Reserve Bank of New Zealand
Te Pūtea Matua

Too little, too late.

2023 Climate Stress Test scenario

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Overview of the Climate Stress Test

We have been carrying out stress testing of banks for a number of years to check how well they would survive a hypothetical severe but plausible future scenario involving various forms of economic downturn. Our regular stress test programme is available on our website which also covers General Insurance and Life Insurance. The key activity for 2023 is the Climate Stress Test (CST) which replaces our annual solvency stress test for our largest banks. It is more exploratory in nature focussing on climate-related risks. This document provides an overview of the exercise and details of the design of the scenario. We plan to release aggregate results in early 2024.

What is the Climate Stress Test?

The CST consists of a severe but plausible scenario in which we specify how the New Zealand economy could be impacted by physical climate change and associated policies. It is hypothetical and does not represent a view of the most likely outcome. Banks take the common scenario and set of variable paths as inputs into their own models to estimate the impact on their profits, balance sheet and capital. The CST adds complications due to the longer nature of the scenario and the new kinds of risk variables, i.e. physical and transition climate-related variables.

Why are we stress testing climate related-risks?

Climate-related risks are already impacting the financial system and the broader New Zealand economy as witnessed by the cyclone and inland flooding affecting Auckland and other areas of the North Island in early 2023.[1] We think it is prudent to explore the more severe aspects of climate-related physical risks, which are expected to increase in the future,[2] combined with risks that may materialise in transitioning to a lower carbon emitting economy, through a stress test of our largest banks. This is consistent with our Financial Policy Remit to achieve financial stability, including having regard to building resilience and facilitating the adaptation of the New Zealand economy to climate change.

The main purpose of the CST is to improve banks' capability in managing climate-related risks. The secondary objectives are to assess financial stability risks and to identify how banks may mitigate climate risks. The objectives differ, mainly in the order of importance, from our annual solvency stress test which is used to assess financial stability risks and whether banks have sufficient capital to support lending during an economic downturn such as the GFC. Stress testing is an important component of our approach to climate-related risks as outlined in our draft Guidance document for managing climate-related risks released in March 2023.[3]

Banks may consider using those elements of the CST that support the scenario disclosures required under New Zealand's mandatory disclosure standard (NZ CS 1). However, it is not a primary objective of the stress test to meet disclosure requirements.

Which banks are involved?

The five largest banks, which hold 90 percent of total bank loan balances (as at March 2023), have agreed to participate. However, other entities can make use of the CST scenario outlined here.

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1 worldweatherattribution.org/the-role-of-climate-change-in-extreme-rainfall-associated-with-cyclone-gabrielle-over-aotearoa-new-zealands-east-coast
rbnz.govt.nz/hub/publications/financial-stability-report/2023/may-2023/fsr-may-23-special-topic-2.

2 IPCC_AR6_WGII_SummaryForPolicymakers.pdf (pp. 13-15).

3 rbnz.govt.nz/have-your-say/2023/managing-climate-related-risks.

Is this the first time the Reserve Bank has stress tested climate-related risks?

No. The 2023 CST builds on previous stress testing of climate-related risks: the 2021 Bank solvency stress test which included drought as part of the scenario; the 2021 General Insurance stress test which included a series of severe storm events; and the 2022 risk assessment of banks' residential mortgages to flooding[4] and agricultural lending to drought and emissions pricing.

How will we know if the stress test is successful?

The stress test will be deemed a success if it assists banks to (i) develop their credit modelling capability to take into account climate-related variables and the longer term nature of these risks; (ii) identify and fill data gaps such as location of properties and counterparty emissions; (iii) resource appropriately; (iv) improve the design of their own alternative scenarios; and (v) incorporate climate-related risks into their strategic decisions. We will also look to identify any systemic issues, related to the physical climate-related risks such as droughts, floods or rising sea levels, or transition risks related to the shift to a lower emitting and climate-resilient economy.

How was the scenario designed?

The scenario was designed by the Reserve Bank beginning in the final quarter of 2022. It has been developed in collaboration with participating banks. We have also consulted with experts from industry, academia and government, and with fellow regulators who have conducted similar exercises including APRA, the Bank of England, and the European Central Bank.[5]

For some of the detailed variable paths we have taken guidance from scenarios developed by the Network for Greening the Financial System (NGFS). The NGFS is an international group of 127 members (at the time of writing), mainly central banks and supervisors, formed to provide research on climate-related risks to the financial system, including providing scenarios that central banks can use for their own purposes to help financial institutions explore the impact of climate change and climate policy on their business models.[6] The NGFS scenarios have been subject to rigorous testing and input from the scientific and economic community.

However, the NGFS scenarios were not specifically designed to be used as a stress test and there are some limitations for New Zealand. Moreover, there are generally wide bands of uncertainty around model results that form the basis of climate scenarios. We have added a number of new and additional elements to the NGFS scenarios which increase the severity of the CST and should provide additional insights for New Zealand. The main adjustments are (i) the inclusion of specific extreme flooding and drought events, drawing from our 2022 climate-related risk assessment exercise; (ii) significant divergence in climate policies between countries; (iii) a ratings downgrade; iv) an operational risk event related to climate risks affecting New Zealand banks; and (v) reduced insurance cover of residential mortgage and commercial property customers. The changes lead to a scenario with a greater combination of physical and transition climate-related risks.

We have left some details of the scenario for banks individually to design. Whilst this may lead to greater variability in results, it will provide us with a range of different views of aspects of this exploratory exercise and help build capability in scenario design.

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4 rbnz.govt.nz/hub/news/2023/03/bank-flooding-risk-assessment-builds-capability-and-highlights-climate-data-gaps.

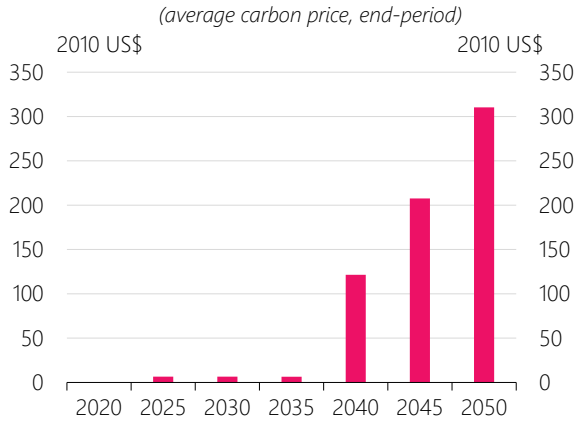
5 For example apra.gov.au/climate-vulnerability-assessment-november-2022, bankofengland.co.uk/stress-testing/2022/results-of-the-2021-climate-biennial-exploratory-scenario, bankingsupervision.europa.eu/ecb/pub/pdf/ssm.climate_stress_test_report.20220708~2e3cc0999f.en.pdf.

6 ngfs.net/en.

What does the scenario look like?

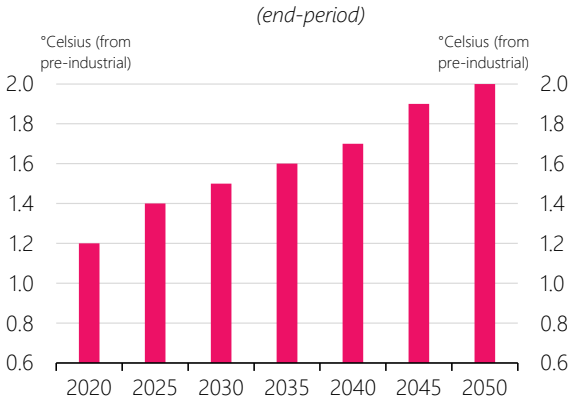
Our scenario is referred to as 'Too Little, Too Late' (TLTL) because limited and delayed global policy action to reduce greenhouse gas (GHG) emissions is insufficient to prevent significant climate change. The scenario covers the period from 2023 to 2050 with the most climate impacts occurring after 2030 as summarised in the following charts.

Figure 1: Emissions pricing – 'Late-movers'



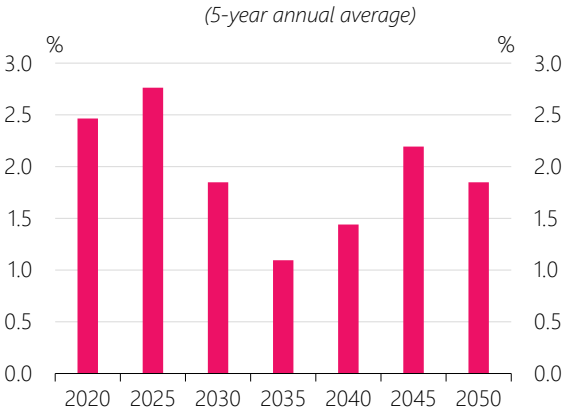
Source: RBNZ, adapted from NGFS. Notes in Appendix B.

Figure 2: Global mean temperature increase



Source: RBNZ, adapted from NGFS.

Figure 3: NZ GDP growth



Source: RBNZ.

Transition risk: A large number of countries only begin to act on reducing GHG emissions in 2036, through a rapid increase in their carbon price. This leads to a period of global high transition risk with frictions in the labour market increasing unemployment, global supply shocks, and lower trade reducing global economic growth. Other countries, including New Zealand, begin transitioning from 2031, exposing them to high transition risks relatively early.

Physical risk: The late policy action sees global temperatures increasing by 0.8° from 2020 to 2050, reaching 2° of warming from pre-industrial levels, and rising sea levels. Physical climate-related risks increase. This leads to lower productivity, increased climate variability over time, with greater extremes (for example wetter winters and drier summers), less predictable seasonal patterns, and more frequent and severe extreme weather events globally and in New Zealand.

Economic impacts: Economic growth slows significantly in the decade from 2031 as we transition to a lower-emitting economy. Later in the decade, the global slowdown lowers trade and capital flows to New Zealand. Unemployment peaks at nearly 7 percent, similar to the GFC. An extreme flooding event in this period compounds the transition risk effects, triggering reduced insurance cover and falling property prices in 'at-risk' areas. An extreme drought leads to a ratings downgrade for banks.

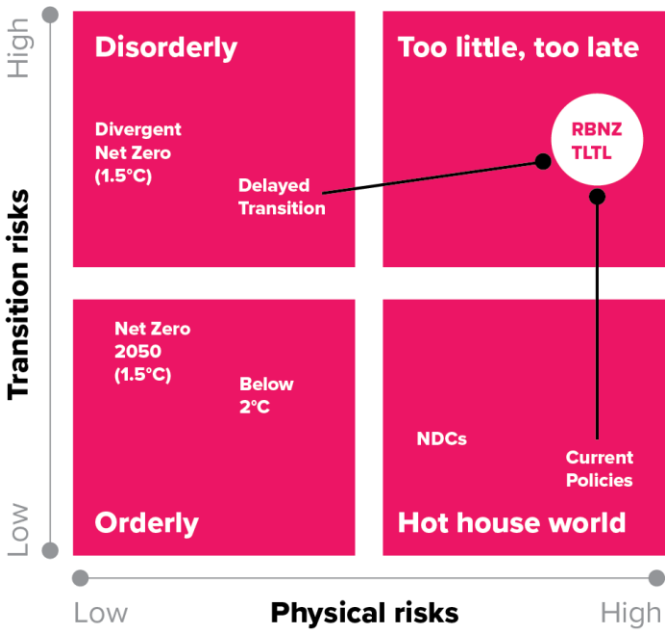
Scenario Design Framework

There are a number of different elements of the CST compared with our traditional stress test that we have allowed for in our scenario design:

- Climate-related risks materialise over an uncertain and extended time horizon, which is likely to extend beyond typical business planning cycles of three to five years.
- The unprecedented nature of climate change means that traditional risk assessment methods that rely solely on historical data have the potential to systematically underestimate the impacts of climate-related risks. This is because of the complex dynamics of interconnected lines of business, non-linear and unprecedented levels of disruption, and compounding of risk when multiple climate impacts collide.
- Data requirements for modelling are different. For example, in analysing flooding risk, banks would ideally have the exact location of a property, characteristics of the structure, and reliable indicators of flood hazards at that location and how they may change over time. Availability and quality of climate data, particularly publicly available data, is limited for some risks.

We have made use of publicly available scenarios developed by the NGFS, which sit in an overarching framework (Figure 4), differentiated according to the severity of transition and physical risk. The six NGFS scenarios (summarised in Appendix A) are shown in the figure. The more stressful scenarios focus on either high physical or high transition risks (compared with the two low risk scenarios). The general approach of regulators to date has been to use one of the NGFS scenarios in each quadrant modifed for local conditions to test high physical or transition-related climate risk. We have decided to design a scenario which would fall into the upper right hand corner of the NGFS framework which has a higher combination of physical and transition risk than any single NGFS scenario.

Figure 4: NGFS scenarios framework (source: adapted from NGFS).



We refer to the RBNZ scenario as **Too Little Too Late (TLTL),** recognising there are a range of potential scenarios that could be developed within the NGFS category of this name, over various time horizons. The scenario is hypothetical and does not represent a view of the most likely outcome.

The NGFS **Delayed Transition** scenario has been used as a guide for transition risk and the **Current Policies** scenario for physical risk. We have deviated from these scenarios in some important aspects, which adds additional stress and should provide greater insights. The add-ons include:

- Lack of international co-operation and co-ordination in enacting climate related policies which increases the cost of transition for New Zealand;
- Extreme weather events — inland flooding and drought — leveraging off our Risk Assessment exercises in 2022;
- An increase in the price and decrease in availability of insurance in locations subject to high and increasing physical climate-related risk;
- A ratings downgrade of banks' long term debt issues increasing funding costs and reducing revenue during the period of the drought; and
- An operational risk event or events triggered by climate-related events such as loss of physical assets during a flood.

The approach leads to a scenario that combines higher transition risk and higher physical risk, with greater potential interaction and compounding of the two, than in the NGFS scenarios we have used as a guide over the timeframe of the scenario out to 2050.

Underlying socioeconomic assumptions, e.g. for population growth, technological progress and productivity growth, are from Shared Socioeconomic Pathway 2 (SSP2), as are those for all of the (Phase III) NGFS scenarios.[7]

Scenario Description

Global Outlook

New Zealand's climate outcomes will depend to a large extent on what happens globally and in particular how effective and timely high carbon emitting countries are in limiting the growth in their GHG emissions.

Transition risks occur as an economy shifts resources to a low emitting economy. This will be felt especially by sectors of the economy that are currently high GHG emitters or dependant on high GHG emitters. The linkages throughout the economy are likely to lead to broader impacts. Changes in the pricing of GHG emissions are the main driver of the transition of the economy in the TLTL scenario. The scenario features both an extended delay in enacting meaningful global climate policies and some divergence in countries' policies.

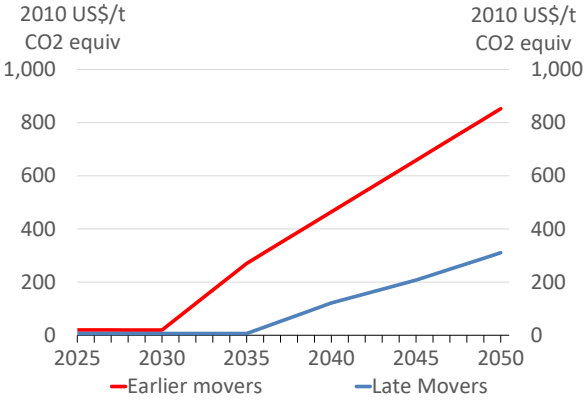
7 A brief explainer of SSPs is provided here: rbnz.govt.nz/hub/-/media/project/sites/rbnz/files/publications/bulletins/2023/rbb-2023-86-02.pdf (p. 5). Narratives for the various SSPs are presented by Riahi *et al.* (2017): "The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview" sciencedirect.com/science/article/pii/S0959378016300681.

After a period of policy delay and emissions prices staying fixed at 2022 levels, the European Union and a cohort of countries including New Zealand (referred to as the 'earlier-movers') introduce policy initiatives to start increasing emissions pricing in 2031.[8] This results in a divergence of the earlier-movers' paths of emissions pricing from those of the rest of the world that leaves them exposed to high transition risk from 2031.

The remaining countries, which account for the majority of global emissions, are referred to as the 'late-movers'. From 2036, as physical risk events continue to increase in severity and frequency, these late-movers enact policies to reduce emissions. This takes the form of a sharp increase in emissions pricing which leads to high transition impacts, slowing world growth.

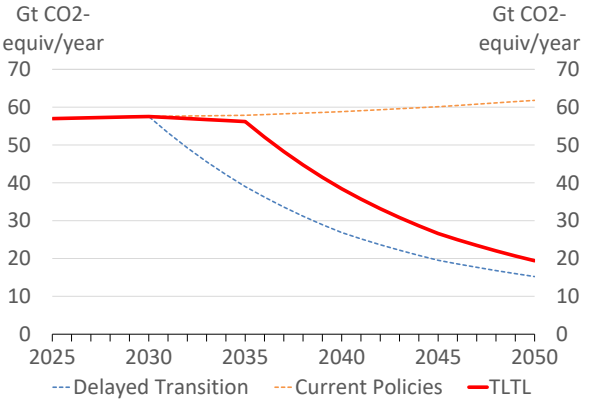
Figure 5 shows the carbon price path. The path for the earlier-movers aligns with their paths in the NGFS Delayed Transition scenario, with the group average increasing after 2030 to reach over $800 (2010 USD) by 2050. For late-movers, the path is that of Delayed Transition but with a further lag of five years. Carbon prices vary between countries within each group, as in Delayed Transition.

Figure 5: Carbon prices (group averages)



Source: RBNZ adapted from NGFS Delayed Transition.

Figure 6: Global GHG emissions



Sources: RBNZ, NGFS. Figure notes in Appendix B.

The delay in introducing these policies and a lack of innovation leaves global **physical risks** elevated and temperatures rising for the entire scenario. Figure 6 shows the TLTL carbon equivalent total global emissions path. It remains close to the current level of nearly 60 gigatonnes (Gt) per annum until 2036. We have estimated total cumulative GHG emissions in the TLTL scenario from the starting point through 2050 are approximately 16 percent greater than in the NGFS Delayed Transition scenario.

We have chosen an adverse NGFS scenario, Current Policies, as a guide for variables related to how the climate unfolds, i.e. physical climate-related risks, out to 2050. Although GHG emissions in the Current Policies exceed our TLTL scenario, the global mean temperature rise in Current Policies is well within the confidence interval of our scenario through 2050.[9] By 2050, global mean temperature rises by 0.8°C in the scenario (equivalent to an increase of 2° from a pre-industrial reference period).[10]

8 In some cases the delayed action in the scenario may represent deviations from policy commitments.

9 ngfs.net/sites/default/files/medias/documents/ngfs_climate_scenarios_for_central_banks_and_supervisors_.pdf.pdf (slide 31).

10 In the Current Policies scenario this is the global temperature path to a 3.2° increase by 2100 relative to pre-industrial levels. However, if our TLTL time horizon were extended past 2050 then physical climate outcomes would be somewhere in between those of the Current Policies and Delayed Transition scenarios.

CST New Zealand Outlook

The scenario for New Zealand can be broken into distinct time periods with different levels of physical and transition climate-related risks. These periods correspond to the reporting periods, i.e. banks will submit results as at the end of 2025 and for each 5 year period thereafter through 2050.

2023 to 2030 – No Transition/Low Physical Risk

Supply chain constraints loosen, central banks are successful in bringing inflation under control, and the global economy emerges closer to a normal growth trajectory. New Zealand's annual inflation rate falls to 2 percent, and the labour market returns to a sustainable level of employment as domestic capacity pressures ease, with unemployment rising to 4.5 percent. International tourism gradually returns to normal.

This period has relatively low climate-related and economic risk for New Zealand. This is by construction in order to establish a baseline to compare with the 20-year period from 2031 to 2050 which is subject to higher climate-related risk, to better identify the impact of climate change in the scenario. To this end, it is assumed that the economic spillover to New Zealand from climate-related events abroad in this initial period is also limited, and that there are no major climate-related events for New Zealand.[11]

New Zealand does not introduce any additional climate policies, aside from those already in place or formally planned, and there is no change in the Emissions Trading Scheme (ETS) price from its end-2022 level. Again, this simplifying assumption is made in order to establish a baseline. However, the scenario does assume that an agricultural levy system akin to the conditionally announced 'ETS backstop' alternative to the He Waka Eke Noa plan starts in 2025.[12]

2031 to 2035- High Transition/Medium Physical Risk

Globally there is a divergence in climate related policy. The earlier-movers including New Zealand implement more stringent carbon pricing. Given the earlier adoption of emissions pricing the New Zealand economy suffers high transition risk impacts from 2031.

The price for agricultural emissions also begins to rise at this time, but at a fraction of the non-agricultural price level both in New Zealand and the other earlier-movers.[13]

There is some shift of global dairy and meat production from earlier-movers to late-movers. However, this shift is limited somewhat by trade policy in earlier-movers' markets. For example, in these markets dairy and meat imports from late-mover countries would be subject to border taxes linked to carbon price differences.

Global emissions remain elevated because of a lack of widespread policy action and slow technological progress. Adverse weather-related events increase in frequency and severity compared with the previous five-year period. Domestic emissions begin to fall in response to increased policy stringency.

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11 This means that the scenario abstracts from actual events that occurred in 2023, notably the severe weather events in the North Island. Extreme weather events of a similar or greater severity feature later in the scenario.

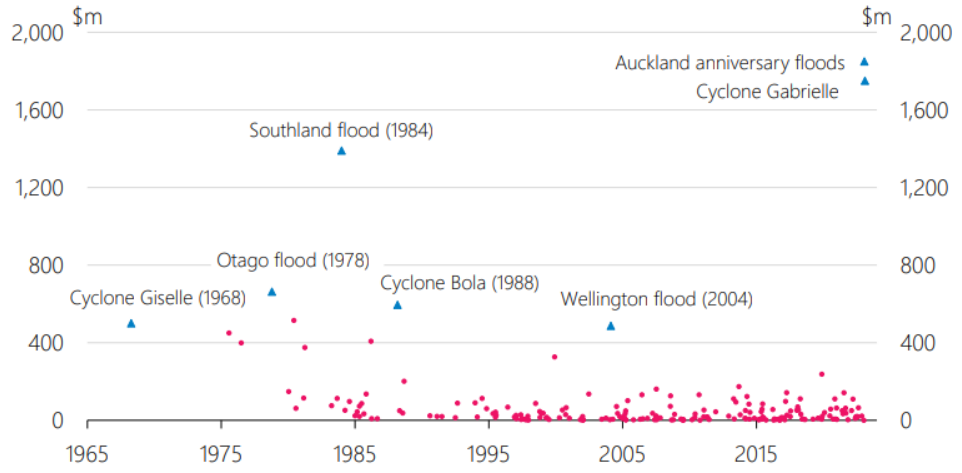
12 This assumption for agricultural emissions pricing is made for simplicity and because it produces a path that we view as appropriate for the scenario, not to represent a view on the most likely outcome. The 'ETS backstop' is summarised here: hewakaekenoa.nz/pricing-options-february/.

13 This simplifying assumption is intended to capture what the net effects would be from more complicated assumptions on varying agri emissions pricing regimes within the earlier-movers group together with border taxes based on differences in emissions prices.

New Zealand's GDP growth rate declines significantly, unemployment increases, and house prices fall. This is weighed upon by high domestic transition costs of moving to a lower carbon economy and associated frictions in resource allocation. There are competitive pressures from producers in countries with lower carbon pricing, against a backdrop of physical climate hazards affecting our trading partners flowing through to exports and tourism (see the following section for an overview of New Zealand's GDP in the TLTL scenario).

There are a number of weather events in the range of $400 million to $800 million of insurance claims like those shown in Figure 7. This trend of increasing frequency of costly events continues throughout the scenario. There begins to be significant repricing of insurance for properties in flood zones, partly driven by higher reinsurance costs which are passed on to customers, for both coastal storm-tide flood zones and inland flood zones nationally. This marks the beginning of falling insurance cover, either from customers not renewing policies which are proving too expensive, or insurers excluding flood risk from new policies for properties that are at the highest risk of flooding or retreating altogether from these areas.[14] This bears negatively on residential and commercial property values in flood zones, already affected by the slowing economy.

Figure 7: Total value of weather event insurance claims (excluding EQC payments)



Source: RBNZ, May 2023 FSR

2036 to 2040: High Transition/High Physical Risk

Rising physical impacts of climate change around the world forces late-movers to enact policies to lower their GHG emissions. However, the carbon prices in the earlier-moving countries remain well above the levels of the late-movers.

The increase in world carbon prices and the chronic effect of higher temperatures on global productivity has a significant impact on global GDP, including GDP of New Zealand's largest trading partners. This causes an economic slowdown globally and in New Zealand, with rising unemployment and falling asset prices, especially for more emissions intensive sectors.

14 In this period, 10 percent of all residential properties 'at risk'—defined as those in a current 1% annual exceedance probability flood zone—for inland flooding are either uninsured or subject to exclusions for flooding. It is higher for coastal flood zones (20 percent) due to the added effect of sustained rising sea levels.

The period is also marked by two 'extreme' flooding events in the Auckland region. These events are similar to the severe weather events that occurred in the North Island in early 2023. Reduced insurance cover for flooding continues with further property price falls in these areas. Results from the 2022 flooding sensitivity showed that roughly one quarter of residential mortgage exposures in Auckland were for properties touching flood zones.[15]

2041 to 2045: Medium Transition/High Physical Risk

The delay in global emissions pricing by the late-movers group sees temperatures and physical risks continue to increase. There is a persistent drag on economic growth and increased frequency of weather events around New Zealand.

In addition, due to changes in global weather patterns, the North Island suffers an extreme drought event — two back to back years of drought beginning in the 2041/42 dairy season — affecting the agricultural sector. The combination of droughts is equivalent in severity to a 1-in-100 year return period. The first year of the drought is similar to the conditions experienced in 2012/13 on the North Island, and repeated for a second year after a dry winter. The cause of the drought is from a persistent slow-moving or 'blocking' high pressure system over the Tasman Sea and New Zealand over the summer season. The drought is particularly severe for much of southern Northland, Auckland, Waikato, Bay of Plenty, North Island Central Plateau, Gisborne and Hawke's Bay. The dry conditions are widespread across New Zealand, one of the factors limiting the amount of feed stock that can be supplied by the South Island.

The drought reduces economic growth and affects investors' view on the New Zealand economy. Rating agencies downgrade the rating on long term debt issues of banks by one notch. The downgrade lasts for the five-year period, and ratings are restored at the end of 2045 after recovery from the drought. Term funding is available but the cost of this funding increases and banks' net interest margins decline in this period as banks absorb the higher funding costs. These impacts cause the government to pause the increase in emissions pricing on the agriculture sector.

Insurance repricing continues. Public risk-sharing policies are put in place to limit insurance retreat from inland flood zones. This limits the share of uninsured residential properties to 25 percent of total properties at risk of inland flooding in all regions.

2046 to 2050: Low Transition/High Physical Risk

Although global GHG emissions have fallen significantly they are still above net zero and average temperatures continue to rise. There is an increased frequency of smaller flooding and other physical climate-related events.

In this period the impact of coastal flooding comes to a head, with sea levels rising consistently, reaching 26 cm above the 1995-2014 average by 2050.

An increase in storm tide flooding events over this period combined with the higher sea levels leads to further insurance impacts for those properties most exposed, with 60 percent of properties at risk of coastal flooding in all regions uninsured from coastal flooding. This causes a further fall in house prices for properties in coastal flood zones.

15 rbnz.govt.nz/hub/publications/bulletin/2023/rbb-2023-86-02.

Operational Risk Event

As in previous stress tests, the scenario includes additional losses by way of an operational risk event (or series of small events). This part of the exercise is designed to encourage banks to think through a potential scenario that could be a climate-related risk in the future.

The operational risk event(s) is to be climate-related and cover any risk outside of credit, market and liquidity. It could be due, for example, to loss of customer records or damage of banks' physical assets due to a climate-related event.

New Zealand GDP in the TLTL Scenario

Overall, climate effects have a significant impact on New Zealand's economic performance in the scenario. Real annual GDP growth troughs at near zero percent and unemployment peaks at 6.8 percent, similar to the worst years of the GFC. However, in the scenario the macroeconomic slowdown is drawn out over a much longer period of time compared with the GFC or other historical benchmarks, as physical climate effects on the economy get worse over time.[16]

Figure 8 illustrates the composition of climate effects on real GDP in the TLTL scenario. It adds the impacts from physical and transition climate-related risks, expressed as deviations from a hypothetical baseline GDP absent these risks:

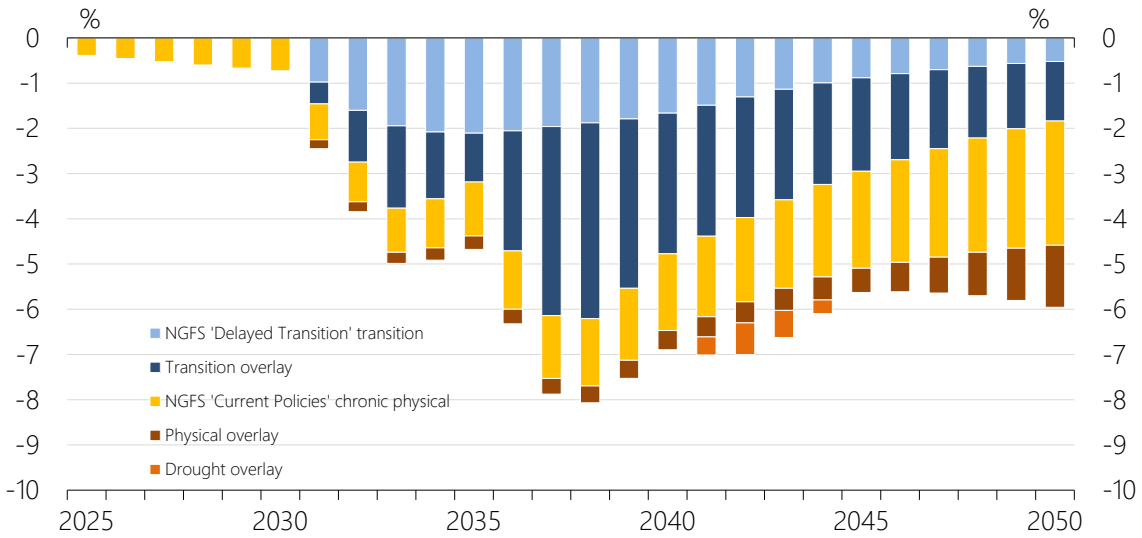
- Chronic physical impact coming from the NGFS Current Policies scenario for New Zealand (from 2023);
- Transition impact from the NGFS Delayed Transition scenario for New Zealand (from 2031);[17]
- An overlay for the impact on real GDP from the prescribed two years of severe drought in the 2041-2042 and 2042-2043 dairy seasons, with lingering effects into 2044 as dairy and sheep and beef farms recover from the drought effects and responses (e.g. de-stocking);
- Overlays for physical and transition-related risk from 2031, to (i) account for features of the scenario, such as the timing of emissions pricing changes and the timing of the agricultural drought, that differ from the NGFS scenarios; and (ii) address wider concerns in the literature regarding uncertainty and potential underestimation of future climate effects on GDP.[18]

16 However, like the underlying NGFS scenarios the TLTL stays anchored to SSP2 assumptions; macroeconomic outcomes could be significantly worse in scenarios based on more adverse SSPs.

17 NGFS results used as components of the TLTL GDP path are from the Phase III NiGEM/REMIND-MAgPIE modelling.

18 See, for example, Ranger, Mahul and Monasterolo (2022): *Assessing Financial Risks from Physical Climate Shocks: A Framework for Scenario Generation* hdl.handle.net/10986/37041; and Gasparini, and Baer and Ives (2023): "A Re-evaluation of the Financial Risks of the Net Zero Transition" ssrn.com/abstract=4254054.

Figure 8: Components of New Zealand real GDP in the TLTL scenario
(% deviation from baseline 'no climate change' GDP)



Sources: RBNZ, NGFS. Figure notes in Appendix B.

The physical overlay is for macroeconomic effects from chronic physical risk not covered in the Phase III NGFS modelling, such as infrastructure damage and supply chain disruptions, and also annual expected values of damage to GDP from acute physical events such as floods.[19] The overlay captures economic spillovers from physical risks increasing abroad as well as domestically. The effects captured in the overlay are assumed to become more severe especially in the last five years of the scenario.

The transition overlay is a combination of three extra sources of transition risk beyond that in the NGFS Delayed Transition scenario:

- Competitive disadvantage for some New Zealand firms due to a greater gap between carbon prices in New Zealand and those overseas relative to the NGFS Delayed Transition scenario. This price gap difference and related part of the overlay is greatest in the early 2030s.
- Frictions in resource allocation, especially in the labour market, in New Zealand's transition to a lower emissions economy, following the Bank of England's approach in its 2021 Climate Biennial Exploratory Scenario.[20] This part of the overlay compensates for the feature of the NGFS modelling that factors of production are reallocated smoothly and efficiently. It peaks in the early 2030s soon after New Zealand increases its emissions pricing.
- Broad economic spillover from a global slowdown occurring in the period from 2036 to 2037 that results from countries that account for most of the world's emissions and economic output increasing their carbon pricing. This part of the overlay is relatively large, and has a persistent effect on global and New Zealand GDP levels as it tapers off gradually.

[19] The physical overlay does not reflect the specific timing of the prescribed extreme flooding events that are part of the scenario.
[20] https://www.cgfi.ac.uk/wp-content/uploads/2023/03/CGFI-Scenario-paper.pdf.

New Zealand TLTL Emissions Path[21]

New Zealand's transition to a much lower-emitting country in the TLTL scenario results in total net GHG emissions falling by 60 to 90 percent from current levels. This would require large cuts to carbon dioxide emissions plus a reduction in GHG emissions from agriculture, which is mainly methane, given the sector contributes around half of GHG emissions in Aotearoa. The range accommodates the Climate Change Response (Zero Carbon) Amendment Act, which references reductions of biogenic methane emissions of 24 to 47 percent.

Emissions pricing is the main policy tool used to drive the transition in the scenario. The prescribed carbon price in the scenario can be treated as a 'shadow price' that includes the costs of all environmental policies linked with GHGs.

The ability of businesses to pass costs on to their customers varies according to differences in the tradability of goods or services produced. Producers of highly tradable products, such as commodities, can pass on some but not all of their increased costs due to competitive pressure from international differences in emissions pricing. It can be assumed that border taxes linked to carbon price differences between countries would be adopted in a growing number of jurisdictions over time in the scenario and this would support partial pass-through of New Zealand producers' costs from emissions pricing. Some business sectors are likely to have higher than average inflation of output prices due to passing on some of the costs of climate-related risks, such as emissions price, however at a national level it is assumed for simplicity that there is no aggregate climate impact on consumer price inflation.

Agricultural Sector

Cuts to agricultural emissions in the scenario occur through a combination of modest productivity gains and reduced herd size (dairy, sheep and beef). Few notable technology breakthroughs allow for on-farm emissions reductions without production decreases. This includes a lack of successful methane inhibitors and/or vaccines. There is some improvement in emissions intensity driven by modest gains in stock productivity.

There is a reduction in land used for both dairy and sheep and beef, with some of the land being re-purposed for forestry. There are two main economic drivers of falling dairy and meat production in the scenario:

- Rising emissions pricing globally — first in the early-moving countries including New Zealand and later more broadly — results in lower global quantity demanded of milk and meat as the products become more expensive and consumers move toward substitutes.[22]
- Higher emissions pricing also increases the value of rural land for alternative uses such as forestry, incentivising land use change.

21 This sectoral narrative is consistent with the carbon prices and emissions results in the NGFS Delayed Transition scenario, but is further informed by He Pou a Rangi-the Climate Change Commission's Headwinds scenario and additional judgment.

22 Declining global meat consumption is an add-on to the NGFS modelling results, which do not account for such substitution effects. The NGFS states: "The scenarios assume an evolution of dietary change in line with historic trends, so increasing meat consumption with rising affluence. Dedicated lifestyle changes as a mitigation option are not considered in these scenarios." ngfs.net/ngfs-scenarios-portal/faq/.

The global geographic distribution of the dairy and meat industries shifts somewhat from countries with higher emissions prices, including New Zealand and the European Union, to lower-cost jurisdictions where emissions pricing is relatively lower in the scenario. This limits the increase in world milk and meat prices somewhat. However, New Zealand producers continue to have a foothold, albeit smaller in absolute terms, in the global milk and meat markets. This could be due to border taxes linked to carbon price differences being adopted in early-mover countries benefiting New Zealand producers in these markets; qualitative differences in New Zealand's products (e.g., grass-fed meat might be positioned increasingly as a 'premium' or 'luxury' product); relatively low costs of pastoral farming compared with some farming methods overseas; and relatively low agricultural emissions intensities compared with other countries.[23]

Forestry Sector

There is an uptake of afforestation in the scenario which could involve land use substitution. Towards the latter end of the scenario, there is a shift towards native forestry as opposed to exotic forestry, although exotic planting remains dominant. Risks to exotic forestry under this scenario are elevated from storms, water shortages, wildfires, pests and pathogens placing some forestry land owners into financial stress.

Transport Energy

Transport emissions fall quickly in the latter half of the scenario. This is largely driven by an increase in the electric vehicle fleet, with almost complete electrification of vehicles by 2050. This is a key driver in bringing total transport emissions down by more than three quarters by 2050. There is limited decarbonisation in aviation and rail.

Non-Transport Energy

Gas and coal play a reduced role in electricity generation in NZ. Concurrently, there is an uptick in renewable energy supply, including from geothermal sources. The energy supply sector reaches net zero emissions by 2050 mainly due to a greater shift to renewables, with a relatively limited role played by carbon capture and storage.

Industry

The industrial sector reaches modest negative net emissions by 2050, mainly through energy efficiency improvements, electrification, and a limited contribution from carbon capture and storage.

Buildings

Residential and commercial buildings reach net zero emissions by 2050 through energy efficiency improvements and electrification.

23 mpi.govt.nz/dmsdocument/51076-Updating-the-carbon-footprint-for-selected-New-Zealand-agricultural-products-an-update-for-milk.

Conclusion

The TLTL scenario is designed to be a severe but plausible scenario focused on climate-related risk. There could be more adaptations than the scenario assumes, such as those included in the National Adaptation Plan for New Zealand, and public mitigants or technological improvements which would lower emissions and reduce the transition impacts. On the other hand we have not assumed any significant non-climate related economic shocks like the ones we normally include in our bank solvency stress test scenarios such as occurred in the GFC, which historical experience suggests could plausibly occur in the 28 year timeframe of the CST. We deliberately avoided this to focus on climate-related risks.[24]

This points to the CST as providing one scenario among many that entities should explore in the context of testing for climate-related risks. And it brings us back to the core purpose of building capability which will help banks test alternative scenarios and better manage their climate-related risks.

The Reserve Bank has a role to play to ensure the financial system in New Zealand is best placed to deal with climate-related risks as they materialise and play its part alongside the global economy to shift to a lower-emission, climate resilient economy. The CST is designed with this in mind.

24 Interactions between climate and non-climate related economic shocks are important to consider as they would be expected to amplify the financial impact from the climate-related shocks, but in order to isolate the effect of each type of shock and their interaction multiple scenarios would have to be run (i.e., one with climate-related shocks only, one with non-climate related shocks only, and one with both) and doing so would have been impractical for this stress testing exercise.

Glossary

Acronym	Term
CST	Climate Stress Test
CCC	Climate Change Commission
CCS	Carbon capture and storage
ETS	Emissions Trading Scheme
GHG	Greenhouse gas
NGFS	Network for Greening the Financial System
TLTL	Too Little Too Late – RBNZ constructed climate stress scenario

Appendices

Appendix A: NGFS 2022 Scenarios

The NGFS has developed six scenarios which are differentiated according to the severity of transition and physical risk:[25]

- Two Orderly scenarios assume climate policies are introduced early and become gradually more stringent. Both physical and transition risks are relatively subdued.
- Two Disorderly scenarios explore higher transition risk due to climate-related policies being delayed or divergent across countries and sectors. For example, carbon prices typically peak at higher levels for a given temperature outcome. In Delayed Transition, which informs the construction of our scenario, new climate policies are not introduced until 2030 and the level of action differs across countries and regions based on currently implemented policies. Global annual emissions do not decrease until 2030. Strong policies are then needed to limit warming to below 2 °C. Carbon dioxide removal technology and negative net emissions are limited.
- Two Hot house world scenarios assume that some climate policies are implemented in some jurisdictions, but globally efforts are insufficient to halt significant global warming. In Current Policies, the one on which we base the physical risk component of our scenario through 2050, only currently implemented policies (as at 2022) are preserved. In Current Policies, global emissions grow until 2080, leading to 3.2 degrees of warming by 2100 and severe physical risk including irreversible sea level rise. For benchmarking to Representative Concentration Pathways (RCPs), the NGFS notes that "[....] the 'Current Policies' scenario is close to the high temperature scenario (RCP 6.0) by the end of the century".[26]

Appendix B: Chart Notes

Figures 1 and 5: Emissions prices are from the NGFS Phase III Delayed Transition REMIND-MAgPIE results, but delayed by an additional five years for all countries except the EU, New Zealand, and the cohort of other earlier-movers.

Figure 4: 'NDCs' stands for the 'Nationally Determined Contributions' NGFS scenario.

Figure 6: Net GHG emissions from NGFS Phase III IAM scenario data (Delayed Transition and Current Policies) (REMIND-MAgPIE model, 'Emissions|Kyoto Gases' variable); the TLTL global net emissions path in the figure was estimated by the Reserve Bank based on these two NGFS paths.

Figure 8: NGFS results are from the Phase III NiGEM/REMIND-MAgPIE modelling, except the 'Delayed Transition' transition impact on GDP is paused for one year and begins in 2031 for consistency with the TLTL scenario narrative and to help establish a stable 2026-2030 baseline period.

25 The NGFS scenarios referred to throughout this document are the 'Phase III' scenarios, released in September 2022, which use SSP2 assumptions.
26 ngfs.net/sites/default/files/media/2022/11/21/technical_documentation_ngfs_scenarios_phase_3.pdf.

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