub Actions:

1. ‘Ka noho’ – wairua and ngākau: Assist rangatahi to reconnect with mātauranga Māori to nurture skills and awareness around what it means to be self-sufficient.

2. ‘Teina’ – hinengaro: Enable educational programmes focused on reviving ancient Māori food practices as a way to help rangatahi and their whānau understand self-sovereignty beginning with food sovereignty.

3. ‘Te tangata’ – tinana: Promote, progress and fund current and emerging initiatives, programmes and groups who are actively committed to the restoration, sustainability and protection of food sovereignty systems within their communities. (Auckland Council, 2020)

3.2.2 Construction

For the purpose of the ECCRA the Construction Sector comprised of the following subsectors: infrastructure, residential and non-residential subsectors.

“We are the company of a million chances. We provide opportunity regardless of your background, formal training or convictions. We are whanau, you can fall in and out of love but we allow them to keep coming back.” – Interviewee

Construction is the dominant industry for Māori-owned businesses across nearly all regions in New Zealand, with more Māori-owned businesses in Construction than any other industry. The construction sector is a vital component of Auckland’s economy and in 2019 it employed over 86,000 people, with a large number of these being Māori (19,000 according to MBIE, 2015). Nationally more than 2,400 Māori-owned businesses are based in the Construction sector (TPK, Te Matapaeroa, 2019). Most reports have a considerable lack in detail around what areas of construction these Māori owned businesses work in, their size and turnover. A large number of businesses have simply self-identified as being self-employed (MBIE, 2015).

Given the tribal area for most of the iwi and hapū in Tāmaki Makaurau is comprised of urban areas, their settlement assets received or their chosen investments resulting from cash settlements, lean towards commercial property assets. Many of these are then leased back by the Crown but many include tracts of land dedicated to residential property development, retirement homes, school grounds or other commercial or industrial properties. Those iwi and hapū in the area with the biggest asset bases are almost entirely property based and most include development.

Although there are a large number of iwi and hapū that have ancestral ties to the Tāmaki Makaurau region (as detailed below), Ngāti Whātua Ōrākei is one of the largest earning iwi in New Zealand with their entire asset base invested in property, which funds the aspirations of their people (TBD, 2018). All of Ngāti Whātua Ōrākei’s investment properties are in the Tāmaki Makaurau region. Its properties include:

- Quay Park, which has 29 ground leases which include the Spark Arena, a Countdown supermarket, apartment blocks, other apartments and commercial building
- Eastcliffe on Ōrākei Retirement Resort at 217 Kupe Street, Ōrākei; and
- North Shore Development Lands. Ngāti Whātua Ōrākei purchased 28ha of North Shore land from the Crown as part of the WAI388 Claim.

With a total property asset base of over \$1.2b and a net worth of over \$900m, all located in the Tāmaki Makaurau region, Ngāti Whātua Ōrākei’s exposure to impacts within the construction industry in Tāmaki Makaurau is significant. Any assessed impacts on the construction industry may have a considerable impact given their future development aspirations. Prioritising planning for impacts within the construction industry will be key, to ensure the impacts of any disruption in the industry are well planned for. Waikato-Tainui also have two significant hotels based adjacent to Auckland Airport; one is still under construction.

Ngāi Tai ki Tāmaki have also recently settled their Treaty claims and have received \$12.7 million in

commercial assets (New Zealand Government, 2018), with the settlement for Ngāti Tamaoho (New Zealand Government, 2017), including commercial assets. Te Ākitai Waiohū have also recently settled. As part of their settlement financial redress they received the ability to work with the Ministry of Housing and Development on property development opportunities. The potential risks identified for the construction industry may directly affect iwi and hapū in the region and their ability to access and take advantage of their assets to help fulfil their aspirations into the future.

Table 10: Risk Summary – Construction sector.⁵

Risk Summary
<p>On the basis of the more limited diversification of business interests within Māori entities in the Tāmaki Makaurau region and the resulting consequences of these risks all being highly relevant, the risk for Māori may be increased. With both large numbers of Māori employees in the industry as well as Māori-owned businesses, alongside the significant iwi and hapū asset base in the sector, the consequences for Māori business as a whole may be significant.</p>
<p>The values baseline of operations, often with a key focus on environmental impacts, for most Māori businesses means that they may be acknowledging, prioritising and planning for the identified risks to the industry, albeit they may not have the financial resources to support their planning. Given the value of the industry to the Māori economy and with fewer ways to diversify practices to minimise the impact of these risks, it may be important for Māori businesses in the industry to plan for these challenges.</p>
<p>The non-sector specific barriers already identified above apply to the construction sector.</p>

Table 11: Insights from interviews – Construction sector

Key Risks Identified through interviews
<ul style="list-style-type: none"> • Risk 1- Maritime - There are very few or no alternatives. This equals delays. Proposed remedy of budgeting more downtime and tendering for easier, less complex tenders. • Risk 2-4- and 6-11 are all currently planned for. There are strategies and plans in place for business continuity. There is an issue around access to reliable data to enable decision making. i.e. Have you factored enough down days based on weather (heat or storms) within contracts. • Risk 5 - Flights are a huge issue. As a Trans-Tasman company this impacts our governance or shared upper level management resource but there are digital options.
Sector comments from interviews
<ul style="list-style-type: none"> • Lower productivity - Low income jobs lead to vulnerability, and if there is disruption and an increase in this, then it exposes those employed within the industry. This is relevant to a high number of Māori. • Looking to options for moving to higher productivity to combat this • Land and construction are a big part of the picture for iwi • Keen to be part of property negotiations and discussions but these are huge amount of money • Insisting on inclusion through procurement is essential • Must be part of the stories around development. But there is sometimes wasted resource going in circles with korero. • Aiming for true partnership and true trust

⁵ Note: Risk summaries are based on literature and data review only, due to limited interview data across sectors.

- An impact may be moving to subcontracting, to minimize (or outsource) the risk and minimise costs
- Concerns around larger or prime contract holders shifting risks down to subcontractors. This will realistically mean a large number of Māori providers may carry this. These are also the ones that employ a huge number of Māori.
- Māori are often hit earlier rather than later by headwinds
- Operating rationale includes providing better opportunities for Kiwis so our good people don't keep leaving to Australia. Focus on:
 - paying minimum of \$30 hour, time and a half and penalty rates and pay people what they are worth
 - pricing jobs accordingly and including these costs.
 - work on professionalism and expertise not just price
 - giving multiple chances even when people make mistakes over and over
- Provide staff with financial assistance, poor credit and education around finance, bank set up etc. Access to services. If they can't access finance we give it to them i.e: finance car for them until they paid off from their pay. All done with contracts. Only ever had one not pay.
- Also have career pathways from labourer to ownership. Labourer to business partner is the dream. Realistically it is about providing an opportunity to get to the top. Goal is move people on - succession planning.
- Amotai isn't necessarily capturing everything that is 'Māori' and there are many that can stand on their own two feet.
- Values baseline can result in being more vulnerable. Some Māori businesses go under as they don't know how to access support.
- Biggest potential clients are pākeha who own everything. They own all the supporting services and buy them all out. "We have to rely on our relationships. The work we are getting are old friends and University friends. Sometimes it's great delivery that gets more wins."
- Decision making is the actual problem, everything run by pākeha. "Council decision makers, white, procurement white. All white faces, Māori don't feature."
- Different focus on environmental, and social stuff. Keen to work together to get work but the pākeha view encountered is 'I'm going to get the job and you are going to work for me.'

3.2.2.2 A Future Scenario for Māori Business in the Construction Sector

"We employ more Māori and Pacifica people and know that most reasons why social statistics are poorer is because of financial stressors. If we can lift them up financially then that will help them in all areas." – Interviewee

This future scenario sees the values baseline operations for most Māori businesses within the industry means that they will be acknowledging, prioritising and planning for the identified risks to the industry. With fewer ways to mitigate or diversify practices to minimise risks, innovation kicks in. Innovative construction technologies and solutions are developed that remove reliance on supply chains, with locally sourced products emerging across the board. With Māori as keen early adopters of technological advancements, and an increased focus on protecting their people and valuable sources of profit to achieve their aspirations for their people, the construction industry remains a vibrant of the Māori economy in Tāmaki Makaurau.

Taking on board the challenges they find themselves facing as employment disappears with the growing risks that climate change brings within the industry, Māori construction contractors fill the growing voids and work together as industry teams. They operate with autonomy but use their

collective power and relationships to minimise risks and access preferential rates to level the playing field against the bigger players in the industry. They have prepared for and planned for the risks identified and have led the industry with innovative solutions which they then export worldwide. The collective of Māori construction businesses in Tāmaki are in significant demand as the lowest footprint operators in the industry and strong local supply chains powered through whakapapa connections and whanaungatanga. As the largest employer of Māori in the industry offering wrap around support for their people, empowering their whanau and aligning with their principles and values-based operations.

Table 12: Opportunities for Māori Business – Construction sector.

Opportunities identified in ECCRA	Opportunity for Māori Business
<ul style="list-style-type: none"> • Additional opportunities from demand for low-carbon buildings and infrastructure • Increased energy efficiency of houses and other buildings leading to reduced operational energy costs • Strengthened local supply chains • Increasing demand for locally produced goods and services as imports increase in relative price due to higher transportation costs • Onsite electricity generation and microgrids may increase resilience to disruption to external energy network shocks • Ability to expand into new markets through the provision of low-carbon goods and services • Access to new financial products (e.g. green bonds, sustainability linked loans, sustainability linked bonds) to support business growth 	<ul style="list-style-type: none"> • Given the long timeframes in these scenarios, the likelihood of innovative construction technologies cannot be discounted, especially with Māori as keen early adopters of technological advancements, with an increased focus on protecting their people and valuable sources of profit to achieve their aspirations for their people. • Opportunity for remote Māori businesses to secure more efficient and reliable power supply • Opportunity for unique Māori provenance story throughout export markets <p>Opportunities identified through interviews</p> <ul style="list-style-type: none"> • Opportunities around housing and construction, property development and thermal requirements, will be decreasing, and may even out against risks • Green Waste, recycling, job creation and linking Māori businesses together in this space – circular economy • Re-deployment of staff - Partnership or procure the work to someone else

3.2.3 Screen

For the purpose of the ECCRA the Screen Sector comprised of the following subsectors: film sector infrastructure and filming locations subsectors.

“Climate Change always has impacts for us. It’s not 2040, its now. We directly see the impacts and they directly impact us as a business.” – Interviewee

Although it is clear that art and creative industries include a large number of Māori artists, there is

very little data accessible on Māori business in the screen sector, and none that indicated this by region. There is however, significant revenue brought in by overseas production and film projects choosing to film both within the environmental and cultural contexts that New Zealand has to offer. This trend makes being positioned within this industry more and more profitable and attractive for Māori businesses. Motion Picture and Sound Recording Activities were identified as one of the top six sectors for self-employed Māori in the Tāmaki region 4.3% (ATEED, 2020).

A number of Māori owned and operated businesses were identified through connections and searches. Mahi Tahi Media operates out of Auckland and states that they are an innovative production company creating television, and digital and livestream content. Kura Productions operates within the Auckland region also and identified themselves as a Māori television and film production company.

The company is a joint venture between Quinton Hita and South Pacific Pictures. A further 5 members were detailed within the Māori Screen Professionals Directory provided by Ngā Aho Whakaari, Māori in Screen, an organisation based in Auckland. The members were writers, directors, producers, actors and publicists in the industry. With so little data available given the obvious size of the industry, the assessment has been based more heavily on the Māori context.

Table 13: Insights from interviews – Screen sector.

Key Risks Identified through interviews
<ul style="list-style-type: none"> • Risk 5 - Most worried about flight disruption • Risks 9 and 10 – seasonality and eco-systems will have a huge impact on ability to continue main popular shows being filmed • Risk 2 - ICT – Also concerned • Risk 1 - Maritime – Also concerned
Sector comments from interviews
<ul style="list-style-type: none"> • Always impacted by Climate Change. It's not 2040, it is now. • Directly see the impacts and they directly impact on business operations • Weather patterns are considerably less predictable. Have impacted already on our weather contingency days increasing drastically. • Ecosystem impacts are also very real. It directly impacts staff, their ability to catch/fish, what they catch as well as the weather itself. This directly impacts budget. • All NZ shows and content are coastal or in the environment • Operators in the screen industry are capital-light so they are more fluid and moveable • The creative and indigenous voice is growing and it's an emerging economy • More resilient and more able to move with locations • Building the production and digital space is essential. Boutique operators having a resurgence

“The creative and indigenous voice is growing and it’s an emerging economy.” – Interviewee

3.2.3.2 A Future Scenario for Māori Business in the Screen Sector

This future scenario sees Māori businesses within the future screen sector as being low impact

environmentally, digitally focused and creating high value outputs that use innovative tools to create value and tell their stories. The screen sector is heavily involved in supporting the knowledge-based economy and particularly through the huge increase in online learning and demand for creative, engaging content.

This places Māori screen industry professionals as leaders and kaitiaki of mātauranga and knowledge alongside mana whenua. Integral in telling and sharing stories on their own terms. Increasing demand for indigenous content that is locally produced is highly valued and attracting more and more rangatahi and pākeke into the industry both in front of and behind the screen into high value industries.

Technology and how we view content has driven Māori businesses to lead through innovative ideas and practices, resulting in productions that are fluid, moveable and low impact on te taiao.

Table 14: Opportunities for Māori Business – Screen sector.

Opportunities identified in ECCRA	Opportunity for Māori Business
<ul style="list-style-type: none"> • A higher percentage of the workforce sourced from Tāmaki Makaurau to minimise aviation emissions and costs • Increase investment in technologies such as landscape scanning, augmented reality, virtual reality, animation etc to reduce the need to travel to sites during production • Increasing demand for locally produced goods and services as imports increase in relative price due to higher transportation costs • Onsite electricity generation and microgrids may increase resilience to disruption to external energy network shocks • Ability to expand into new markets through the provision of low-carbon goods and services • Access to new financial products (e.g. green bonds, sustainability linked loans, sustainability linked bonds) to support business growth 	<ul style="list-style-type: none"> • Increased opportunities for Māori artists and creatives both on and behind the screen • Increased opportunity for advancing the knowledge economy as an opportunity, kaitiakitanga, owning these stories and their presence in the industry • Opportunity for remote Māori businesses to secure more efficient and reliable power supply • Opportunity for unique Māori provenance story throughout export markets
	<p>Opportunities identified through interviews</p> <ul style="list-style-type: none"> • Be leaders in the industry • Use product placement or sponsorship from EV suppliers • Try to strengthen more digital or weightless exports and support development of these industries

3.2.4 Visitor Economy

For the purpose of the ECCRA the Visitor Economy Sector comprised of the following subsectors: tourism, business and major events and international education subsectors.

*“The reality is they need to start calling it manaaki not, tourism/hospitality.”
– Interviewee*

Within data reviewed, the Visitor Economy is not separately identified in standard classifications of industries. Rather, the 'tourism sector' is defined as a combination of some of the activities in various sectors, for example, retail trade, accommodation, transport, and art and recreation (BERL, Te Ohanga Māori, 2018). However, a number of recent studies were compiled with data collected just prior to the COVID-19 pandemic. Post COVID-19 the realities and struggles for the tourism industry in New Zealand have been significant. Domestic travel has increased and enabled some businesses to survive, but not to the extent they did pre-COVID. Given that international travel may be impacted for years to come, the overall fragility of the industry may make transition and preparedness all the more challenging for this sector, or it may provide an opportunity to regroup and consider its future.

With 537 Māori-owned tourism businesses identified nationally, Māori businesses make up 4% of all identified tourism businesses. 300 of these were Māori-owned businesses in Accommodation and Food, 141 Māori-owned businesses in Arts and Recreation, and 96 Māori-owned businesses in other tourism industries (including Transport Services, Motor and Transport Equipment Rental and Hiring, and Travel Agency Services). Tāmaki Makaurau was not identified as a region with typically higher levels of Māori ownership of tourism businesses. Across the board, Māori tourism businesses employed more than 11,000 people in 2019 and more than 3% of all employees in the industry (TPK, Te Matapaeroa, 2019).

There are two industries where Māori-owned businesses are making higher margins than non-Māori owned counterparts. These are Accommodation and Food Services; and Rental, Hiring and Real Estate Services. A proportion of this would be included within this Visitor Economy sector and the other in the Food and Beverage sector. These statistics are encouraging, in comparison to the overall data that indicates margins for Māori businesses generally are considerably less than for their non-Māori counterparts (TPK, Te Matapaeroa, 2019).

Māori enterprise in this sector was continuing to see significant growth pre-COVID. Authentic Māori tourism experiences are highly sought after and are growing in number. In the Tāmaki Makaurau region, specific data was again hard to access. However, here are some assumptions that can be made in relation to the risks identified in the ECCRA. In relation to cultural heritage sites, the likelihood of Māori being employed in reasonable numbers and being active businesses in the industry is high. This will only continue to increase as awareness and the value of indigenous stories is becoming more popular in the tourism experience and as part of the New Zealand story. This may increase the risk ratings for Māori business on this basis.

Waikato-Tainui, as one of the largest iwi in the country, have connections within Tāmaki Makaurau and operate Novotel Auckland Airport Tainui. This hotel opened in 2011, and comprises of 263 rooms, conference and business facilities and a restaurant and bar. The hotel operates directly alongside Auckland Airport. The hotel was developed as a joint venture with Auckland International Airport Ltd (20%) and Accor (10%). Waikato-Tainui are also part of a joint development with Auckland Airport to develop the Te Arikiniui hotel, which will offer 5-Star accommodation alongside their Novotel Tainui. These are considerable investments and may be significantly impacted by the risks identified within the ECCRA (Waikato-Tainui, 2020).

Impacts on Māori cultural and heritage sites and waahi taonga will also have an impact on the tourism industry. However, the connections that Māori have and role that Māori business plays in both enhancing and protecting these sites within tourism businesses make these risks and consequences considerably greater for Māori businesses and for Māori overall.

Table 15: Risk Summary – Visitor Economy sector

Risk Summary
The tourism sector is heavily reliant on Māori taonga, culture and people in Tāmaki Makaurau and the ability for Māori businesses to be front and centre in telling their own stories and histories within the tourism sector may only increase over time. With technological advancements and increases in commercial asset bases, these business opportunities may increase thus increasing the risk profile.
The consequences for Māori further increase due to the cultural connection to these sites over and above the financial impacts of changes to business operations that they are dependent on.
The importance of the industry to Māori business and culture within the region is noted, due to the number of Māori businesses and iwi and hapū commercial entities that exist within the sector and subsectors.

Table 16: Insights from interviews – Visitor Economy sector.

Key Risks Identified through interviews
<ul style="list-style-type: none"> • Risk 1- Thinking of alternative routes is critical. Flexible itineraries- so there can be real time responses. • Risk 2 - ICT- important as very dependent but social media – less so for boutique operators; ICT is an enormous risk for the University. • Risk 4 - Road networks- Interested in rail again and air connectivity- other ways of not being overland- off the beaten track. • Risk 5 - International flights- critical for customers. • Risk 6 - Critical for customers. • Risk 7 - Things to visit are critical for tours. • Risk 9, 10- Coastal stressors- visitor days and festivals etc- i.e: where to go if normal is out? – Need good terms and conditions regrading safety and cancellations. • Risk 11 - People exposed- safety is paramount, staff, suppliers, visitors. • Most worried about Risk 4 (road networks) and 10 (fisheries). • Other risks of medium importance. Least worried about Risk 8 (assets, crops) and environmental as there are strategies in place to protect. • Risk 11 - is a big risk because air travel and conferences are critical for international students and academics.
Sector comments from interviews
<ul style="list-style-type: none"> • Expressing manaakitanga when all opportunities to do that is being compromised – how? • Really impacted by COVID. 70% of businesses currently do not operate anymore. • Highlighted those sites of significance that are co-managed with DOC. Those iwi relationships need to be managed as they need to navigate disruption. • Auckland is hugely reliant on the visitor economy, in every way. All businesses are connected with this. • Without strong balance sheets or no capital to lean on, this is hard. All of this is cyclical but for Māori business there are more barriers and the risks are higher. • Lack of support across the industry, how we treat each other in any industry is most important • There is going to be a problem with price cutting. That is not how to survive. Prioritise good living and value what we have. ‘We are holding prices, not dropping like everyone else.’

- Would rather have valuable staff who want to work with us. Being fair. Our standard of living is high in New Zealand. The playing field is not level internationally.
- Navigating outside and around the motu is a challenge, you need to have the right to operate. Whose stories are they to share? Others are happy for to share their stories, some have us do it.
- ‘Our best is local people in local areas, and that’s what our people want to hear’
- Clients aren’t here to just visit, they bring their own experiences. You learn as much as you can. Rāhui is one of the best examples. Operated West Auckland touring. Couldn’t control it that, but it was something that was being played out in the media and they operated right through that zone by managing it.
- ‘The reality is they need to start calling it manaaki not, tourism/hospitality’
- Manaaki is innate
- ‘We are pretty mainstream and have mostly non-Māori customers. It’s just who we are, part of our experience’
- ‘If you look at indigeneity, you are even more isolated as a minority. Your belief systems and what you see as important is different.’
- Yes, these things will impact absolutely because the Māori entity within the University probably haven’t been consulted around the planning for these risks and business continuity.
- That lens won’t have been considered, therefore there will be impacts
- The tools used in emergency and risk stages - Concerns about IP issues and indigenous lenses for these portals once in the international domain.
- Would prefer to have online portal for international services and then have it governed by our own not international law, as once online control is lost.
- The University numbers managed to stay steady even with the borders closed as they needed to reflect and look to local resources. But they didn’t consider that for every international student meant 5 x New Zealand students – that’s a carbon footprint issue. It worked out because of the online classes through COVID, but it was not designed like that it just happened by default.
- Limited consideration of these sustainability impacts, income was the priority
- Think there is a clear flaw in hospitality. Rent way too high, labour way too expensive. In store 6 hours a day but primarily sales are in 1 hour of the working day. 15% profit is made stretched across the remaining hours – it is not sustainable or smart.

“How do we express our manaakitanga when your opportunity to do that is being compromised?”

3.2.4.2 A Future Scenario for Māori Business in the Visitor Economy

This future scenario sees the ability for Māori businesses to be front and centre in telling their own stories and histories within the tourism sector and this will only increase over time. Māori are and have always been drawn to this industry and with technological advancements and increases in commercial asset bases, these business opportunities increase exponentially. Authenticity in tourism is paramount, with travel for the coming decades become more experiential and indigenous focused, Māori businesses are actively sought out by customers both nationally and internationally.

Innovation sees digital hospitality experiences enjoyed by many with Māori tourism leading operators in this space, creating employment for their people and high value jobs in tourism innovation. As with the screen sector, there becomes a connection between Māori industry as kaitiaki of mātauranga and knowledge alongside mana whenua, and integral in the telling and sharing of stories on their own

terms. Sites of significance are only experienced by visitors alongside Māori experts and this knowledge is highly valued and passed down through whakapapa within the industry, and creates employment and a resurgence in mana whenua knowledge holders being engaged within the sector. Within the sector these skills are also leveraged and accessed to support the international education sector, developing programmes that are internationally recognised across the indigenous knowledge space and sees the strengthening of existing Māori businesses across the sector as a whole.

Table 17: Opportunities for Māori Business – Visitor Economy sector.

Opportunities identified in ECCRA	Opportunity for Māori Business
<ul style="list-style-type: none"> • Increased opportunities for recreation, tourism and conservation due to afforestation • Higher education institutions may benefit from funding made available for low- carbon research • Higher education institutions may be able to develop new service offerings to equip students for professions likely to prosper in a low-carbon economy • Increasing demand for locally produced goods and services as imports increase in relative price due to higher transportation costs • Onsite electricity generation / microgrids may increase resilience to disruption to external energy network shocks • Ability to expand into new markets through the provision of low-carbon goods and services • Access to new financial products (e.g. green bonds, sustainability linked loans, sustainability linked bonds) to support business growth 	<ul style="list-style-type: none"> • Increased opportunity for authentic cultural tourism owned and operated by Māori • Enhance connections between the Visitor Economy and Māori research institutions, for Māori businesses to benefit from the increased funding for mātauranga Māori or Māori perspectives in climate adaptation/mitigation-based research, as well as these new career pathways being developed. This evolving knowledge economy provides opportunity for enhancing and growing the visitor economy. • Opportunity for institutions and Māori organisations to focus on increasing Māori uptake into these new professions • Knowledge economy is a huge opportunity, kaitiakitanga, owning these stories and their presence in the industry • Opportunity for remote Māori businesses to secure more efficient and reliable power supply • Opportunity for unique Māori provenance story throughout export markets
	<p>Opportunities identified through interviews</p> <ul style="list-style-type: none"> • Resolving the costs of having a storefront. Going digital from kitchen to consumer • Reducing footprint by containing site and being solely delivery based. More control over everything to mitigate risks • Create online ordering direct through a channel (ie: Microsoft Teams) and streamline ordering, getting people ordering just because they get an alert to say someone else has. Can become a huge new revenue stream • Promote eating healthy and team relationship building. Alerts when teams are eating together

4. Transitional climate change risks

Transitional climate change risks and opportunities are identified as those that may result from the process of adjustment towards a low-carbon economy.

“In contrast to the physical climate change risks posed by climate change, climate-related transitional climate change risks and opportunities are highest in the next few decades (as action is taken to reduce emissions), are broader in scope, and are dependent on the speed and scale of transition.” (AECOM, 2021, page 53).

Transitional climate change risks and opportunities resulting from transition evolve as a result of a number of things and include risks related to costs imposed or resulting from policy and litigation, technological improvements, market shifts in supply and demand, as well as reputational risks for organisations.

4.1 Assessment

The assessment for identifying transitional climate change risks within the ECCRA was again based on the transition scenario within the ECCRA technical report (AECOM, 2021). Both transitional climate change risks and opportunities were not rated as the physical climate change risks were, as they are too ambiguous to have a specific risk rating. These have been considered in the same manner for this part of the review in a Māori context.

The ECCRA (AECOM, 2021) does indicate that a general assessment of the level of risk depends upon ‘the ability of the economic entities within the sector/subsector to absorb costs or to pass costs on to consumers, and the sensitivity of consumers to changes in products and prices.’ (AECOM, 2021, page 54). This was echoed by the interviewees’ insights and was a key driver in the risks and barriers that they identified for transition.

Many of the impacts and effects of the identified transitional climate change risks are also relevant to the physical climate change risks that have been detailed throughout this report, specifically the challenges identified in Māori business contexts. These challenges simply increase any identified risks and often create an uneven playing field when considering risks in transition. Across all sectors the challenges identified for Māori businesses above will increase transitional climate change risks including access to funding (34%), people – capability & capacity (31%) and access to capital (18%) (BDO, 2020).

4.1.1 Insights on Transitional Climate Change Risks from Interviewees

A summary of insights gained from interviewees when discussing the identified transitional climate change risks from the ECCRA is included below. The majority of these insights were in relation to transitional climate change risks, as well as transition actions and were relevant across the sectors, with additional sector specific insights identified within the right-hand column.

Table 18: Insights from interviews – Transitional climate change risks across sectors.

Key transition insights from interviewees	Sector specific insights on transition
More limited financial backing or foundation to support transition	<p>Visitor Economy</p> <ul style="list-style-type: none"> • Very hard in our industry. There is stuff we would like to do. Vac-packed but how do we do that. Bio vac-packing. • We switched to biochem not plastic bowls. Wooden chopsticks • Hospitality is one of the worst in sustainability. Have managed to reduce better food waste, stocking systems to reduce waste.
Lack of available cost-effective options for transition	<p>Food and Beverage</p> <ul style="list-style-type: none"> • We are seeing mitigation in the food and beverage space • Comfort is taken in the need for food and as a result, in our business, the reliance on the supply of food. • Our population is small and we do have the ability to move and adapt. For example, removal of round up and pesticides, would be a big change in reasonable timeframe.
Access to capital to support transition	<p>Construction</p> <ul style="list-style-type: none"> • Move to being more digital. Keep a handle on hours worked, what they are achieving in those hours and recording what has impacted us and creating a calculator. • Use data to adapt our practices and use the digital information to do that. Buying into programmes that personalise our business and hone our skills. • Improving workmanship and practices. Inhouse practices and improving practices to refine and save costs. • A lot of companies are trying to de-risk by having to absorb with another company to take on risks or to step up. • Currently not fit for purpose electric vehicles for what we need • We are paperless and minimise waste through measure to cut processes.
	<p>Screen</p> <ul style="list-style-type: none"> • Have moved away from higher emission and higher fuel use vehicles, boats and outboard motors. 4 stroke outboards, not 2 stroke so less fuel consumptions, 1/3 less fuel and no oil. Vehicle v8s changed to swifts, hiluxes etc. • Rechargeable batteries on site – 8 year ago transition, mics etc reduced waste. • No generators. Two off grid properties, all solar, generator backup It is 100% cost prohibitive to move to electric vehicles.

The table below details the transitional climate change risks identified within the ECCRA. These have been considered in a Māori context as contextualised earlier in the report as with the physical climate change risks. Considerations resulting from this assessment are reflected in the additional column in the table below.

Table 19: Transitional climate change risks applying to all sectors including Māori business considerations.

Transition risk	Commentary from ECCRA	Considerations for Māori
Increased costs of transporting input materials across the sectors due to increasing fuel costs	Risk depends upon the distance inputs to production must travel, the distance to consumer markets, and the mode of transportation. This risk applies to land-based transportation, aviation and shipping	The ability of Māori businesses to absorb the costs varies considerably. With Māori SMEs experiencing greater financial exclusion (TPK, 2019), their access to additional capital may be challenging. Further pressure on their balance sheets may not assist with this.
Higher electricity costs causing reductions in demand, or reductions in profit margins	Risk depends upon the energy intensity of the production of a good or service, the ability of the business to absorb costs or to pass costs on to consumers, and the sensitivity of consumers to changes in price	
Increased costs of inputs to production due to price on carbon	Risk depends upon the volume of material inputs, the emissions intensity of the material, and the technological viability of decarbonising the relevant production and supply chains.	
Additional capital outlays required for fuel switching and energy efficiency retrofits in response to policy, regulation, consumer demand or market signals, stressing balance sheets and cashflows.	Risk depends upon the magnitude of the capital outlays required, and the ability of the business to access necessary capital.	
Stranded assets: Investments see their economic life curtailed due to technological, regulatory and/or market changes, stressing balance sheets	Risk depends on current or likely future existence of substitutes for production processes or goods and services, the emissions intensity of assets, asset adaptability, asset useful life, and the capital intensity of sector outputs.	

<p>New costs of compliance associated with carbon- related regulation such as the TCFD causing reductions in profit margins via increased operating costs</p>	<p>Risk depends on the size of the business (i.e. employees, market capitalisation) and ownership structure(i.e. public, private), and emissions intensity of sector.</p>	<p>Increasing operating costs for SME's may continue to be a challenge and the additional challenges facing Māori businesses such as access to finance, and access to necessary human resources (BDO, 2019) may compound these risks.</p>
<p>Reputational risk if skills required to the transition, or prosper from the transition, are not present in the labour market</p>	<p>Risk depends on the need for new skills(i.e. is the transition driven through changes to labour, or capital, the adaptability of the labour-force, the ability to attract appropriately skilled workers from outside the Tāmaki Makaurau region.</p>	<p>In a number of the sectors reviewed there were issues around availability of workforce and access to human resources to fill these gaps. This may be compounded where Māori haven't been supported through the necessary educational pathways to meet the needs of the market.</p>
<p>Increased risks from wildfires due to afforestation efforts</p>	<p>Risk depends upon locations of assets and workforce exposure to smoke. Risk may also flow through transport networks and other linear infrastructures.</p>	<p>Māori entities on average own larger amounts of marginal land which is often in scrub or forestry, increasing exposure to these risks(Harmsworth et al, 2010)</p>
<p>Reduction in the competitiveness of exports if other markets do not take action to reduce emissions.</p>	<p>Risk depends on importance of exports to the sector</p>	<p>For the food and beverage sector, exports were noted as increasingly important for Māori business (King et al, 2010) and this is part of their provenance story. This may add further pressure where their focus on premium products is more significant.</p>
<p>Increased Directors and Officers (D&O) liability insurance costs</p>	<p>Risk depends on size of the business and likely liability under transition scenarios</p>	<p>Additional risks in some cases when considering added complexities of governance in iwi and hapū organisations and operating structures (Funk, 2008)</p>

Appendix A: Māori Context and Te Ao Māori

1. Contextualising Māori Contexts

The key issues relate to the impacts and responsiveness of Māori businesses to the proposed risks identified. To have a clear understanding of the context from which Māori businesses operate, we need to consider a number of contextual issues below.

1.1 Te Ao Māori and Mātauranga Māori

Ko Rangi

Ranginui – Sky Father

Ko Papa

Papatūānuku – Earth Mother

Ka puta Ko Rongo

Gave birth to Rongomatāne – God of Peace and Cultivated Foods

Ko Tanemāhuta

Tanemāhuta – God of Forests and its Wildlife

Ko Tangaroa

Tangaroa – God over Sea and Fishlife

Ko Tūmatauenga

Tūmatauenga – God of conflict and human behaviour

Ko Tāwhirimatea

Tawhirimatea – God of weather

Ko Haumiatiketike

Haumiatiketike – God over the uncultivated Foods

Tokona ra ko te rangi ki runga ko te papa kiraro

Through the separation of Ranginui to the sky and of Papatūānuku to the earth

Ka puta te ira tangata, kite whai ao ki te ao marama

Humankind was birthed, from darkness (not knowing) to light (to being enlightened)

Tihei Mauriora¹

Māori perspectives of the world are based on the proposition that the environment is an interacting network of related elements, each having a relationship to the other and to earlier origins (Durie, 1998). Illustrated in the karakia (incantation) above, the personification of the earth and the sky as the parents Rangi and Papa, underlines the point by comparing the features of the environment to a family, and as a model for examining the connections and interdependencies which occur between

forests and oceans for an example (Durie, 1998).

The karakia aims to explain that people are part of nature rather than superior to it, and that people exist in a state of balance with other elements without dominion over the natural environment. New Zealand's landscape therefore represents ancestors from whom people are descended.

Mātauranga Māori is an integral element of understanding and engaging with and in the Māori world (Te Ao Māori). It spans Māori knowledge, culture, values and worldview (Hikuroa, 2018), and is embedded in the relationship between people and natural resources, and the relationship between people and their bodies of knowledge as mātauranga Māori is explained through whanaungatanga (kinship) (Tuatahi, 2011).

Pūrākau (story telling around histories and mythology) and maramataka (Māori lunar calendar) are forms of mātauranga Māori, and comprise knowledge generated using methods and techniques consistent with scientific methods, but explained according to a Māori worldview, often binding people, places and relationships (Smith et al, 2016). Mātauranga Māori gives expression to Māori ways of doing, aspects of Māori knowledge and Māori worldview and is often aligned with aspirations (Royal, 2012).

1.2 Kaitiakitanga and the role of Kaitiaki

Durie (1998) describes kaitiakitanga as the act of guardianship that requires clear lines of accountability to whānau, hapū and iwi and is more frequently associated with obligation rather than authority. The Waitangi Tribunal report (2012) shares the view regarding this description, but extends that the description lacks the spiritual dimension that animates the concept and is a product of whanaungatanga, or the intergenerational obligation that arises by virtue of the kin relationship. The Tribunal reports that it is not possible to have kaitiakitanga without whanaungatanga, and vice versa that whanaungatanga creates kaitiakitanga obligations (Waitangi Tribunal, 2012).

Overall, kaitiakitanga in an environmental context is about upholding the care of the ancestors whom are manifested in the landscapes that Māori live within. In environmental terms, the kaitiaki approach is holistic and provides for restoration of damaged ecological systems, restoration of ecological harmony, increased usefulness of resources, and reduced risk to present and future generations (Matunga, 1993). In the role of kaitiaki, whānau, hapū and iwi as tangata whenua, Reverend Māori Marsden (Royal, 2003) suggests that there are three principles that guide kaitiaki:

- Humankind's contribution is to enhance and maintain the life support systems of Papatūānuku
- People should treat Papatūānuku with love and respect in recognition of her life supporting function, her role in the creation of the natural world, and her place in our own whakapapa, and
- No-one owns Papatūānuku, but are recipients, and therefore stewards, of the natural environment.

¹ The karakia is "a" karakia, and not "the" karakia and is being used to provide context to the interconnectedness between environs and people. It is also important to note that there are many variations to this karakia.

Additionally, the Māori concept and practices of food supply and food security are integral to Māori as they emanate mana (authority), demonstrate manaakitanga (reciprocity of kindness, respect and humanity), and mahinga kai (traditional food gathering places and practices). It is in the latter where the relationship between environment and community and individual health is prominent, whilst also reinforcing whakapapa (genealogical ties), cultural identity and resilience (McKerchar et al, 2015). The ability to provide ample food is a measure of wealth, representing economic and social power, and hence bestowing mana.

1.3 Kaitiakitanga and Response to Climate Change

There is ample research and interview data recorded in a number of reports and articles over the previous decades to gain a reasonable understanding of how Māori view climate change in relation to Te Ao Māori (Law Commission, 2001, Packman et al, 2001, Harmsworth, 2005, 2010, Ministry of Agriculture and Forestry, 2007).

Based on this research, addressing climate change can be seen as being aligned with general principles of kaitiakitanga and on this basis there is a view that Māori are supporters of climate change policy and planning that strengthens and regulates our response to climate change.

This does however need to be within context and acknowledge any limitations or barriers that present for Māori in working through the implementation of policy changes.

Harmsworth et al (2010) notes that Māori landowners interviewed as part of a project indicated that the unique characteristics of Māori land under Te Ture Whenua Act (e.g. collectively) mean policy and initiatives should be specifically tailored to a different process and timeframe in order for Māori business to equitably engage and take up opportunities (Harmsworth et al, 2010).

Māori have clearly prioritised and taken action to be both involved and show leadership in the climate change arena. Being engaged with and forming a response to the effects, impacts and economic risks and opportunities that climate change represents is a key priority for Māori. The Climate Change Iwi Leaders Group was established in 2018 and provides a collective voice and forum for iwi on climate issues. Individual iwi are also developing their own climate strategies to ensure preparedness and alignment with their intergenerational perspectives.

Substantial research on Māori responsiveness to effects and impacts of climate change has been undertaken, most notably the two National Science Challenges; Deep South and Resilience to Nature's Challenges. It is noted that there are research projects that explore the effects and impacts on Māori communities and the economic risks and opportunities for Māori business/commercial activities. These kaitiakitanga perspectives have a broader approach towards responding to climate change rather than specifically focusing on reducing emissions.

The application of fundamental values within kaitiakitanga and opportunity to practice tikanga are key to maintaining and fulfilling the role of kaitiaki. The practice of tikanga (in land use) is addressed further within the context of climate change and tikanga within this report.

The ability for kaitiaki to make their own decisions around what land practices and uses to which land is put is a key element of tino rangatiratanga and the primary method of putting values into practice (Reid et al, 2013).

1.4 Land and Resource User (Contemporary) Application of Kaitiakitanga

For Māori, the whenua (land) is a source of identity, food, and other resources that have sustained people for hundreds of years. As described in the above paragraphs, the whenua is Papatūānuku, the Earth Mother. Land is also the site of waahi tapu (sacred sites) and waahi taonga (historical sites and other places of significance to Māori), such as urupā (cemeteries), battlegrounds, and locations for gathering precious resources (Ministry for the Environment, 2015). Before the arrival of colonial settlers, all land in New Zealand was held as customary land. One of the primary tasks of the early Native Land Court was to define the boundaries of that land and convert it from communally held land by allocating owners and shares, and this has evolved into the Māori land system that exists today, especially distinguishing how land is valued in this modern era (Māori Land Court, 2017).

Māori Freehold Land is considered to hold two values, an economic value and a cultural value. The economic interest in Māori land is, like general land, an economic asset that may be used, and if considered appropriate sold, however, unlike general land, there are significant restrictions on the sale, lease or mortgaging of land. What also may differ are the values around how the land is managed, whilst recognising and providing for the association of its owners (whanau, hapū, iwi) with the land. This association or cultural interest, can be in whole or in part with Māori land and referred to or revered as a taonga tuku iho of special significance to Māori passed from generation to generation (Hikuroa, 2018). All of these elements of Te Ao Māori provide positioning and context and feed into behaviours, values and decision making for Māori. This is particularly relevant where settlement occurs after years of negotiation and results in return of land or property. Considering being forced to part with that property again for any reason, can be hugely distressing.

1.5 Statutory Influence on Kaitiakitanga and Māori Land Management

Although we have defined Māori business within the context of this report and our analysis, we also need to define Māori land as it is relevant in assessing the adaptive capacity and vulnerability within this context. This involves identifying the differences between land ownership and structures and the nuances of these that change the way land is able to be used, and the way and speed with which any changes are likely to be made in relation to any Māori businesses operating on these types of land, or within these types of structures.

Although Māori land includes individually or collectively owned general land, many Māori are working on or with land and making decisions around land that is owned under Te Ture Whenua Māori (Māori Land Act) 1993 (TTWMA). This act defines the types of ownership structures (Journeaux et al, 2017) that can govern and own Māori land and therefore this influences agricultural or horticultural enterprises. These entities are defined under the act as:

Table 20: Types of Māori Land

Types of Māori Land	
Ahuwhenua Trust	designed to manage blocks of multiple owned Māori land and are the most common structure used by Māori landowners.
Māori Incorporation	a body corporate with perpetual succession and with powers which, in form and basic structure, are similar to the joint stock company.
Whenua Topu Trusts	these trusts are similar to the Ahu Whenua trust in that its structure is designed to manage the entirety or major proportion of a tribal estate. It differs in one aspect however, in that the individual's land-owning interests are not maintained.
Whānau Trusts	trusts used by whānau to halt the fragmentation of share interests. The Whānau Trust holds the interests in the land and additional members are added to the list of owners without receiving individual interests

(Adapted from Journeaux et al, 2017)

The challenges that such land ownership sometimes presents are not insignificant.

The ownership structures of Ahuwhenua Trusts, Māori Incorporations, Whenua Topu Trusts and Whānau Trusts each have some constraints, and these should be considered in the context of Māori land ownership, Māori businesses and decision making, land use changes (Reid et al, 2013). Although there is the ability to operate as a more commercially oriented structure (such as Ahu Whenua Trusts and Māori Incorporations) there are still a number of barriers that need to be considered when compared with operating a farm or business operation for non-Māori. The way these elements impact decision-making on Māori land is what makes these processes different from general individuals or organisational land/business owners in at least three important ways:

- Restrictions on alienation (sale) limit the use of assets from being used as collateral, limiting owners' access to credit; Inability to borrow against collectively owned land from traditional (read lower interest) institutions thereby limits uptake, choices for transition and the ability to take up new and emerging technologies.
- Non-economic benefits, such as access to traditional medicines, hunting, providing social welfare, and maintaining a cultural connection to the land, are sources of value, in addition to economic returns; this foundational perspective and desire to retain ownership, derive non-economic value and connection to lands, makes decision making considerably more complex for Māori.
- Long-term, intergenerational impacts receive consideration in most decisions. These differences all stem from cultural values applied to resource allocation decisions (Funk, 2009). It could be argued that both TTWMA and proposed climate change policy may in fact align with these perspectives in more ways than one.
- Further, acknowledgement of the spin off issues around frustrations with limitations of the act and related governance structures, resulting in often heated and emotional trustee meetings that are not conducive to timely, effective or focused decision making on major issues that may

be required (Dell, 2017).

The context of this research and identification of key issues, is important as it significantly changes the responsiveness of Māori business and landowners to new strategic opportunities by affecting the process of decision-making (Reid, 2013).

However, it does need to be acknowledged that for many larger iwi, land holdings are often held under general freehold title, and often with very effective governance in place. Further, land acquired by iwi directly is not likely to be TTWMA land and therefore some of the restrictions identified do not exist in these instances. Not being able to borrow against assets is also not necessarily an issue where considerable wealth has been accrued and lenders are proactively willing to lend. Smaller trusts and incorporations may be hit harder by these issues and barriers. Their ability to mitigate or navigate their way through them is always more limited due to capital, resources and skillsets.

Appendix B: Māori Business Characteristics, Challenges and Operating Rationale and Insights

1. Māori Business Characteristics, Challenges and Operating Rationale

Māori perspectives are entrenched in a deep commitment to future generations through intergenerational decision making. This is based on an enduring relationship with the whenua and the role of humans as kaitiaki. This foundation aligns well for businesses planning for climate change using scenarios that are still considered by many to be far out of traditional business horizons. As with all businesses, Māori businesses are still struggling with the same complexities, operating in the current environment and the realities of shorter-term planning and solutions. In addition to this reasoning, the more sizeable nature of iwi and hapū commercial investments and resourcing make this intergenerational planning more prevalent and a bigger expectation for iwi and hapū commercial enterprises.

The baseline for considering impacts on Māori business rests with the interconnectedness of Māori (and their businesses) with the natural environment. 50% of the Māori asset base has been assessed as being in climate sensitive primary industries including forestry, fisheries, agriculture and to some extent tourism. The Ministry of Foreign Affairs and Trade (2017) notes this as 50% of the fishing quota, 40% of forestry, 30% in lamb production, 30% in sheep and beef production, 10% in dairy production and 10% in kiwifruit production.

“Related to this, about 60% of Maori businesses are export-dependent compared with some 30% for the national average (TPK, 2002). This situation can create a different economic playing field for Maori that can result in different objectives and different outcomes (Packman et al. 2001).”
(King et al, 2010)

The reality for the Tāmaki Makaurau region however, is that the Māori asset base looks considerably different to that outlined as the national norm and requires different considerations detailed further below.

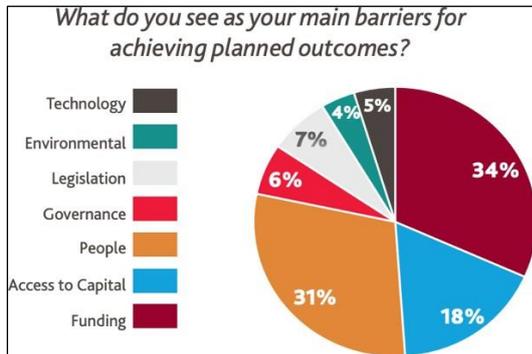
Although the ECCRA does not include consideration of technological advancements to help mitigate and adapt, for these dominant industries that Māori occupy, this may be critical to their ability to mitigate impacts. Through kōrero with interviewees it was clear that Māori businesses have already engaged and are investing in significant research and development in these spaces to identify adaptation actions, mitigation strategies, opportunities for transition and development opportunities. Some private Māori businesses are at the forefront of innovation and technological advancements within these industries.

1.2 Challenges Faced by Māori Business

In terms of business makeup, research indicates that the distribution of the size of Māori-owned businesses is similar to non-Māori-owned businesses. Both Māori-owned and non-Māori-owned businesses are similar in terms of enterprise size, employee count and on GST size (TPK, Te Matapaeroa, 2019).

The primary challenges that Māori businesses face include access to the following:

Table 21: Barriers to achieving outcomes for Māori business



(BDO, 2020)

With the following top three barriers comprising of by far the biggest challenges:

- Funding (34%)
- People – capability & capacity (31%)
- Access to capital (18%)

In the context of this review, these challenges may equate to an increase in vulnerability, potentially reducing businesses adaptive capacity and their ability to access the resources necessary to achieve their aspirations in all areas. This is particularly relevant where action is required to plan and prepare and strengthen their resilience in the face of climate risks and impacts.

An inability to access funding and capital is often flagged as the primary challenge in development for Māori landowners, and further for Māori business owners, particularly SMEs who experience financial exclusion in far greater numbers than non-Māori business owners. This may directly result in an inability to resource the necessary adaptation actions, or remedial work as a result of consequences of the identified risks, and/or to access the necessary advice where capability or capacity are not in house.

In the context of transitional climate change risks, all three of these primary challenges pose an increased risk for all sectors and all risks identified (in this context Visitor Economy and Food and Beverage); and Rental, Hiring and Real Estate Services (TPK, 2019). This finding can in itself provide a great impetus for further research into why these reduced margins exist.

Governance remains critical and is highlighted as one of the major factors of influence for vulnerability and either increasing or decreasing consequences (MfE, 2019). For Māori entities this continues to remain a challenge, with larger and sometimes less suited governance arrangements existing due to the legislative requirements of managing post settlement assets.

Identifying the differences between land ownership and the nuances of these that change the way land is able to be used, and the manner and speed with which these changes are likely to be made, is key to considering any barriers and subsequent impacts.

The other additional component for Māori commercial entities is that they are often diverse in their ownership compared to mainstream corporations, having increasingly spread their operations across sectors. In the Tāmaki Makaurau region the primary sources of income are nearly all interconnected

with the industries and sectors under consideration within this report. For example, Ngāti Paoa, in addition to their reasonably strong farming assets base, the primary other area of investment that they have pursued is property development (Ngāti Paoa, 2016). Ngāti Whātua o Ōrakei owns an asset base 100% property focused, but has an interest in tourism operations in partnership (Ngāti Whātua, 2020). The direct connections between the construction risks and development, as well as the risks identified for farming or tourism, make the level of exposure greater for iwi and hapū when they are operating with multiple businesses or operators thereby being exposed to risks contemporaneously.

1.3 Māori Business Insights from Interviewees

The interview process within this review enabled a window into the operations of the Māori businesses engaged. Those interviewed were keen to contribute input around how they felt their businesses were different to others in the industries and the interviews gave them an opportunity to reflect on this question.

Some key statements of note across the sectors were:

“There is no one Māori perspective on this nor are the situations the same for all.”

“It’s easy for us to think intergenerationally.”

“The key things for iwi are increasing capacity of mana whenua and supporting our own. How do we realise aspirations.”

“Whanaungatanga, we adopt our staff, it’s a whanau. We don’t treat them like employees and this impacts on how we are as employers. We definitely are not the same as other ‘businesses’.”

“The situation for iwi/hapū is very different than that of small to medium businesses in these industries. Iwi have decision making powers and links to businesses. Māori business will be far less resilient and have a far smaller asset base.”

“The primary reason Māori businesses face more headwinds is because they are newer in a lot of these spaces and emerging means less resilience and less ability to learn off others, bounce ideas around and less likely to have other businesses in a group to buffer that investment.”

“There is a greater expectation on Māori to be working and actioning sustainably.”

1.4 Operating Rationale for Māori Business

A recent report by BDO indicates that the primary purposes for businesses within the Māori sector were:

- Cultural, social, & environmental outcomes
- Profit to drive purpose
- Employment
- Asset growth (BDO 2020).

The operating rationale for many Māori businesses underpin their decision making and are considered

akin to economic KPIs within the business realm. In the context of Māori commercial entities operated by iwi and hapū PSGE, their commercial entities are guided by vision and purpose that is centred primarily on increasing the wellbeing of te taiao and te tangata. These PSGEs collectively uphold these expectations on behalf of their people and provide oversight and budget to ensure these priorities are upheld. The BDO (2020) report indicated that the top three keys to success for achieving their purpose in the sector were deemed to be:

- Happiness & well-whānau
- Financial performance
- Cultural wellbeing

Both the purposes identified and the keys to achieving them acknowledge the role that profit plays, and the reality is that Māori commercial entities are still focused on achieving profit for their tribal members benefit, similar to other corporates driven by shareholder returns. The difference lies in the direct link between the use of those funds for wellbeing of the collective, (with most parent entities being Charitable Trusts driven by charitable purposes) rather than the personal gains of individuals. For Māori businesses owned collectively by iwi and hapū members, any impacts on these businesses are immediately amplified by virtue of the number of people that are relying or supported by that business' success. This is to some extent magnified within Māori owned SMEs who also have been found to operate under similar values-based rationale (TPK, Te Matapaeroa, 2019).

Each iwi and hapū collective, Māori business and individuals have their own identified aspirations, however the Independent Māori Statutory Board (IMSB) have developed in consultation with mana whenua and mataawaka a set of goals and aspirations for Māori within the region.

These value baselines equate to increasing impacts when a business or commercial enterprise faces financial hardship or is forced to pivot without forethought or planning. This is not only true for Māori commercial entities; it also influences many private Māori operations who through the influence or visibility of these expectations of their iwi, or their own aspirations, seek to uphold the key tenets of kaupapa and tikanga Māori. Principles of manaakitanga, whanaungatanga, kaitiakitanga and kotahitanga for example, often guide Māori business operations. These expectations and guiding principles do however also reduce exposure to some of the risks identified by enabling swifter and earlier adaptation and mitigation measures to be adopted, and therefore spreading the costs of adaptation and mitigation earlier without compromise. Businesses perceive mitigation and adaptation actions as a normal part of conducting business rather than an additional cost.

The focus on supporting other Māori, achieving social good and wellbeing, alongside caring for our environment is a paramount objective for Māori businesses. Although these foci are becoming increasingly more common as motivators for non-Māori business, as a rule they are not a baseline of operations. It is the norm and in fact often an expectation for Māori businesses to be reaching, helping and supporting their own and te taiao. This creates an increased exposure for whanau and an increased impact when things become challenging for their business.

As a result of these principles, procurement is a big reason for economic impact or heightened exposure to risk being different for Māori business. Māori businesses often have increased focus on helping whanau through job opportunities and higher familial connections in the workplace. This also influences their decision making and resulting tipping points, which sees businesses retaining staff

longer than they would have, if there were no familial links to staff, putting the business under further pressure. Considering this alongside the knowledge that the wriggle room found within margins in non-Māori businesses differs considerably for those comparable sector Māori owned businesses. With smaller margins often comes greater exposure, and fewer options.

Research has also found that Māori-owned businesses employ more Māori. With 43% of employees of Māori-owned businesses being Māori, compared to 14% for non-Māori-owned businesses (TPK, 2019).

Often all employed members of a whanau can be contributing to the running of the same business and the family unit may be solely dependent on its profitability, rather than having a family member employed elsewhere to buffer any financial hardship resulting from a downturn. When a business such as this face difficulties this can have a deeper impact on whānau within the business and also on the business' other non-financial objectives, such as their commitments to te taiao.

Appendix C: Review of Māori Economy in Tāmaki Makaurau

1. The Māori Economy in Tāmaki Makaurau

The iwi and hapū recognised by the Crown in the Tāmaki Makaurau region are:

Table 22: : Iwi and Hapū recognised by the Crown in the Tāmaki Makaurau region

Ngāti Whātua	Ngāti Tamaoho	Ngāti Manuhiri
Ngāti Whātua o Kaipara	Te Ākitai Waiohua	Te Kawerau ā Maki
Ngāti Whātua o Ōrākei	Ngāti Maru (Hauraki)	Ngāti Te Ata Waiohua
Te Uri o Hau	Te Patukirikiri	Te Ahiwaru
Ngāti Rehua	Ngāti Paoa	Waikato, Waikato-Tainui
Ngāti Wai	Ngāi Tai ki Tāmaki	Ngāti Whanaunga
Ngāti Tamaterā		

Although this assessment originates from the ECCRA, an economic assessment, the values or drivers for Māori as iwi and hapū, are at the heart of all they do. The pursuit of these drivers in the case of iwi and hapū entities and often for private Māori business, are often visible in the development of their business interests. These business interests are also in turn intended to support the pursuit of their goals and aspirations.

Of these iwi and hapū within the region, some have resolved and settled grievances with the Crown under Te Tiriti o Waitangi settlement claims processes. This has resulted with the Crown providing redress in the form of cash, Crown properties with perpetual leases, reserves, and protected areas, commercial property and access to other assets that become available in the future under ‘rights of first refusal’ agreements. Many of these iwi and hapū have established PSGEs to govern and manage these assets and these entities play a significant role in the Auckland Māori economy.

In considering the Māori economy at a national level, it is a current and future force to be reckoned with. According to a report by BERL, the financial value of the Māori asset base in 2018 totalled \$68.7 billion comprising:

- \$39.1 billion assets in the businesses of 9,850 Māori employers
- \$21.0 billion assets in trusts, incorporations, and other Māori entities
- \$8.6 billion assets in the businesses of 18,600 self-employed Māori.

Key elements of this economy include significant growth in the Māori population and labour force which indicates that Māori will be a rising proportion of the future workforce. An increase in the diversity of the Māori asset base has been seen, with the primary sector dominance beginning to disperse, which accordingly assists with spreading risk and increasing resilience (BERL, 2018).

This economy is an engine of growth with the businesses of Māori employers becoming increasingly prominent and with high numbers of skilled Māori moving into entrepreneurship and employing considerable numbers of people. Iwi and hapū organisations are growing at a faster rate than all New Zealand businesses, and had an 18% increase in employees since 2012 (Stats NZ, 2019).

The data indicates which industries dominate the Māori economy:

- Natural-resource based sectors continue to dominate with assets in agriculture, fishing, and forestry totalling \$23.4 billion (This includes \$8.6 billion in sheep and beef farming; \$4.9 billion in dairy farming; \$4.3 billion in forestry; \$2.9 billion in fishing and aquaculture; and \$2.6 billion in other agriculture (including horticulture)).
- \$16.7 billion of assets in real estate services, including commercial, industrial, and residential property
- \$4.9 billion of assets in the manufacturing industry, including \$2.3 billion in food processing and wood and paper manufacturing
- \$4.2 billion of assets in transport
- \$3.1 billion in construction (BERL, 2018).

The Tāmaki Makaurau region alone receives over a \$12.5 billion share of this economy. The largest in the country. Further, 14,700 Māori Sole Traders have been identified in recent research, with 3,795 of these based in Tāmaki Makaurau (TPK, Te Matapaeroa, 2019). The research also identified 1,389 Māori owned businesses in the Tāmaki Makaurau region.

The Māori economy accounted for 9% of the Auckland economy (Sense Partners, 2020), however it is inaccurate to base such assessments on data alone, particularly for the Māori economy where the strength of Māori SMEs is often discounted or has not been quantified.

We do know however that the 'value' that Māori business brings outside of the obvious economic returns, is great. These are often intangibles that are not easily quantified in monetary terms, but do contribute considerably to the wellbeing of people and the environment; this of course is good for our economy.

Other sector specific Māori data that was of interest detailed that there were two overall for Māori business are considerably less than for their non-Māori counterparts (TPK, Te Matapaeroa, 2019).

Further sector specific data is included within the sector summaries in the report.

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