He Pou a Rangi | Climate Change Commission

The cascading risks of climate change in infrastructure and agriculture.

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A joint report by Deliberate and Urban Intelligence

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Executive summary

This report was commissioned by He Pou a Rangi | Climate Change Commission (the Commission) as part of the evidence base for the second National Climate Change Risk Assessment (NCCRA) (due mid-2026). The NCCRA identifies the most significant risks facing the country from the current and future effects of climate change to advise the Government on where adaptation efforts and policies should be directed in the first instance. This informs the Government's National Adaptation Plan (NAP).

This report is jointly delivered by Deliberate and Urban Intelligence. It is focused on two distinct examples (provided by the Commission) and is intended to help better visualise and understand the subject matter areas of:

- The cascading risks from extreme rain and wind on infrastructure.
- The cascading risks from drought, with a particular focus on the agriculture sector.

Data was gathered during two workshops (one for each subject) held in Wellington in May 2025. Various subject matter experts were drawn from industry and academia to attend. The workshops produced a vast amount of qualitative data, ranging from very detailed insights to high-level observations. These informed the development of the causal diagrams.

A summary of the insights from this work are below. No prioritisation or hierarchy of importance is implied in the order they are written.

Shared insights (across both causal diagrams)

- Nearly all risks cascade to some, or all, of the social factors.
- Most social factors tend to be locked in reinforcing loops, meaning they spiral together (whether in a desirable direction or an undesirable one).
- Stressed social areas cascade to risks in governance systems and processes.
- Reduced social capital reduces collective decision-making capability, which can reduce service levels and lead to lower greenhouse gas (GHG) emissions due to the uncoordinated reduction in activity required to maintain service levels. In the long run this may be more costly and disruptive because of the potential uncoordinated nature of any response.
- Most activity, including adaptation, (e.g. building/repairing infrastructure or modifying farming activities) is constrained by access to capital/finance. We can anticipate increased tension between the desire to undertake adaptation activity and the ability to finance it. Current expectations of what levels of existing infrastructure and agricultural activity may be possible in the future may need to be reduced.
- Insurance is critical to enabling activity, particularly infrastructure. Insurance retreat is likely to constrain future adaptation activity. Current expectations of what levels of existing infrastructure and agricultural activity may be possible in the future may need to be reduced.
- Technological advances (e.g. efficiency gains or alternative delivery models) may alter how some activities are undertaken. This likely reinforces existing expectations around

levels of activity that may not be achievable (e.g. due to increased costs or other compounding risks).

- Those with better access to resources are more likely to adopt and benefit from technological innovations. Therefore, technological innovation adoption is also unlikely to be evenly distributed, and it may exacerbate existing inequalities.
- Adaptation interventions should be equally (or more) focused on maintaining and strengthening social cohesion and adaptive capacity, as opposed to just on technical interventions. People's ability to make decisions about adaptation is impacted by most risk pathways in the diagrams.

Insights particular to infrastructure (wind & rain)

- Good condition and maintenance supports high levels of service from infrastructure, reducing vulnerability of infrastructure to climate hazards. However, societal expectations evolve over time and sustained levels of service in line with existing expectations may encourage higher desired levels of service in the future. Similarly, sustained levels of service lower than existing expectations, due to various constraints, may force communities to accept lower levels of service in the future.
- Technological Innovations may provide alternative service models that reduce the need for traditional infrastructure, which may contribute to the abandonment of existing networks (e.g. mobile communication methods reducing the need for physically connected networks). Meaning collective infrastructure may not generate enough income to operate.
- Infrastructure retreat may lead to services retreating from one area and needing to be (re)established in another. Both risks may involve compulsory acquisition/raupatu[1] of land.
- Construction activity relating to repairs, maintenance and construction of new assets is currently positively correlated with higher GHG emissions. Increased risks to infrastructure mean more repairs and rebuilding, and further GHG emissions.

Insights particular to agriculture (drought)

- Drought leads to competition for constrained resources. This reduces farm income and increases stress on individuals and communities.
- Recurring drought and sustained pressures on ecosystem health may increase water regulation in the longer term. This may constrain water extraction or additional inputs, but also leads to additional stress and costs for farmers.
- There are conflicting feedback loops relating to farmers' wellbeing in response to activity or stressors. Which ones dominate will depend on the individual context. Total farming activity is constrained by access to capital and resources.
- Stored water interventions will likely provide a temporary buffer of water availability during drought. They also reinforce higher water-dependent agricultural activities in

[1] *Raupatu* is a te reo (Māori language) term that refers to something being taken away from someone without consent, especially land. It is a term often used to refer to the historical confiscations of Māori land by the Crown.

the longer-term, risking higher impacts from more severe drought events that the water storage buffer may not cover.

- As growing capacity and production reduce during drought, so can GHG emissions. For example, due to de-stocking of animals and/or reduced activity/lost crops. Although some reactionary activity such as buying in feed, may sustain GHG emissions. Yet these will likely occur in an unplanned or reactive way, potentially generating undesired impacts on other social and economic factors.
- Drought can reduce water levels in hydro-electricity dams and electricity generation. While losses in hydro-electricity generation could be compensated by further expansion of other renewables, it is also possible that electricity may be generated from fossil fuel-powered generation to compensate.

These diagrams may be used by the Commission in the following ways.

1. At a minimum, show how everything is interconnected. An introductory insight yet useful for some audiences.
2. They can inform the design of narratives to help explain cascading risk.
3. They help identify where risk domains overlap or cascades are shared, identifying:
    a. Where risks may be shared across the Commission's domains of interest;
    b. Where seemingly unrelated domains may cascade to shared ‘downstream’ areas.
    c. Where a single ‘upstream’ domain may cascade to multiple ‘downstream’ areas.
4. Where identified feedback loops link multiple risks, these can be used to explore these risks as dynamic (i.e. they will change over time).
5. They can be used to identify helpful metrics or indicators.

1. Introduction

He Pou a Rangi | Climate Change Commission (the Commission) are building the evidence base to inform the development of the second National Climate Change Risk Assessment (NCCRA). This will be delivered by mid-2026.

The purpose of the NCCRA is to identify the most significant risks facing the country from the current and future effects of climate change in order to prioritise where adaptation efforts and policies should be directed in the first instance. This means systematically and consistently considering and assessing the risks to Aotearoa New Zealand's economy, society, environment, and ecology from the current and future effects of climate change. The NCCRA informs the Government's National Adaptation Plan (NAP).

To support the 2026 NCCRA, the Commission seeks to better understand the cascading risks associated with climate change impacts. This report for the Commission is jointly delivered by Deliberate and Urban Intelligence. It is focused on two distinct examples and is intended to help better visualise and understand the subject matter areas of:

- The cascading risks from extreme rain and wind on infrastructure.
- The cascading risks from drought, with a particular focus on the agriculture sector.

For the purposes of this report, agriculture as a term covers pastoral farming, arable farming, and horticulture. We recognise that the sectors are different; however for brevity, sometimes in this report, these diagrams are referred to as the infrastructure or agriculture causal diagrams.

To visually demonstrate the cascading nature of these risk areas, the Commission specifically sought the use of causal diagrams (properly called causal loop diagrams, or CLDs, herein referred to as causal diagrams). Staff at Deliberate and Urban Intelligence have a strong track record in the use of causal diagrams, and have been involved in some of the first applications of causal diagrams in Climate Change Risk Assessment (Cradock-Henry et al., 2020).

Data was gathered during two workshops (one for each subject) held in Wellington in May 2025. Various subject matter experts were drawn from industry and academia to attend. Comprehensive discussions were held, using a technique designed to encourage an exploration of risks that cascade beyond the obvious and the immediate. As a result, significant amounts of qualitative data were collected, ranging from very detailed insights to high-level observations.

Given the level of data collected and the complexities involved in both subject matter areas, two versions of the causal diagram have been developed for each area. A high-level summary version for accessible insights, and a more detailed version for deeper analysis. The summary version is described in the main body of the report, while additional descriptions pertaining to the detailed version, and a summary of each feedback loop in the detailed version, are contained within the appendices.

A section of key or generalisable insights is also provided for the Commission to help inform their NCCRA work.

We recognise that a separate report has been commissioned to deal specifically with risks in the Ngā mea hirahira o te ao Māori domain. We suggest that the causal diagrams described in this report may be used as a lens through which to consider the findings of that report, and vice versa. There is likely to be significant overlap. We note that this does not infer that the system's perspective as described in this report could be compared to a Te Ao Māori perspective or worldview.

We also acknowledge that when commissioned, it was intended that the causal diagram developed for infrastructure was also intended to explore cascading risks *between* different types of infrastructure. During the workshop and diagram development, it became clear that significant work in this area already existed (not using causal diagrams), and that such inter-infrastructure cascading risks were very context specific. It was therefore difficult to draw any insights outside of very high-level ones that were unlikely to add to already existing knowledge. Therefore, this work focuses on the cascading risks within the two areas described.

This report is structured in the following way:

- The second section describes what a causal diagram is and how to read one.
- The summary wind and rain with infrastructure and then drought in agriculture causal diagrams are described in the third and fourth sections, respectively.
- The final section outlines key insights common across both diagrams as well as some specific to each, and some ways to use the diagrams are described.

2. What are causal diagrams?

Causal diagrams are a qualitative tool of system dynamics or systems thinking. They are a visual way of conceptualising how different variables are interconnected via different influences.

They are particularly focused on moving beyond linear cause-and-effect thinking to a circular, interconnected perspective, focused on feedback loops. This shift is crucial for grasping the complexity of systems where causes and effects influence each other dynamically over time, which is essential for understanding the impacts of climate change that are rarely linear or isolated.

By enabling stakeholders to visualise and discuss system structures and feedback, these diagrams help identify critical risks, potential interventions, and areas needing further research or policy focus, thereby informing more effective climate adaptation strategies.

How to read a causal diagram

Simply put, causal diagrams are collections of variables connected by arrows of influence. This allows us to trace influence along pathways, through multiple variables. They have a particular interest in circular pathways of influence, as these create feedback loops that influence how variables behave over time.

Causal diagrams contain two types of feedback loops that drive system behaviour. **Reinforcing feedback loops** lead to exponential growth or decline, exemplified by phenomena such as compounding interest or algae blooms. Meanwhile, **balancing feedback** loops stabilise systems by seeking equilibrium, much like a thermostat. Recognising these loops helps understand how variables behave and interact within a system, providing a basis for strategic interventions.

To read a causal diagram, you need to understand the following:

1. As you follow influence through a diagram, it is effectively describing to you how "**more or less of this** (current variable), leads to **more or less of that** (the next variable)".
2. Variables are written in such a way that they have an **inherent sense of direction**. That is, they can either go up or down. For example, 'morale' instead of 'increased morale'.
3. There are two types of arrows that denote two types of relationships between variables.
    a. **Solid arrows** denote a **same relationship** (variables move in the **same direction** – if one goes up, so does the other, and vice versa).
    b. **Dashed arrows** denote an **opposite relationship** (variables move in the **opposite direction** – if one goes up, the other goes down, and vice versa).
4. Two small lines across an arrow represent a **relative delay**. This influence will take longer to present than others represented in the diagram.
5. Sometimes a variable of particular interest is shown as a **stock and flow**. The analogy of a **bathtub** helps here - think of the boxes as a bathtub where things accumulate. This helps us better understand accumulation in systems. Some variables may

influence whether the bathtub variable **increases** (things **flow into** the stock); while others may influence whether the bathtub variable **decreases** (things **drain the** stock).

6. **Stocks** can be part of **causality chains and feedback loops**.

Figure 1 demonstrates how the above concepts work.

While straightforward, these concepts can take some getting used to. To help with this, they are explained in more detail in Appendix Appendix 1.

We are particularly interested in how various feedback loops interact and the impact this will have on the way variables of interest trend over time. Causal diagrams do not seek to quantify how these things may trend over time. But they do provide a valuable tool to aid understanding of the broad directions that variables may trend, in response to changes in other variables captured in the diagram.

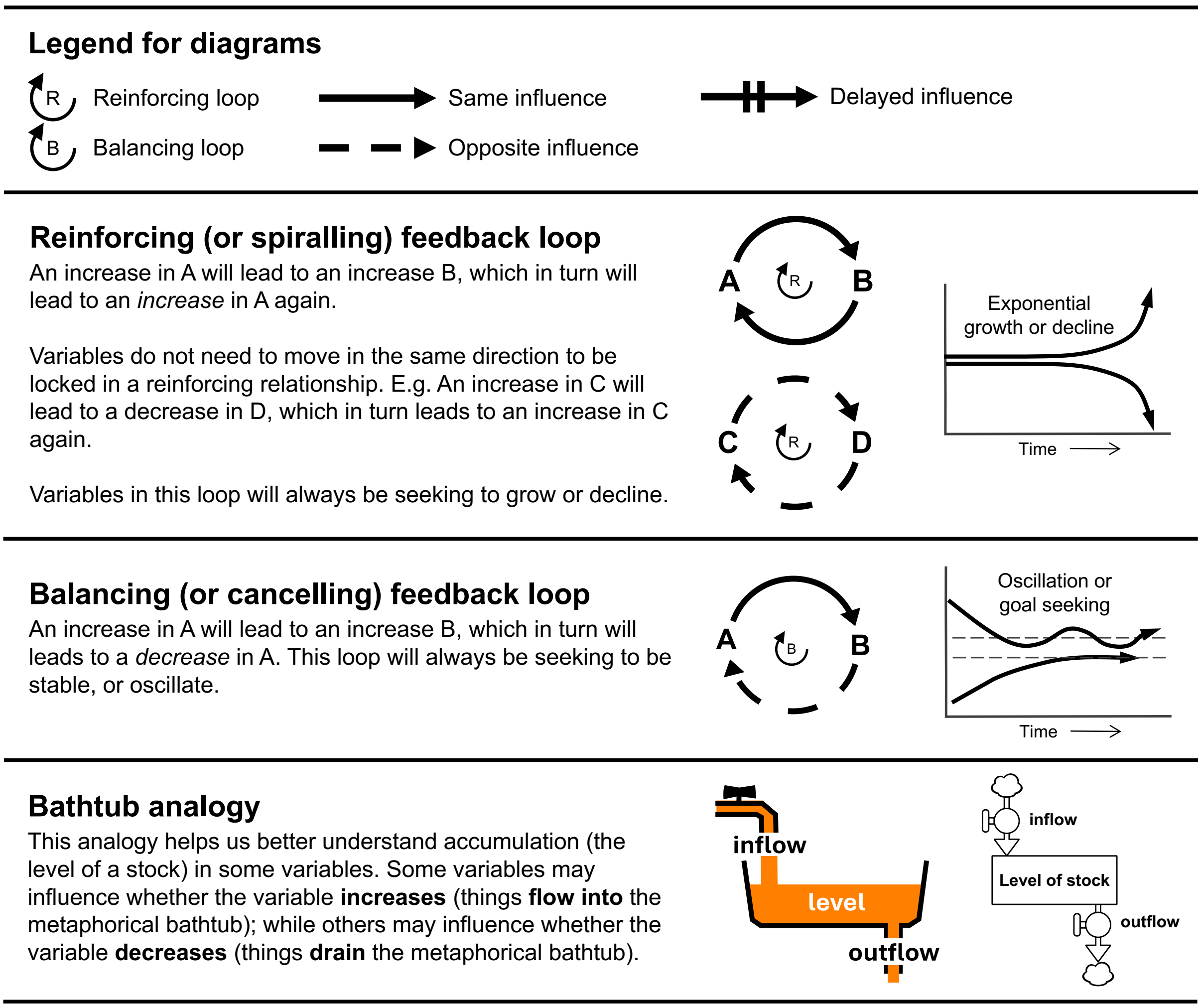


Figure 1: How to read a causal diagram

3. Infrastructure (wind & rain events) summary causal diagram

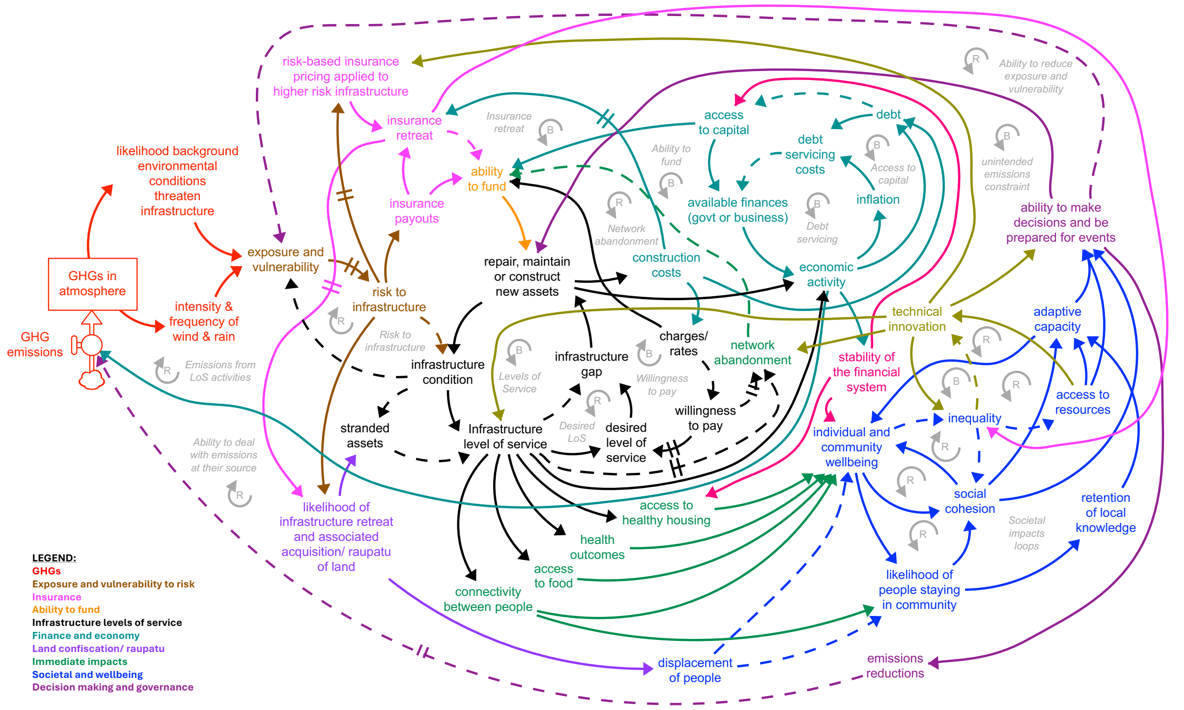


Figure 2: Infrastructure summary causal diagram

This diagram provides a comprehensive framework for understanding how impacts from an increasing intensity and frequency of wind and rain events (as hazards) cascade through infrastructure systems, social structures, and financial mechanisms.[2] This systemic perspective may be a useful consideration for policymakers, planners, and stakeholders aiming to build resilient infrastructure and communities in the face of a changing climate and evolving risks.

In the following description of this diagram, references to variables in the diagram (either in full or in part) are *italicised*. References to named feedback loops are in ‘quotation marks’. In the images, highlighted feedback loops are emphasised with thicker arrows.

Climate change as a driver of cascading risk

The summary infrastructure diagram employs the bathtub analogy to illustrate how *greenhouse gas (GHG) emissions* accumulate in the atmosphere, thereby driving both an increase in the *intensity and frequency* of extreme weather events and a change in the *background environmental conditions* that influence infrastructure. This accumulation of GHGs is pivotal because it both directly escalates the climate-related hazards that

[2] While these diagrams were developed in the Aotearoa New Zealand context, there may be generalisable insights that transfer to other countries and contexts.

infrastructure is exposed to and also influences background environmental conditions that make infrastructure vulnerable to these hazards over time.

This cascades into *risk* and potential damage to infrastructure through the degradation of *condition* and *level of service*. This highlights the role of emissions control as a foundational step in reducing the cascading risks to infrastructure.

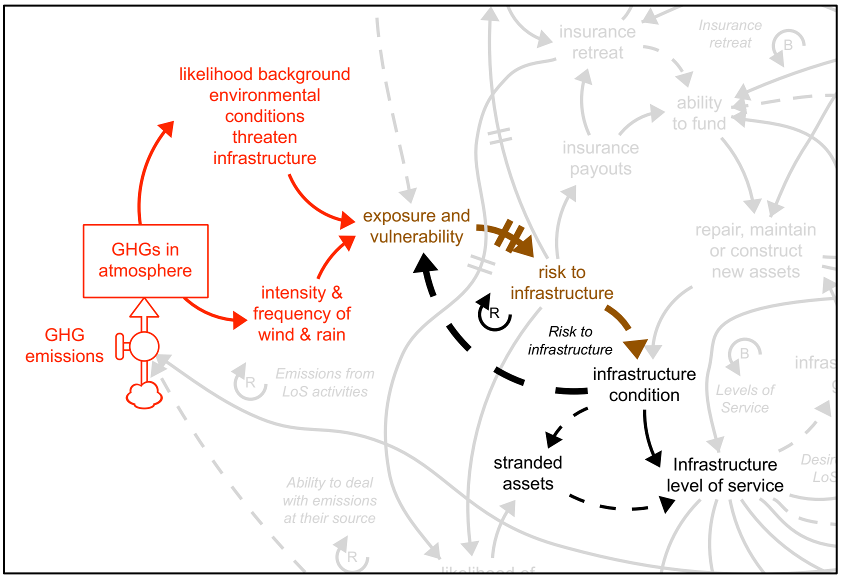


Figure 3: Climate change as a driver of cascading risk

Levels of service from infrastructure

The core 'levels of service' (LoS) balancing loop between *infrastructure condition* and their *levels of service* captures the natural maintenance cycle: good *condition* supports high *levels of service*, reducing *repair* needs and preserving *condition*, thus reducing vulnerability of infrastructure to climate hazards.

However, the reinforcing 'desired LoS' loop illustrates how societal expectations evolve over time. That is, sustained *levels of service* in line with the *desired levels* are likely to encourage higher *desired levels*, while sustained *levels of service* lower than desired may encourage reduced expectations. This dynamic reveals the psychological and social dimensions of infrastructure resilience, where public expectations can either drive investment or acceptance of decline.

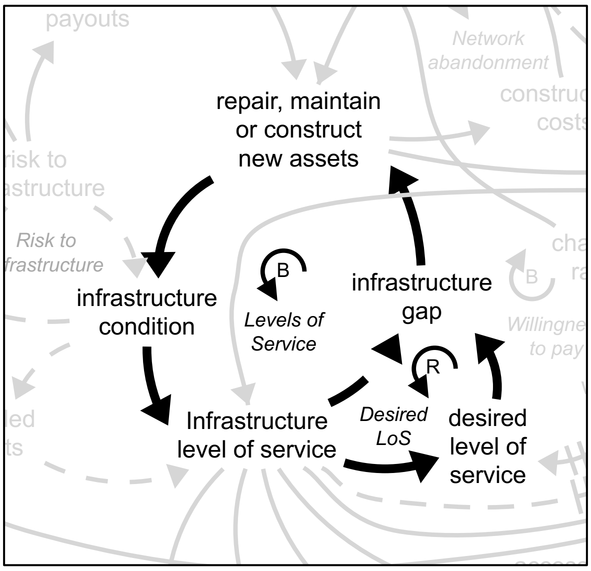
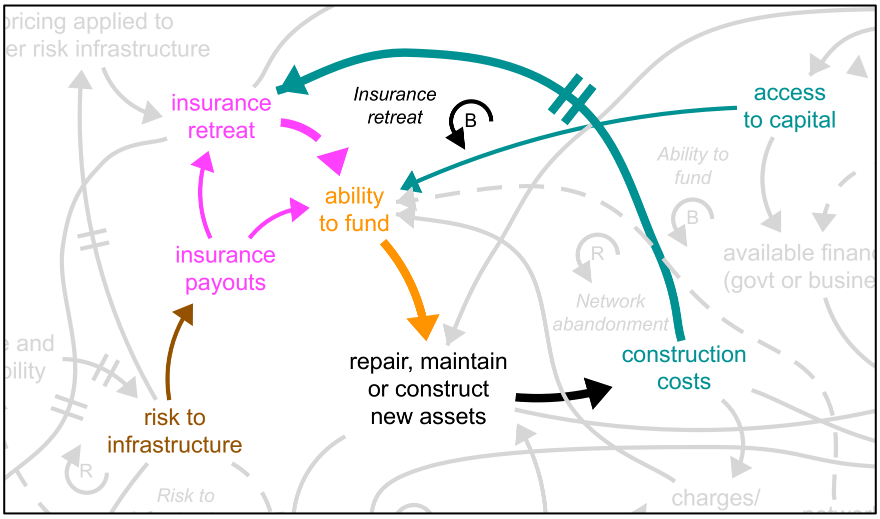


Figure 4: Levels of service from infrastructure

Interplay of insurance, funding, and infrastructure viability

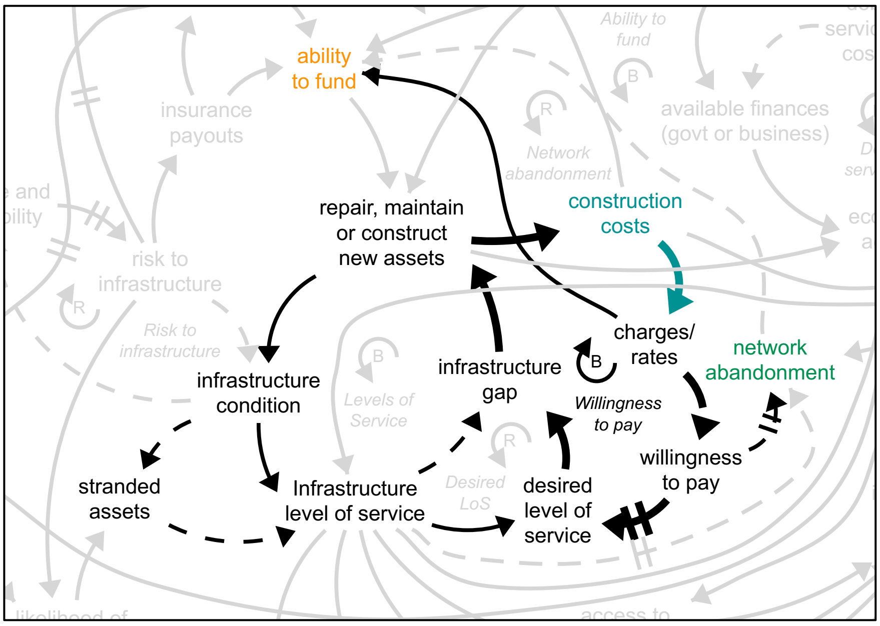
Insurance mechanisms are critical for maintaining stocks of infrastructure. It is also acknowledged that not all major infrastructure assets are insurable - some elements may be (e.g. buildings) while others may not (e.g. some roads or power pylons). Therefore, the relationships explained here may not apply to all infrastructure types. But they may apply to some. For non-insurable infrastructure the relationship relating to 'access to capital' may be more important.



As *insurance payouts* support repair funding; however, increasing *risk* can lead to insurance retreat, which reduces the *ability to fund* infrastructure ('insurance retreat' loop).

Figure 5: Insurance retreat

Simultaneously, more *repairs and maintenance* drive up construction *costs.* This decreases peoples' *willingness to pay*, putting pressure on the *desired levels of service* and reducing *infrastructure maintenance or repairs* that occur ('Willingness to pay' loop).



This insight reveals how escalating risks can erode the financial foundations necessary to sustain infrastructure, leading to a downward spiral of declining service levels and abandonment of assets (leading to stranded assets).

Figure 6: Willingness to pay

The concept of *network abandonment* - where infrastructure services are withdrawn by the provider due to unsustainable costs, or customers/users disconnect from services, resulting in declining demand - illustrates a critical tipping point (see the 'network abandonment' loop). *Abandonment* reduces infrastructure *funding* capabilities and consequently *levels of service*, but it might also open up space for *technical innovation* or alternative service models. Understanding this tension is crucial for planning adaptive pathways that strike a balance between retreat and investment. There may be equity impacts from technological innovation, this is explained in the *The role of technical* innovation section.

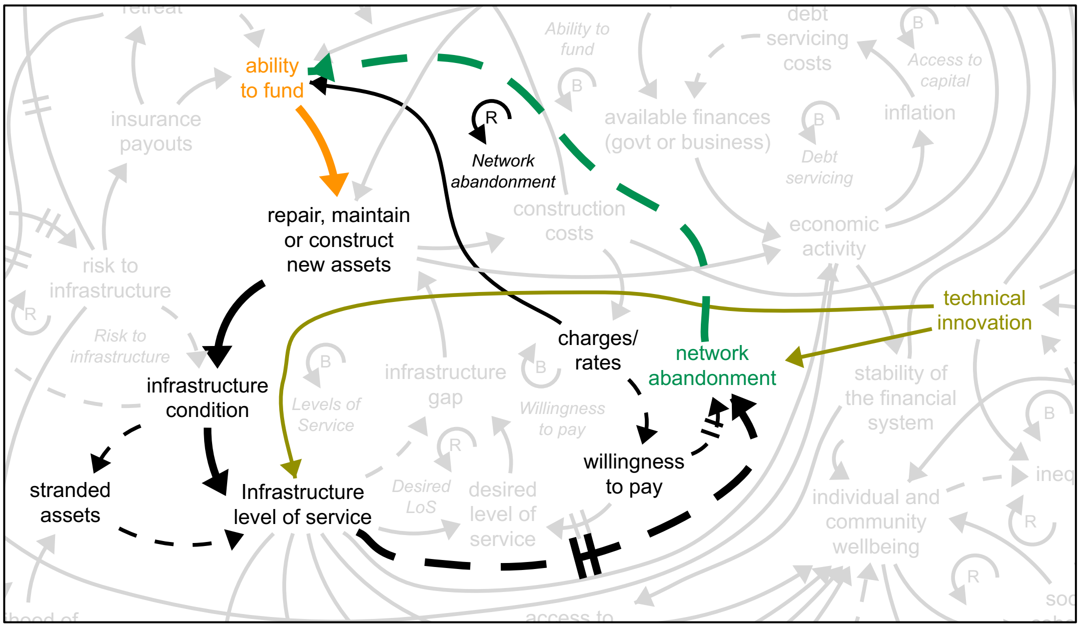


Figure 7: Network abandonment

The ability to fund assets is also linked to access to capital, debt, and debt servicing costs. Access to capital is not unlimited, so additional construction will increase debt, reduce access to capital and the ability to further fund assets (see 'access to capital' and 'ability to fund' loops).

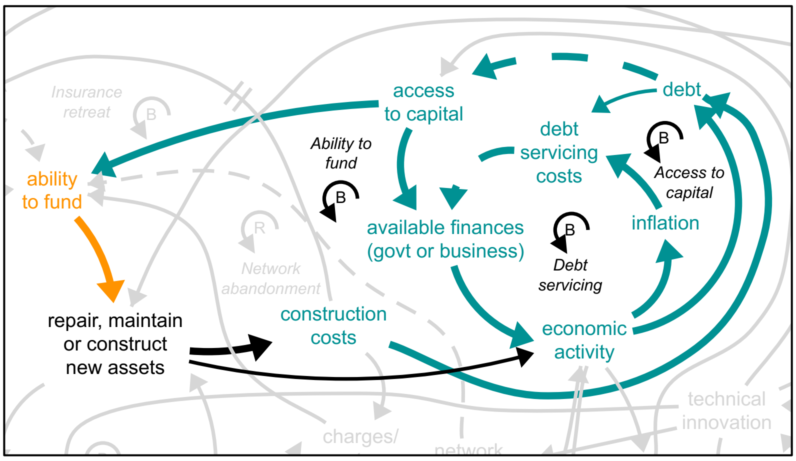


Figure 8: Ability to fund, access to capital and debt servicing

One dynamic to note is that if continued repairs or maintenance are required, this will increase the level of economic activity, which in turn will have an influence on inflation. This would increase debt servicing costs, reducing available finances for infrastructure providers ('debt servicing costs' loop).

Social wellbeing outcomes of infrastructure performance

The inclusion of access to *housing*, *health*, *food*, and *connectivity between people* demonstrates that infrastructure is not just a technical or economic issue but a deeply social one. Declines in *infrastructure levels of service* directly impair both *individual and community wellbeing*, with flow-on impacts to *social cohesion* (see 'societal impacts' loops). These social cascades illustrate how *infrastructure failure (or reduced levels of service*) can erode *social cohesion* and the *knowledge retained within communities*, exacerbate *inequality*, and reduce individual and community *adaptive capacity*. This makes both resilience and recovery (represented by the variable *ability to make decisions and be prepared for events*) even more challenging.

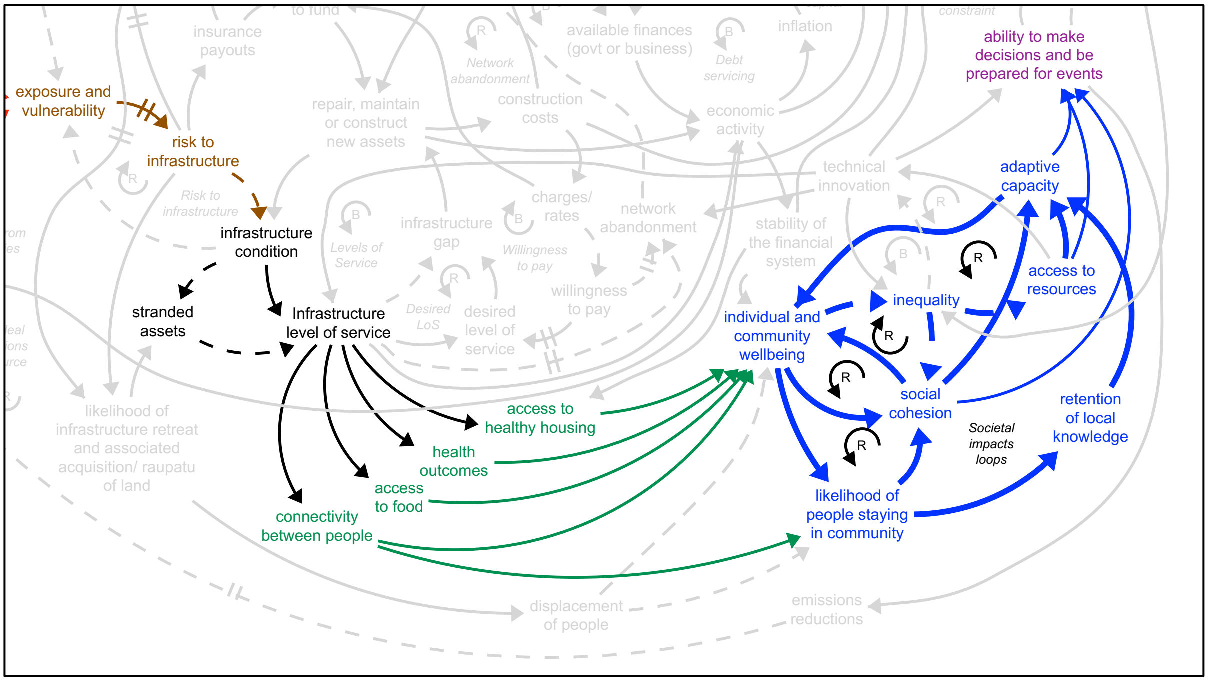


Figure 9: Social wellbeing outcomes

Adaptive capacity and decision-making feedbacks

Adaptive capacity, defined as an individual or the community's ability to respond and adjust, is central to several reinforcing loops within the diagram. Higher *adaptive capacity* improves *decision-making and preparedness*, which can reduce *exposure and vulnerability*, thereby mitigating risk ('ability to reduce exposure and vulnerability' loop around the top of the diagram). Conversely, declining *infrastructure levels of service* reduces *wellbeing* and erodes *adaptive capacity*, reducing the ability to reduce *emissions*, thereby increasing *GHGs in the atmosphere* and *risk to infrastructure* in a reinforcing feedback cycle ('ability to deal with emissions at their source' loop around the bottom of the diagram). This insight underscores the importance of strengthening social systems and community agency alongside physical infrastructure investments.

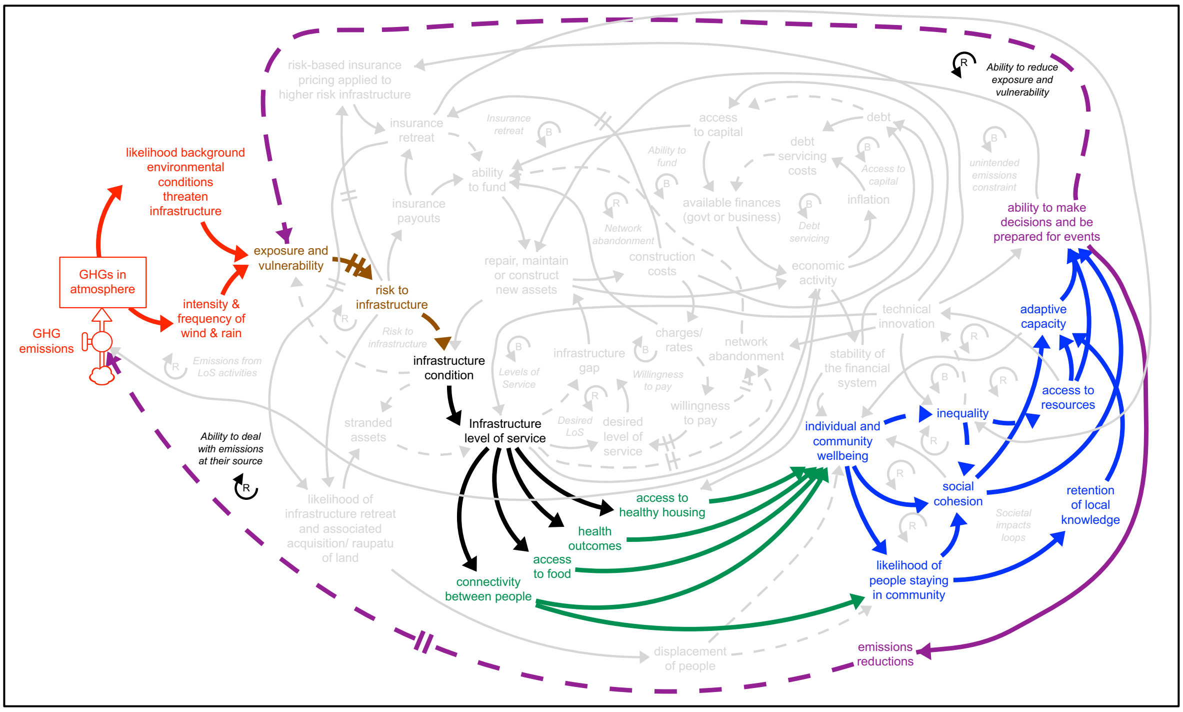


Figure 10: Adaptive capacity and decision-making - reinforcing feedbacks

Adaptive capacity is also involved in a significant balancing feedback loop through *GHG emissions*. High *risk to infrastructure* (from GHG emissions) may reduce infrastructure levels of service over time, which may reduce *social factors* and *adaptive capacity*, thereby decreasing the *ability to make decisions and be prepared for events.* As this reduces, so does the *ability to repair or maintain infrastructure*, which is a contributor to *economic activity*.

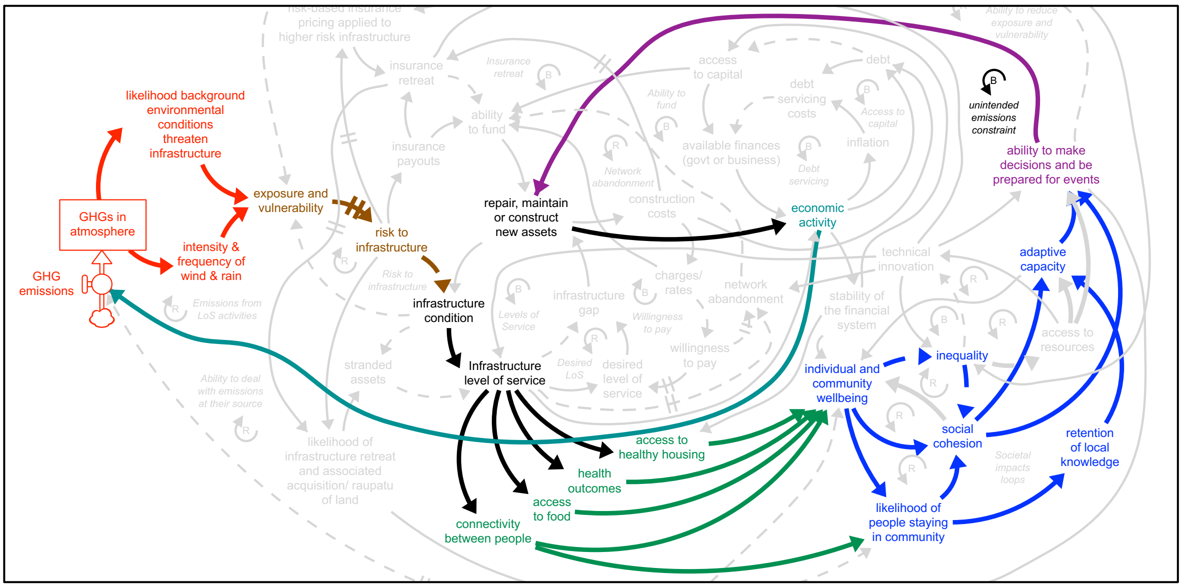


Figure 11: Adaptive capacity and decision-making – balancing feedbacks

A reduction in *economic activity* may reduce *GHG emissions*, but in an undesirable way, as it comes from a reduction in societies *adaptive capacity* and *ability to make decisions and be prepared*. This insight also highlights the importance of strengthening social systems and community agency alongside physical infrastructure investments.

The role of technical innovation

Technical innovation is often put forward as a potential lever to improve decision-making and infrastructure performance, while also influencing how people meet their needs. *Innovations* can provide alternative service models that reduce the need for traditional infrastructure, which may increase the *abandonment of existing networks* (e.g. mobile communication methods reducing the need for physically connected networks). Those with better *access to resources* are more likely to adopt and benefit from *technological innovations*. Therefore, technological innovation is also unlikely to be evenly shared and it may exacerbate existing *inequalities*. Consequently, attention should be paid to potential unintended *inequalities* that may occur when seeking solutions through *technological innovation*.

These insights highlight the crucial role of research and development in climate adaptation strategies and underscores the need to integrate emerging technologies into resilience planning.

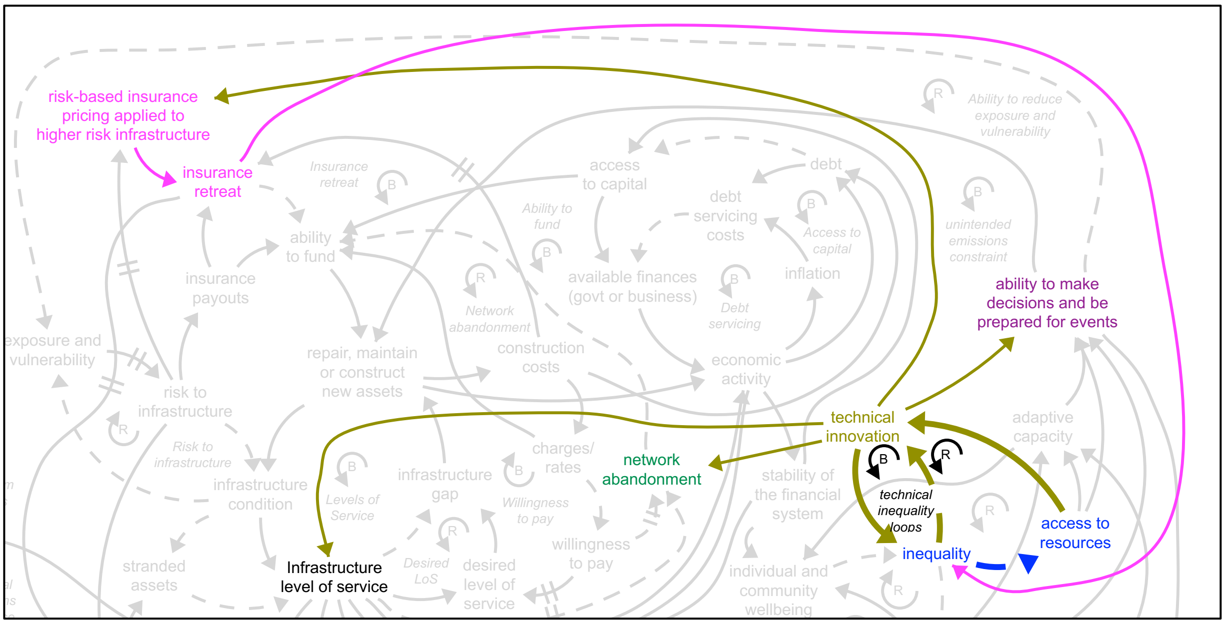


Figure 12: Technical innovation

4. Agriculture (drought) summary causal diagram

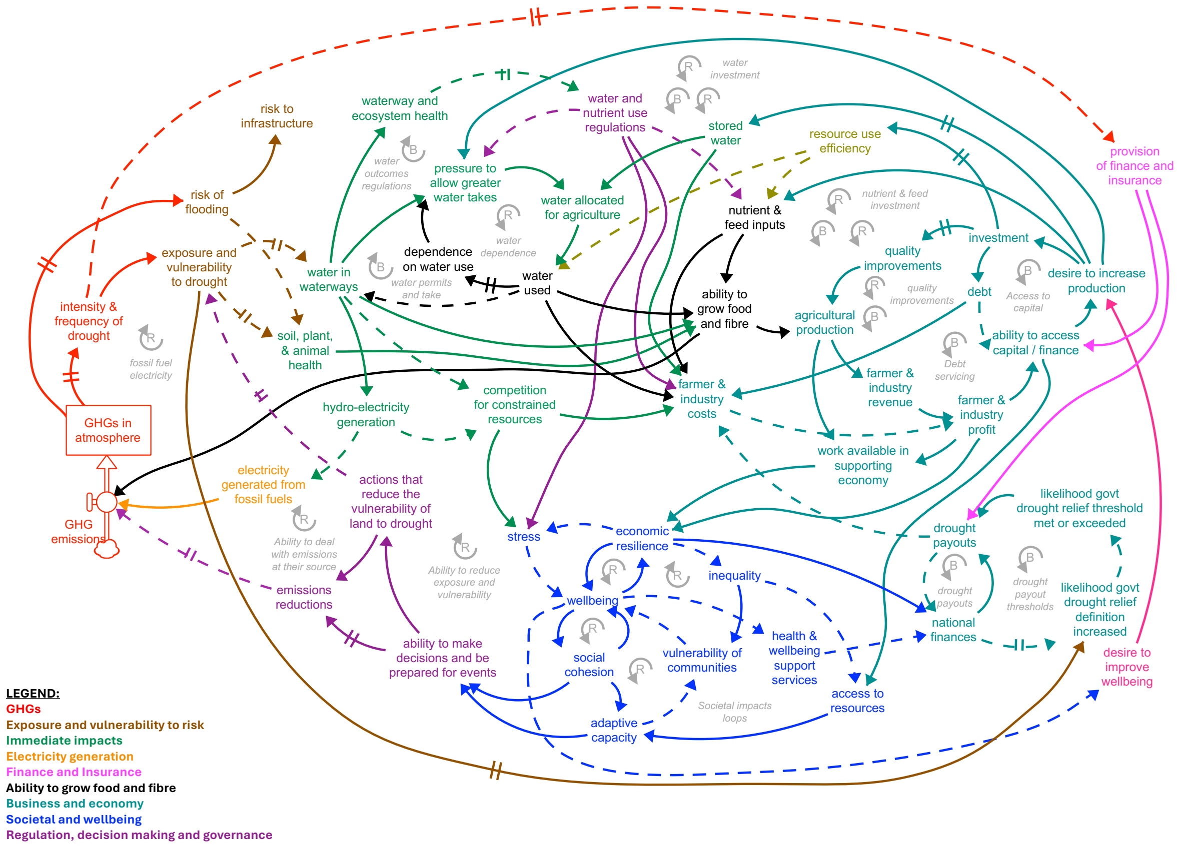


Figure 13: Agriculture summary causal diagram

This diagram offers a nuanced framework for understanding how drought impacts on the agricultural sector cascade through environmental, economic, and social systems. This highlights the importance of integrated strategies for policymakers, planners, and stakeholders, to build resilience and reduce climate change risks in agriculture.

In the following description of this diagram, references to variables in the diagram (either in full or in part) are *italicised*. References to named feedback loops are in ‘quotation marks’. In the images, highlighted feedback loops are emphasised with thicker arrows.

One the cascading impacts of drought is an increased risk of flooding (explained in the following section). The relationship between *risk of flooding* and *risk to infrastructure* provides a way of linking between this causal diagram and the infrastructure one described in the previous section.

Emissions-drought relationship

The "bathtub" analogy is again employed to illustrate how the accumulation of GHGs is pivotal because it both directly escalates the climate-related hazard (drought) that agriculture is exposed and vulnerable to. This leads to both reduced *water in waterways* and has a consequential impact through reduced *soil, plant and animal health*. These cascading risks undermine the potential productivity of agricultural systems. This foundational insight underscores the role of emissions reduction in mitigating *drought frequency and severity*, linking climate change drivers to agricultural vulnerability.

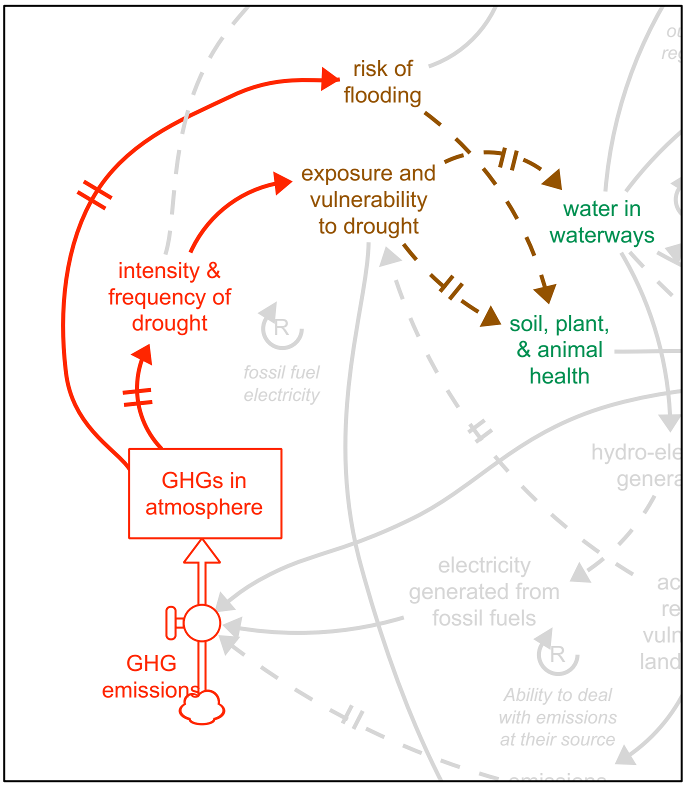


Figure 14: Emissions-drought relationship

The risk of flooding was highlighted as a cascading risk due to the likelihood of hardened or hydrophobic soils after a drought. This inhibits the ability of soil to absorb water when it a drought does break, increasing the risk of flood. This also has a consequential impact on *soil, plant and animal health*.

Systemic implications of water availability

Lower water availability cascades into reduced waterway and ecosystem health, ability to grow food and fibre, and hydroelectric power generation, as well as increased competition for constrained resources.

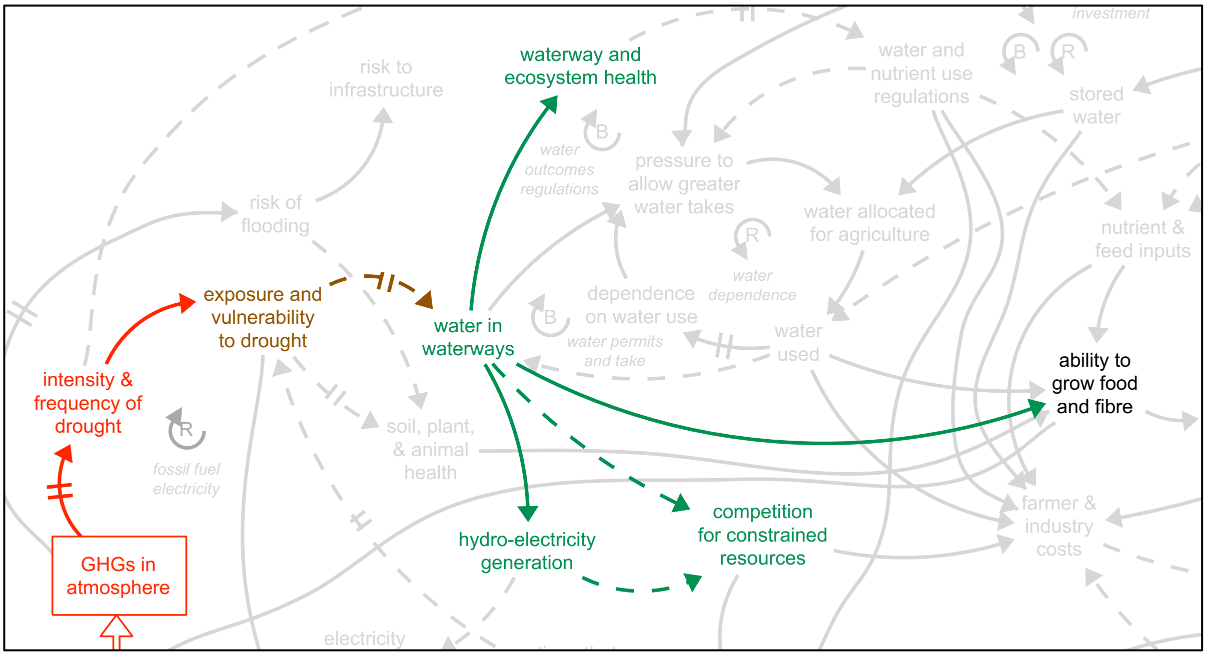


Figure 15: Water in waterways

This heightened *competition* raises *costs* and *stress* on communities. While losses in hydro-electricity generation could be compensated by further expansion of other renewables, it is also possible that electricity may be generated from *fossil fuel-powered generation* to compensate. This creates a reinforcing feedback loop that exacerbates GHG *emissions* and, in the longer term, the *likelihood of drought* conditions.

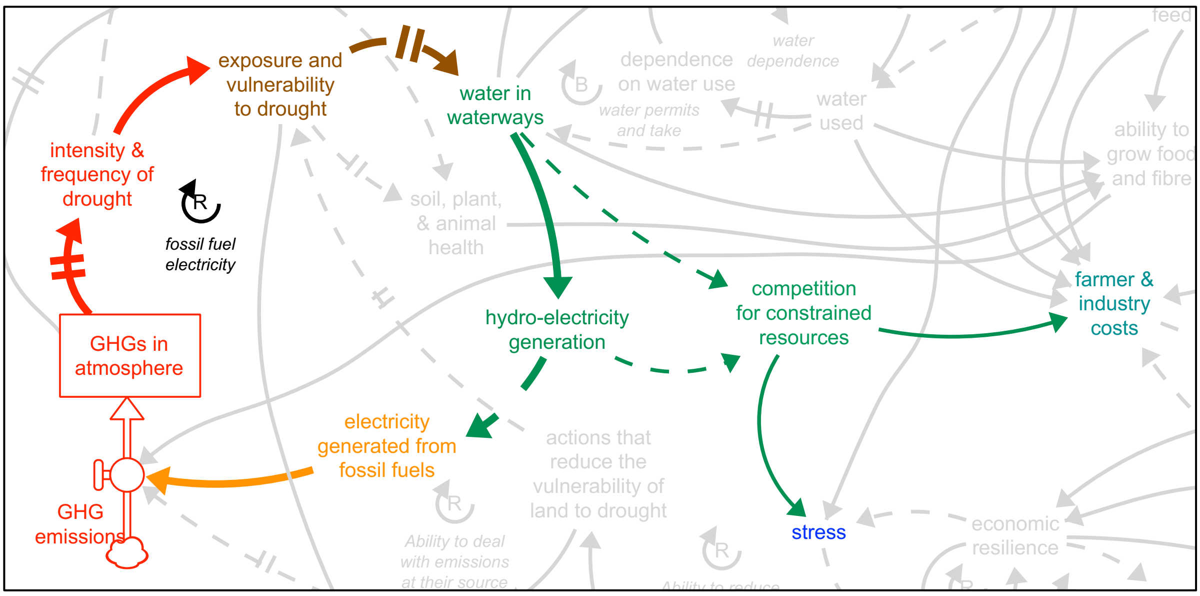


Figure 16: Reduced hydro-electricity and GHG emissions

Social feedbacks related to water use

The causal diagram highlights several feedback loops that both balance and reinforce the need to use water. *Social pressures* (e.g. to allow or constrain water use) and *regulations* (that actually regulate water use) help manage *water use* (‘water permits and take’ balancing loop) within the context of the water outcomes we want for waterways (‘water outcomes regulations’ balancing loop).

At the same, the *use of water* itself can lead to lock-in effects that support existing activities at their existing level of water dependence. This sustains and may increase agricultural activities *dependence on water use* because of the perception that water will continue to be available (‘water dependence’ reinforcing loop), encouraging ongoing investment in higher water-use activities. Investment in *stored water* facilities may alleviate pressures on *available water* in the short term but encourage expansion of activities in the longer term – hence *dependence on water use*. Despite these competing feedback mechanisms, drought still reduces the overall *ability to grow food and fibre*, which impacts *revenue* and *profit*.

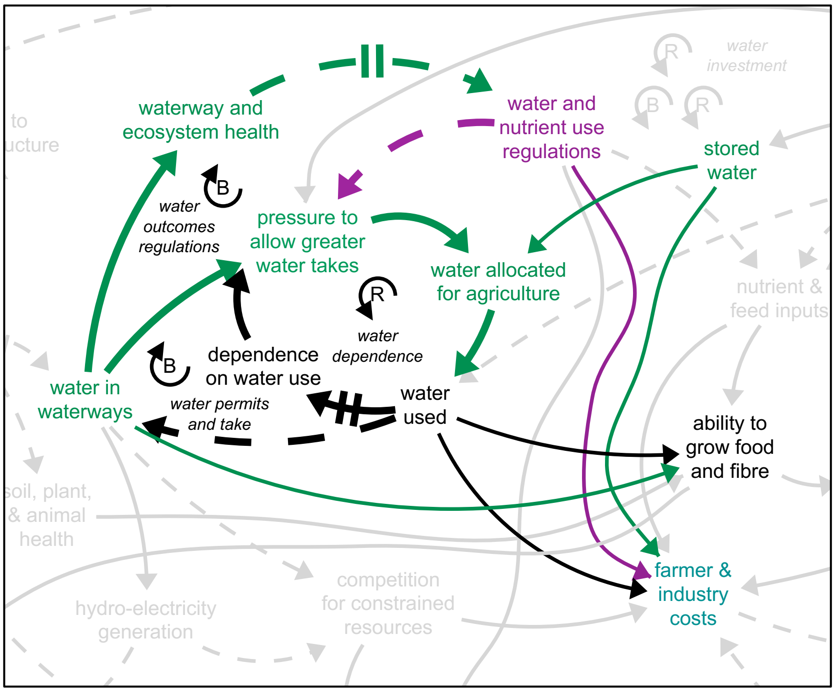


Figure 17: Social feedbacks related to water use

Influence of social and financial dynamics on agricultural practices

Financial dynamics demonstrate how *access to capital*, *debt*, and *investment* decisions influence *agricultural production* and *profitability*. *investment* (‘access to capital’ loop) enables *production expansion* through increasing *resource use efficiency* and *quality improvements* (‘quality improvements’ reinforcing loop), However, *debt* also requires servicing (‘debt servicing’ loop’), which can reduce *profitability*. This demonstrates the delicate economic balancing act farmers face.

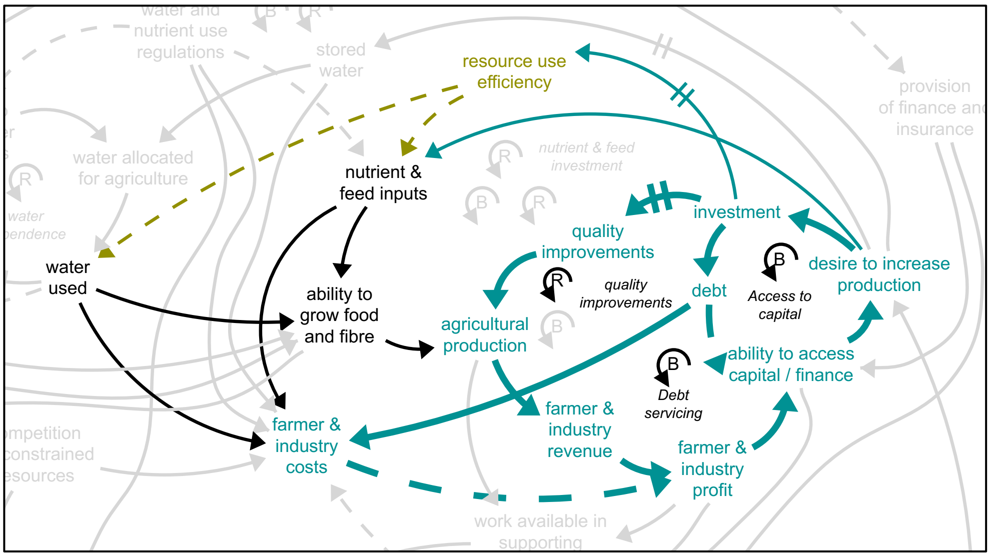


Figure 18: Access to capital, quality improvements and debt servicing

While some of these economic factors reinforce themselves (for example, *quality improvements* increasing *profitability*), these financial results also interplay with social aspects related to agriculture to determine whether such ongoing profit gains are desired or sought. For example, the *desire to increase production* is influenced by the *desire to improve wellbeing*. Improved profitability increases *economic resilience*, reduces *stress*, and increases wellbeing. This balances out the need for further improvements in wellbeing ('quality improvements' balancing loop).

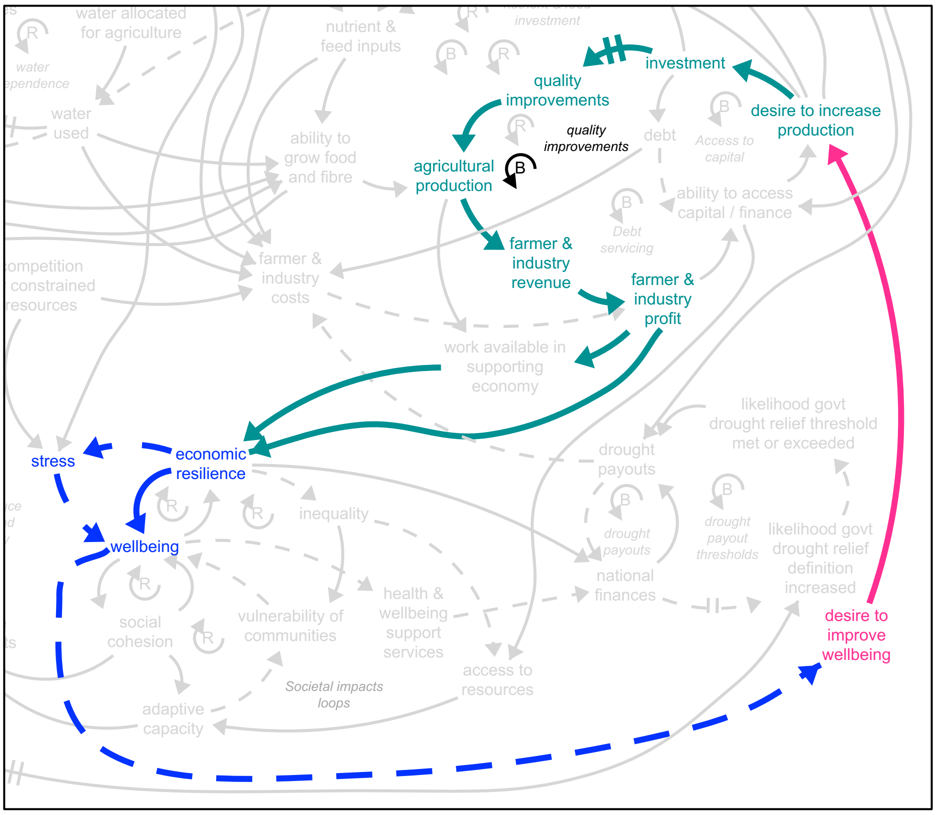


Figure 19: Quality improvements balancing loop

Economic resilience, *wellbeing*, *stress*, and *social cohesion* are deeply intertwined with agricultural and environmental outcomes - all reinforcing and spiralling with each other. High *stress* and *inequality* also reduce *adaptive capacity* and *decision-making*, which impairs *community preparedness* and exacerbates future *vulnerability* to drought. These cascading effects emphasise the need for holistic perspectives that incorporate the various social, economic, and environmental influences. All of these 'societal impacts loops' reinforce with each other - i.e. they tend to all rise and fall with each other.

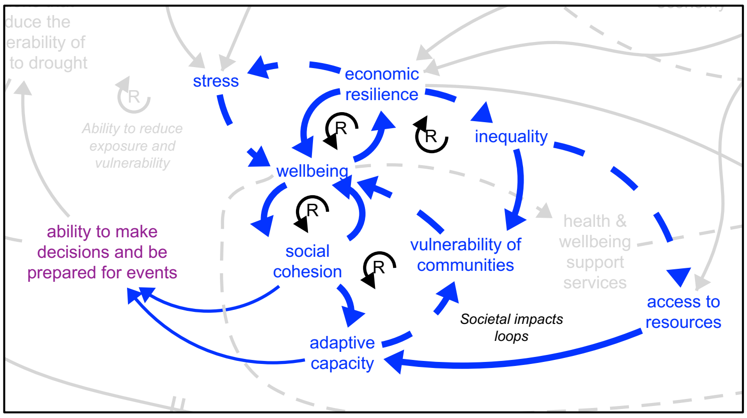


Figure 20: Agricultural social loops

As shown in the infrastructure diagram, the impact of *inequality* is an important factor influencing *vulnerability* and *adaptive capacity*, thereby impacting community *decision-making* and *preparedness* for climate-related events. This insight highlights the importance of strengthening social systems and community agency to help reduce inequalities.

Adaptive capacity and decision-making feedbacks

The ability of farmers and communities to make informed decisions and implement adaptive measures determines their exposure and vulnerability trajectory. Ensuring robust social systems can increase adaptive capacity and decision-making abilities, which can, in turn, feed back into emissions reduction efforts and enhanced resilience. However, poor adaptive capacity risks locking farming communities and systems into undesirable feedbacks of increasing drought exposure, environmental degradation, economic decline, and social stress.

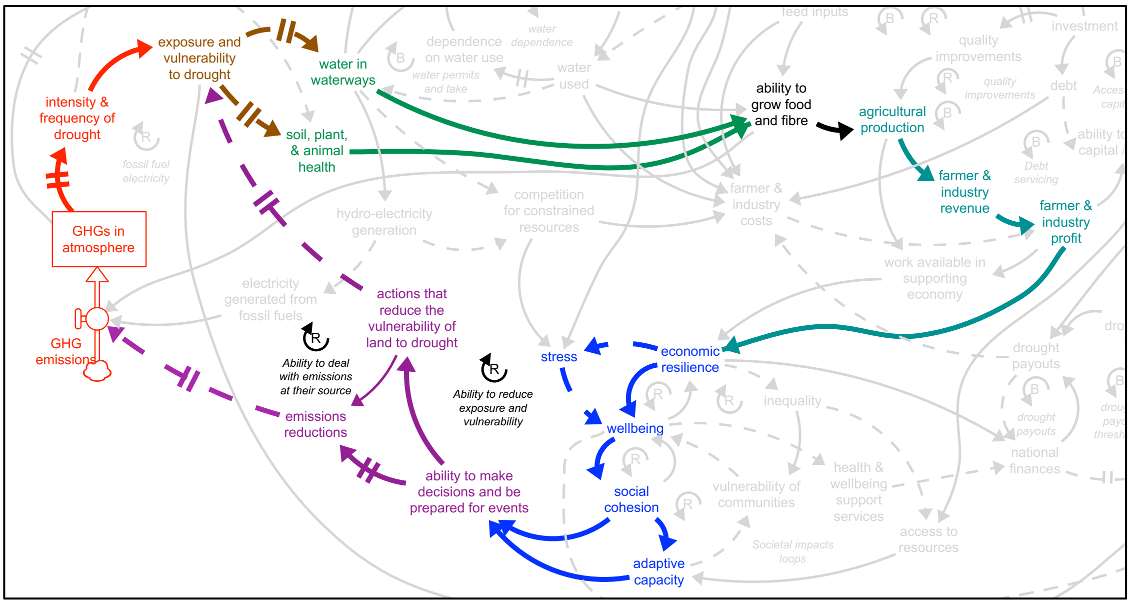


Figure 21: Adaptive capacity and decision-making feedbacks

Finance, insurance and government interventions

This diagram also touches on the role of *government drought payouts* and *national finances* ('drought payouts' loop), showing how increased *drought frequency* may strain *public finances*. It is noted that raising the *threshold of drought relief* may technically improve *public finances* ('drought payout thresholds' loop), at the cost of actual payouts to the agricultural sector, likely increasing the financial risk to farmers.

The complexity of *insurance* availability at the farm level also impacts *access to capital* and *drought payouts* - although these may be private payouts (if any) rather than government ones. *Insurance and finance* are increasingly linked to the *intensity & frequency of drought*, which is increasing due to increasing *GHGs in the atmosphere*. This highlights important cascading risks to the viability of current agricultural systems.

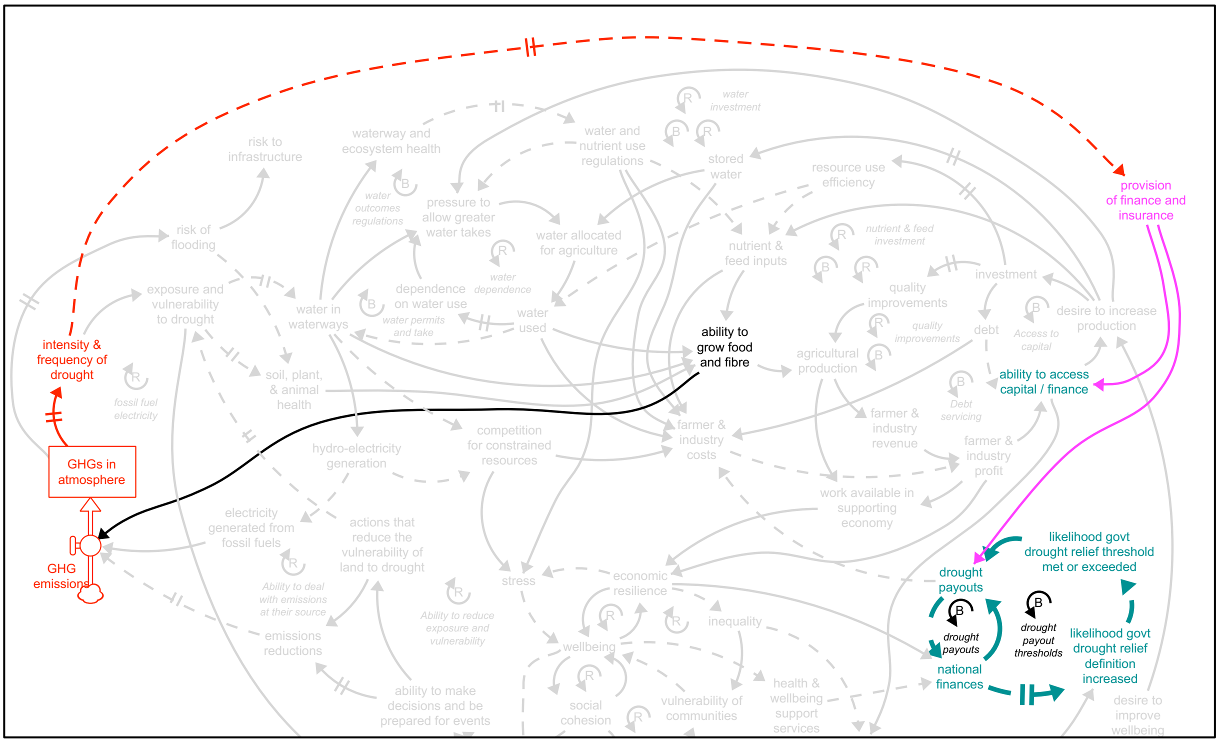


Figure 22: Finances, insurance and government interventions

5. Key insights and how to use the causal diagrams

This section summarises key insights that can be drawn from the causal diagrams and articulates a variety of ways they may be used. These insights are informed by the causal diagrams as well as the discussion and information gathered during the workshops.

Key insights from the causal diagrams

Key insights are outlined firstly as those that are shared across both causal diagrams, followed by those that are particular to the infrastructure and agriculture diagrams.

What is noticeable with the insights, is the extent that social factors come to the fore. Often, when we think of risk and climate adaptation, we think first of technical issues; yet these diagrams and the discussions with subject matter experts remind us that risks from climate change have inherently social elements. Adaptation relies heavily on healthy stocks of social capital because strong social cohesion and adaptive capacity reinforce each other. Communities that retain knowledge, skills, and population are better able to make decisions because they have strong institutions and decision-making capacity. This, in turn, supports their ability to collectively make decisions that enable their preparedness, resilience, and ability to recover in the face of climate change, by improving both mitigation and adaptation efforts. Consequently, many of the shared insights across both infrastructure and agriculture focus on this.

Shared insights (across both causal diagrams)

- Nearly all physical risks cascade through to impact on some, or all, of the social factors. Therefore, it is reasonable to assume that many risks that may be ranked low when considered individually, may collectively compound and present as higher stress in the social areas.
- There are many varied social factors, for example, wellbeing, inequality, sense of community or social cohesion. Most tend to be involved in reinforcing loops. So they tend to reinforce and spiral with each other, whether that is in a desirable direction or an undesirable one.
- Increased stress in the social areas is likely to cascade into increased pressure on governance systems and processes. This will likely present as decreased trust in institutions and reduced ability for communities to effectively make collective decisions. This will impact the ability of individuals and communities to effectively adapt to climate change in the future.
- There is a chance that physical impacts may cascade indirectly through both the infrastructure and agriculture examples in an unplanned or uncoordinated way, damaging social cohesion and reducing human activity – and GHG emissions – as a result. In other words, cascading undesirable impacts may reduce social capital and hinder a community or societies ability to adapt, which counter-intuitively may result in

less GHG emissions. In the long run this may be more costly and disruptive because of the potential uncoordinated nature of any response. Importantly, this set of cascades highlights the need for coordinated adaptation activity that focuses on maintaining social capital as much as it does on technical adaptations.

- Most physical human activity in the diagrams (e.g. building/repairing infrastructure or modifying farming activities) is constrained by access to capital/finance. We can realistically anticipate a growing tension between the ability to undertake activity (whether it be maintaining business as usual or undertaking adaptation activity) and the ability to finance it. Current expectations of what levels of existing infrastructure and agricultural activity may be possible in the future may need to be reduced.
- Similar to the financial point above, insurance plays an important role in enabling or constraining activity, particularly infrastructure. Insurance (partial or full) retreat is likely to constrain future adaptation activity. Current expectations of what levels of existing infrastructure and agricultural activity may be possible in the future may need to be reduced.
- Technological advances may play a role in altering how some activities are undertaken. These will likely tend to focus on efficiency gains (mostly in agricultural activities, e.g. research and development relating to more efficient water or nutrient use), or possible alternative delivery models (mostly in infrastructure - e.g., off-grid electricity). These will tend to reinforce expectations that future levels of activity will be at least the same as current levels of activity. This may not always be the case, for example while technology might contribute to make systems more resilient it may also increase costs and lead to lock-in solutions (e.g. artificial snow production in tourism).
- Those with better access to resources are more likely to adopt and benefit from technological innovations. Therefore, technological innovation adoption is also unlikely to be evenly distributed, and it may exacerbate existing inequalities.
- Adaptation interventions should be equally (if not more) focused on maintaining and strengthening social cohesion and adaptive capacity, as opposed to just on technical interventions. This is because people's ability to make decisions about adaptation - and hence their ability to develop and implement technological interventions - is all impacted by the compounding risk pathways throughout the diagram.

Insights particular to infrastructure (wind & rain)

- Good condition and maintenance supports high levels of service from infrastructure, reducing vulnerability of infrastructure to climate hazards. However, societal expectations evolve over time and sustained levels of service in line with existing expectations may encourage higher desired levels of service in the future. Similarly, sustained levels of service lower than existing expectations, due to various constraints, may force communities to accept lower levels of service in the future.
- Technological innovations may provide alternative service models that contribute to network abandonment (i.e. they may allow people to achieve similar services without the need for collective infrastructure - e.g., off-grid electricity), reducing the pool of people available and willing to pay for services from collective infrastructure, e.g. grid-

provided electricity. This will reduce the ability of collective infrastructure to sustain sufficient income to operate.

- Infrastructure retreat may lead to services retreating from one area and needing to be (re)established in another. This may leave some properties without services and potentially needing to be compensated for their property, as well as new land elsewhere being required. Both risks may involve compulsory acquisition/raupatu[3] of land.
- Construction activity related to continued repairs, maintenance and construction of new assets is currently positively correlated with higher GHG emissions. As risks to infrastructure increase, along with the likelihood of repairs and rebuilding to maintain existing levels of service, so too does the likelihood of further GHG emissions. Consequently, maintaining levels of service at current expectations may result in further GHG emissions. While not to be overstated, the key point is that adaptation involving significant construction is, counter-intuitively, contributing to the increased likelihood of climate hazards through increased GHG emissions.

Insights particular to agriculture (drought)

- Drought can lead to competition for constrained resources (e.g. water, supplementary feed, and processing facilities), which reduces farm income while also increasing stress at the individual and community level.
- Recurring drought will lead to sustained pressures on ecosystem health (through reduced water in the ecosystem). Over time, this may result in increased regulation to try to retain water in waterways/the ecosystem, reduced inputs, or acceptance of degraded ecosystems. Regulation may constrain continued water extraction or additional inputs, and will also lead to additional stress and costs for farmers.
- There are conflicting feedback loops relating to farmers' wellbeing, which may result in a range of possible outcomes depending on which loop dominates for individual properties at any given time. For example, profitability contributes to wellbeing to an extent, yet other reinforcing loops encourage further production and further profitability. Total farming activity is effectively constrained by access to capital and resources.
- Stored water interventions will likely have a temporary effect on water availability by providing a buffer of water to draw on in times of drought. At the same time, this will likely continue to reinforce higher water-dependent agricultural activities in the long run. This may result in higher impacts from drought events that are more severe in the future, which the water storage buffer may not always cover.
- Due to reduced growing capacity and production during drought, GHG emissions from agriculture have historically tended to decline. For example due to de-stocking of animals and/or reduced activity/lost crops. Although some reactionary activity such as buying in feed, may sustain GHG emissions. However, these reductions will likely

[3] *Raupatu* is a te reo (Māori language) term that refers to something being taken away from someone without consent, especially land. It is a term often used to refer to the historical confiscations of Māori land by the Crown.

occur in an unplanned or reactive way, potentially generating undesired impacts on other social and economic aspects.

- Drought can lead to reduced water in hydro-electricity dams and lower hydro-electricity generation. While losses in hydro-electricity generation could be compensated by further expansion of other renewables, it is also possible that electricity may be generated from fossil fuel-powered generation to compensate.

How to use the causal diagrams

We suggest that the causal diagrams described in this report can be used in five ways. These are listed below:

They show how everything is interconnected

At a minimum, they help demonstrate how numerous and how complex the interconnections within these subject areas are.

We note that simply demonstrating complexity is the simplest and lowest-level way that these causal diagrams may be used. For most audiences, this is already acknowledged and should be axiomatic. However, this is still articulated as a use, as for some audiences this will prove beneficial.

Design narratives to explain cascading risk

The causal loop diagrams can be used to create narratives describing how cascading risk can occur. Narratives have a place in the communication of complex ideas to decision-makers and the wider public.

Identify where risk domains overlap or cascades are shared

Qualitatively shading the domains on the diagrams can help the Commission to identify and prioritise risks. It does this by helping to:

a. Identify where risks (or areas of impact) may be shared across domains of interest to the Commission. In other words, do any of the Commission's domains of interest overlap? If so, this could be a way of coordinating risk assessment or action in these areas.
b. Identify where multiple, potentially seemingly unrelated, risks in different domains may cascade to shared ‘downstream’ areas. If so, the risks in these areas may be dealt with by working across various ‘upstream’ domain areas. This is particularly useful for risks (or areas of impact) that are typically further along the chain of cause and effect, e.g., risks to people and communities and governance.
c. Identify where risks in a single ‘upstream’ domain may cascade to multiple ‘downstream’ areas. E.g. risks to ecosystems may cascade to impact many different ‘downstream’ areas.

The following figures demonstrate this shading approach on the detailed causal diagrams.

The first two diagrams (Figure 23 and Figure 24) are all the Commissions domains shaded over the areas that are likely to apply to them, except the *Ngā mea hirahira o te ao Māori* domain, which is shown separately.

Our interpretation of where the *Ngā mea hirahira o te ao Māori* domain may overlap with our diagrams is represented in the third and fourth diagrams (Figure 25 and Figure 26). In these, we have coloured those variables within our diagrams that we consider may overlap with the seven risks to the Māori domain identified in the report commissioned by the Commission for that purpose (Awatere, et. al, 2025).

This has been represented separately as it is acknowledged that, while there will be areas of overlap, te ao Māori worldviews are not only independent of those used to develop the insights in this report, they also drawn on different epistemological foundations and may not be directly comparable.

Seven risks were highlighted in the tea o Māori report. These are listed below and highlighted using colour in figures Figure 25 and Figure 26. The colours used in these two figures are consistent between them but are not consistent with other uses of colour in the other diagrams throughout the report. They are not intended to be comparable.

The seven risks highlighted in the *Ngā mea hirahira o te ao Māori* report are:

1. **Loss of access to taonga (cultural keystone) species**
   Species decline, habitat loss, and regulatory exclusion threaten mahinga kai, seasonal knowledge (maramataka), and tikanga practices rooted in specific ecosystems.
2. **Damage to Māori infrastructure**
   Marae, urupā, and papakāinga face increasing exposure to flooding, coastal erosion, and wildfires. Many sites are uninsured and excluded from adaptation planning frameworks.
3. **Economic losses in primary industries**
   Māori-owned forestry, farming, aquaculture, and horticulture enterprises are vulnerable to multiple climate hazards. Underinvestment in rural infrastructure and lack of access to risk-sharing mechanisms compound these risks.
4. **Disruption to tikanga and hapū/iwi identity**
   Relocation and managed retreat threaten spiritual connections, identity, and intergenerational wellbeing, especially where ahi kā and whakapapa to place are central.
5. **Loss of Indigenous knowledge systems**
   Climate change disrupts mātauranga Māori and its transmission, particularly where species loss and institutional barriers prevent tikanga from being practised or taught.
6. **Legal exclusion and governance failures**
   Māori are often marginalised in climate governance. Tiriti obligations, collective tenure systems, and Indigenous authority are poorly recognised in current policy and planning.
7. **Increased health vulnerabilities**
   Māori communities face heightened risk due to substandard housing, poor water access, and limited healthcare, particularly wāhine Māori, kaumātua, and those in remote areas.

Deliberate
Discuss.Understand.Act.
URBAN INTELLIGENCE

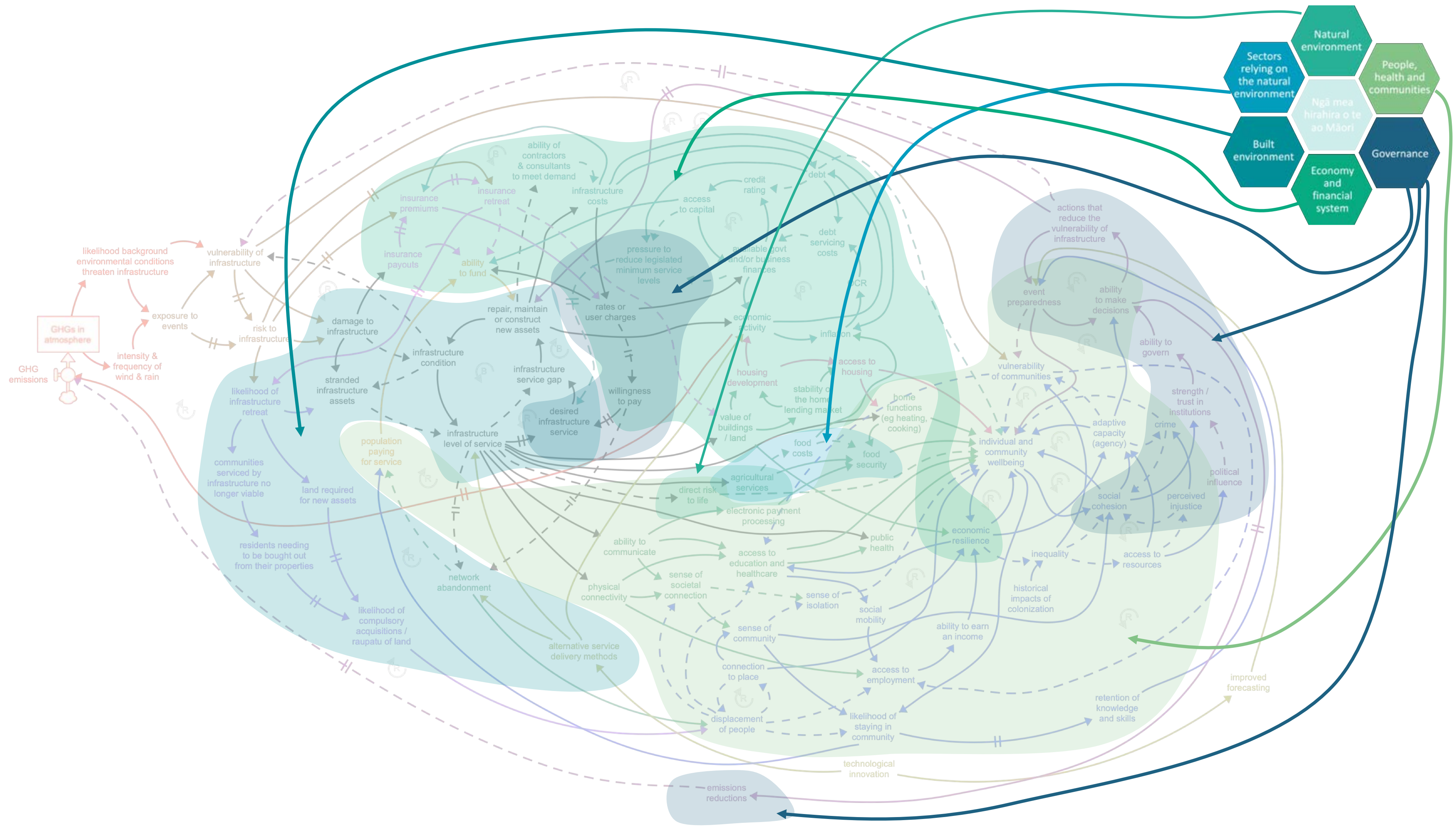


Figure 23: The Commission's domains mapped over the cascading risks to infrastructure causal diagram

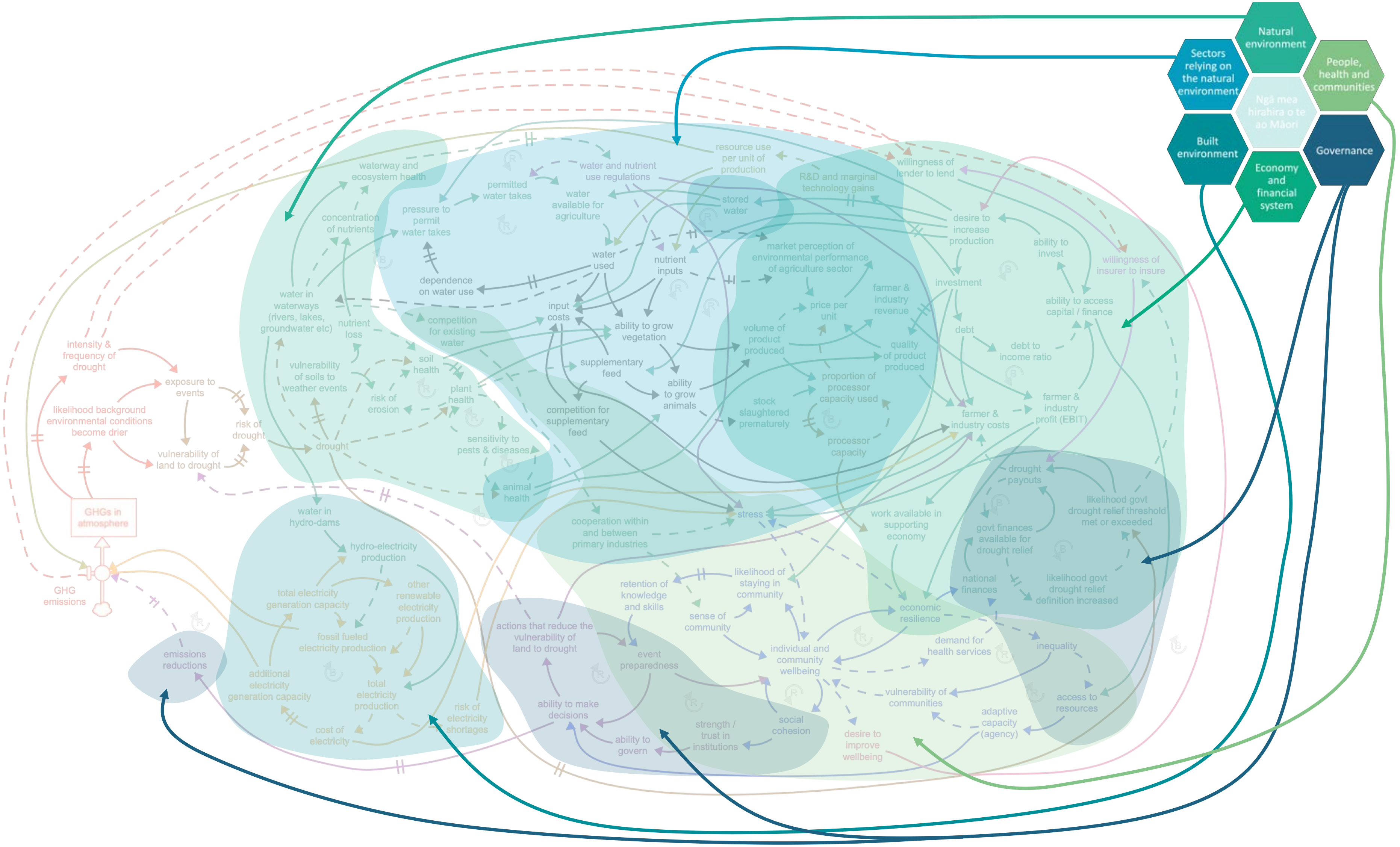


Figure 24: The Commission's domains mapped over the cascading risks of drought in agriculture

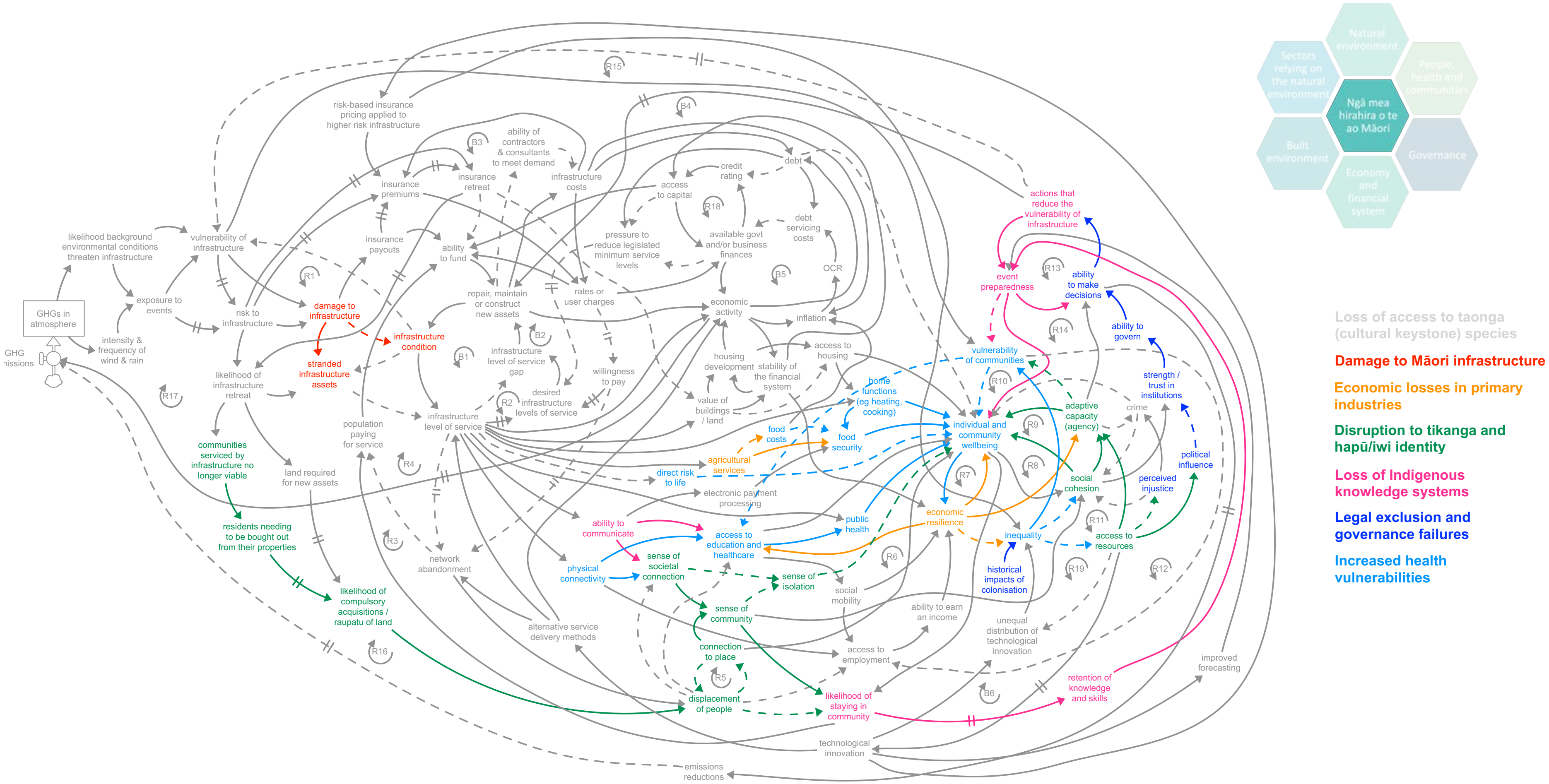
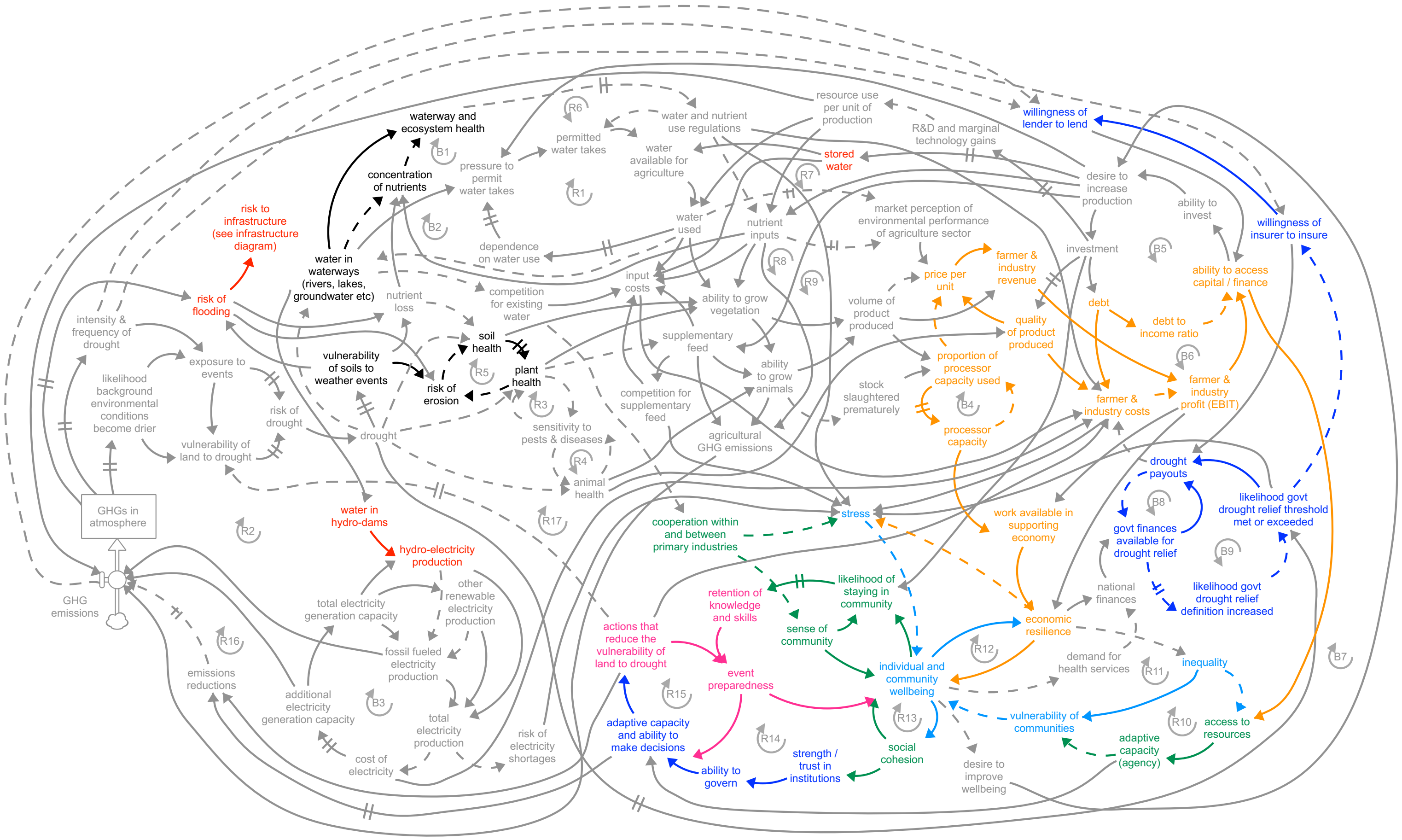


Figure 25: Variables considered similar to the identified tea o Māori risks – extreme wind & rain impacts on infrastructure



Loss of access to taonga (cultural keystone) species

Damage to Māori infrastructure

Economic losses in primary

Disruption to tikanga and hapū/iwi identity

Loss of Indigenous knowledge systems

Legal exclusion and governance failures

Increased health vulnerabilities

Figure 26: Variables considered similar to the identified tea o Māori risks – drought in Agriculture

Use the feedback loops identified to view multiple risks as linked and dynamic

Help view multiple risks as dynamic. Highlighting where risks (or impacts) may spiral or cancel each other out using the feedback loops described in this report.

For example, many of the social variables are linked in reinforcing spirals. The way these variables change over time in response to climate stressors can be qualitatively explored using the feedback loops outlined in either the summary or detailed versions of the report.

Some examples are shown below. Where the feedback loops are used to explore how different variables may change over time, in relation to changes in other parts of the diagram. The variables do not need to be part of the same feedback loops, so long as their pathways of connection are understood.

Figure 27 highlights feedback loops R5 to R12 in the infrastructure diagram. A conceptual example here could be that reduced levels of service in infrastructure (e.g. inaccessible roads) reduce people’s connectivity and connection to place, limiting their access to healthcare services which impacts their health. Both these variables impact their individual and community wellbeing. Declines in wellbeing can contribute to vicious spirals where economic resilience is reduced, social cohesion is eroded, in equalities are exacerbated, and the likelihood of people staying in their communities and sustaining the collective knowledge of how to deal with climate events is lost. All these factors continue to erode wellbeing, which continues to erode these same factors further.

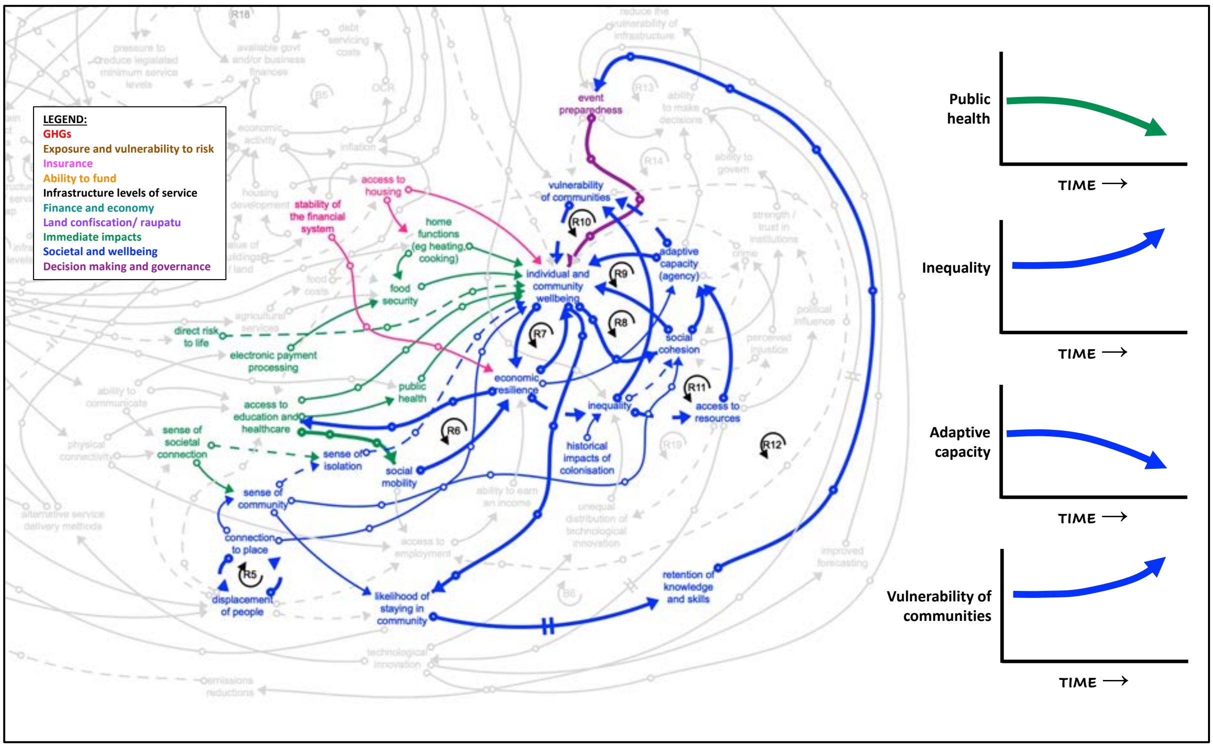


Figure 27: Exploring multiple risks using feedback loops - an infrastructure example

Figure 28 highlights feedback loop R17 from the agriculture diagram. This demonstrates how increased vulnerability to drought reduces plant health and farmers ability to grow vegetation, which is the foundational input to farming. Consequently, farmer profits reduce, individual and community wellbeing declines, as does social cohesion (farmers may become more insular or stressed, or leave the area; or conflict over access to water may increase). This reduces the ability of individuals and the community to work cohesively and make collective decisions that reduce vulnerability of the land to drought (e.g. through collective planting efforts, or implementation of things like water storage), which further increases the vulnerability of land to drought. The cycle carries on and the influences continue to spiral in an undesirable way.

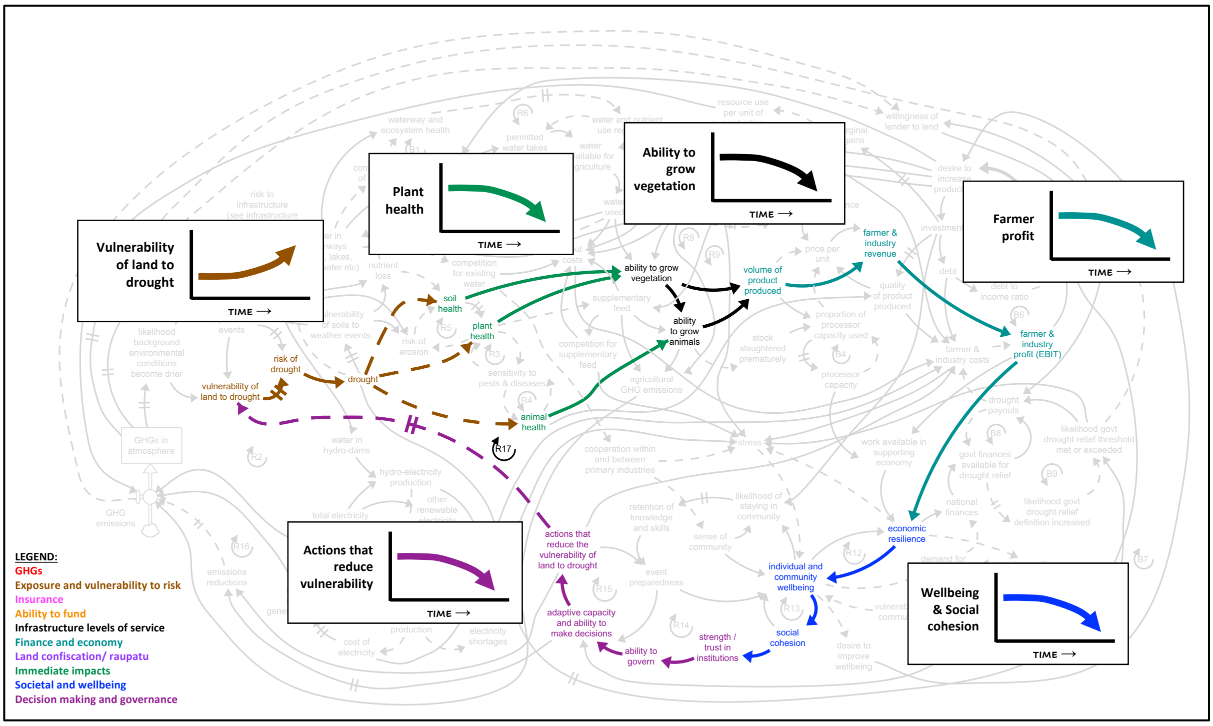


Figure 28: Exploring multiple risks using feedback loops - an agriculture example

Identify helpful metrics or indicators

Finally, the diagrams may be used to help explore or highlight what metrics or indicators may be useful for the variables/risks described. Or identify potential proxy measures that are related to the variable of interest, if that variable is currently difficult to measure. Alternatively, they could be used to map what metrics or indicators are currently available, and therefore where the gaps are.

For example, both diagrams tend to highlight the importance of a number of interconnected social variables. In the first instance, existing and known measures or proxies for variables in the diagram could be collated, highlighting what data was available and where data gaps exist. This could then be used to investigate proxy measures for such gaps. As an example, proxies for farmer stress may include things like declines in discretionary spending (itself being an extension of financial stress), or an increase in the use of helplines like the Rural Support Trust. (These are offered conceptual examples only, not tested options)

6. References

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Awatere, S., Harcourt, N., Kainamu, A., & Masters-Awatere, B. (2025) *Ngā mea hirahira o te ao Māori: Climate Change Risks to the Māori domain, National Climate Change Risk Assessment 2026*. A report for the He Pou a Rangi | Climate Change Commission. Manaaki Whenua | Landcare Research (Hamilton)

Appendix 1. How to read a causal diagram - a detailed explanation

Causal diagrams help us visualise the relationships between different related variables and how they influence each other. This visual articulation of interconnected relationships is called the 'causal structure'. This causal structure helps us understand how the behaviour of variables in the diagram will change over time (or not), in response to changes in factors within the wider causal structure.

This section outlines important fundamental elements of causal structure. These are:

- The bathtub analogy.
- Feedback loops – the basic building blocks of a causal diagram.
- How feedback loops and causal diagrams are annotated.
- Goals and gaps – driving individual loop dominance.
- How influence operates differently upstream and downstream of a change in flow.

Reading this section will help the reader understand and navigate the causal diagram in this report.

The bathtub analogy

Causal diagrams often draw on the analogy of a bathtub. A metaphorical bathtub has been used in the diagrams described in this report. The analogy of the bathtub (Figure 1) represents an accumulated level or amount of something (also called a stock) that is of interest to the issue you are seeking to understand. It may even be the central feature of the issue you are seeking to better understand.

The level of the bathtub (stock) can only be increased by adding more through a metaphorical tap (also called an inflow); and it can only be decreased by removing some of what is in the bathtub through a metaphorical drain (also called an outflow).

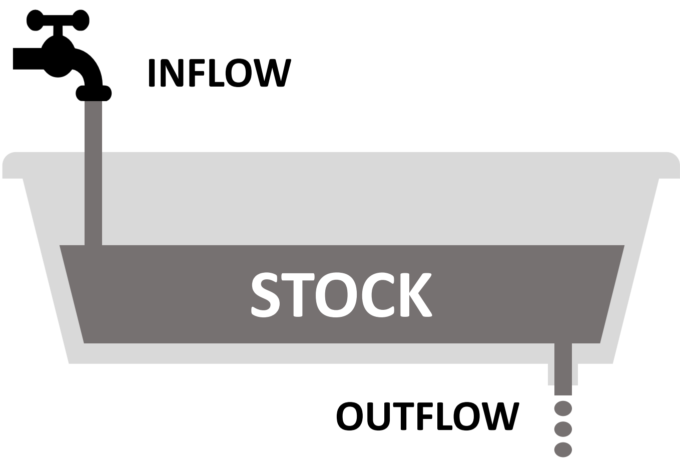


Figure 29: The bathtub analogy

This simple analogy can provide powerful insights. For example, an action may stop an issue from being added to by reducing or stopping the inflow (the tap). This will stop the level of the bathtub from increasing, but will not reduce it. To demonstrate this, think of greenhouse gas emissions into the atmosphere. If all greenhouse gas emissions were to stop tomorrow, this would not cause their level in the atmosphere to reduce; it would simply stop them from increasing.

Another example is an action that may increase the outflow (the drain) from the bathtub in an attempt to reduce the level of the bathtub. But if there is still a significant inflow through the tap into the bathtub, this will reduce the impact of the increased outflow from the drain. Or, if the inflow were to increase more than the outflow, the level of the bathtub would continue to rise, but at a slower rate due to the increased outflow (drain). Greenhouse gases are another good way of demonstrating this point. Even though there are increased efforts to remove greenhouse gases from the atmosphere (i.e. removing carbon by planting trees or using direct air capture technology), if the emissions (the tap) increase by more than the drain, the level of the bathtub will still increase.

Simply put, if more flows in through the tap than out through the drain, the level of the bathtub increases. If more flows out than in, it decreases.

Feedback loops – the basic building blocks of a causal diagram

Causal diagrams focus on moving away from thinking about causality as a linear process, towards a circular one. That is, a linear way of thinking about causality might be that A influences B, whereas a circular way of thinking about causality might be that A influences B, and then B also influences A (Figure 30). This means the causality 'feeds back' on itself, so where this is identified, it is known as a feedback loop.

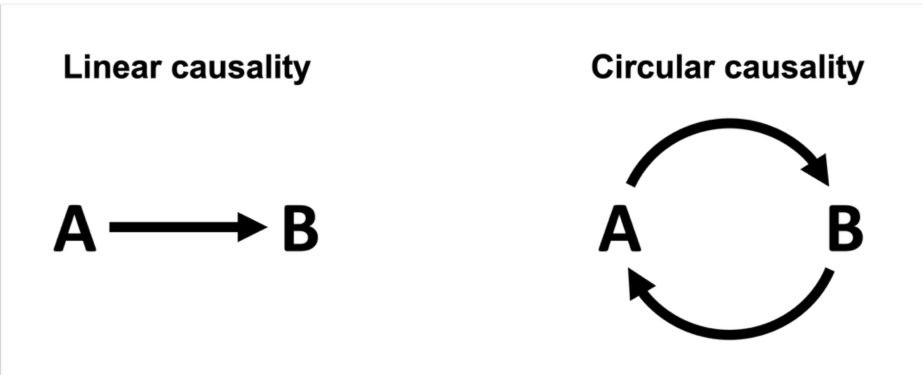


Figure 30: From linear to circular causality

There are two types of feedback loops, reinforcing and balancing (Senge 2006).

Reinforcing loops seek to spiral in the direction they are already heading (hence reinforcing). They can spiral up or spiral down, and they tend to drive growth or decline (see Figure 31). They can also change direction and spiral the opposite way, in response to influences from outside the feedback loop (i.e. how they interact with other influences). But the influence from within the loop will always seek to continue spiralling it in the same direction that it is heading.

A simple example of a reinforcing loop is money in a bank account earning interest. Assuming no withdrawals, the more money in the bank, the more interest earned, thus resulting in even more money in the bank. This influences back on itself in the same direction and has a compounding effect.

Balancing loops seek to cancel or balance themselves out. They tend to create control, restraint or resistance (see Figure 31). Depending on how they interact with other loops, they may not always manage to cancel themselves out or come back into balance, but this is what the influences within them will be seeking to do.

A simple example of a balancing loop is thermostat-controlled heating. Let's say that the room temperature drops, so the thermostat clicks on and generates heat. This increases the room temperature, so the thermostat clicks off, stopping the heating. This has the effect of cancelling itself out.

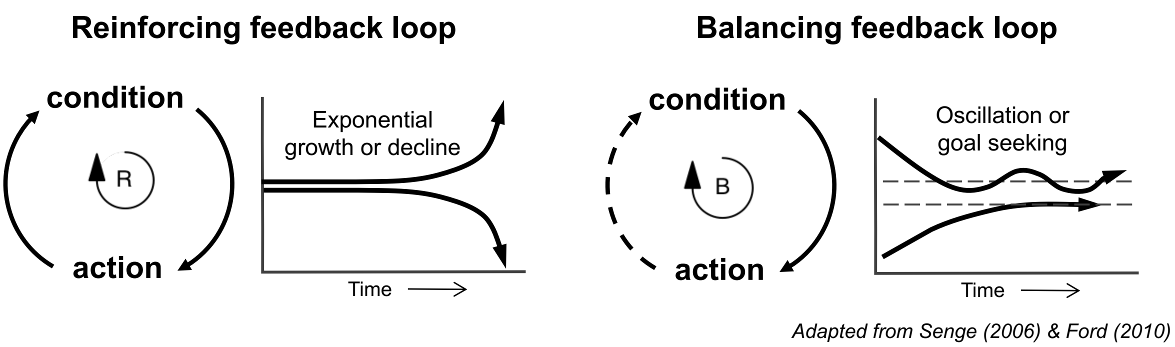


Figure 31: The two types of feedback loops

Feedback loops can be made up of more than two variables and can be linked together to form a causal diagram. How these interact in a wider network of loops and influences provides insight into the influences that may be causing a change in the system over time.

How feedback loops and causal diagrams are annotated

This section describes how feedback loops and causal diagrams are annotated.

Labelling variables

As noted in the bathtub analogy section, an important concept within causal diagrams is demonstrating where things build up (accumulation) or decrease (decumulation). Not all variables need to be represented using the bathtub analogy, but all variables in a causal diagram should be labelled in such a way that they can increase or decrease. This means that they should be described as nouns; have a clear sense of direction; and/or have a normal sense of direction that is positive. Examples to demonstrate this are shown in Figure 32. In this report, when factors from the diagram are referenced in the text, they are italicised.

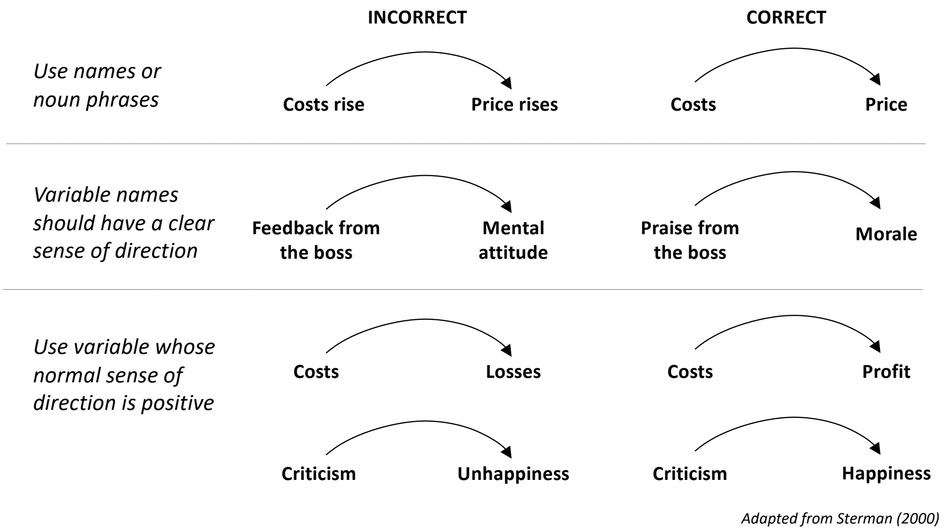


Figure 32: Labelling variables

Annotating loops

Variables within causal diagrams are connected (and made into feedback loops) by arrows, indicating that one factor has a causal relationship with the next. These arrows are solid or dashed lines, because they work in either the 'same' or 'opposite' direction. These terms correspond to the direction of change caused by one variable on another (see Figure 33).

For example, if a change in one variable leads to a change in the next variable in the same direction, it is a same relationship (solid line). Likewise, if the second variable changes in the opposite direction, it is an opposite relationship (dashed line).

Relative delays in the cause-and-effect influence between two variables, when compared to other influences outlined in the causal diagram, are annotated as a double line crossing the arrow. An example of this is shown in Figure 33.

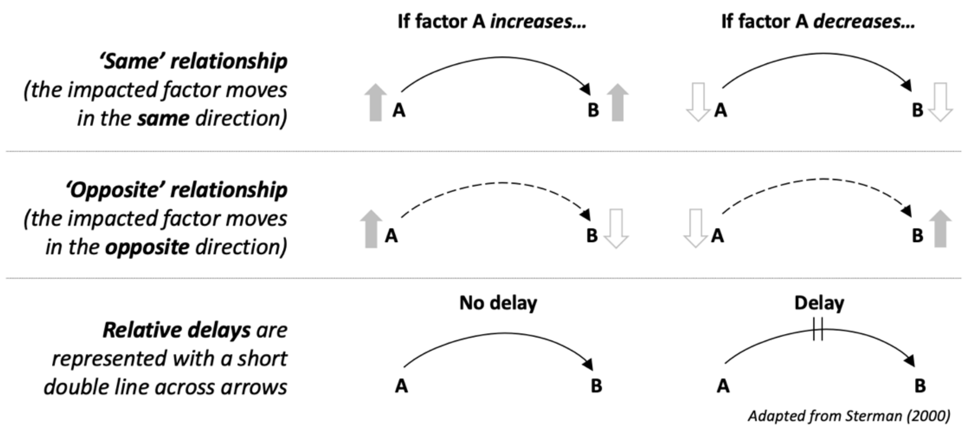


Figure 33: How arrows and delays are labelled in causal diagrams

Goals and gaps – driving individual loop dominance

Realising that multiple loops are operating together to generate the behaviour you are trying to understand is the first useful insight of a causal diagram. A further useful insight is understanding that not all loops operate at the same strength all the time. Different loops can dominate at different times. For example, the behaviour generated in a causal diagram might be dominated by a period of growth, but when a physical limit is approached (e.g., the available space in a pond for algae to grow) a balancing loop will start to dominate, therefore slowing the rate of growth.

One useful mechanism for gaining insight into the strength of a balancing loop is the 'goal/gap' structure. This is a feature within the causal diagram that combines both the desired or aspirational level for something (a 'goal'), with its actual level. The difference between these – aspiration versus actual - is the 'gap'. The higher the desired level and the lower the actual level, the greater the 'gap'. The result is a movement toward activities/decisions that narrow the gap between desired and actual states. The lower the desired level and the higher the actual level, the lower the 'gap'. This usually leads to decreases in activity because it is nearer its goal.

An example of filling a glass of water is shown in Figure 34. Initially, while the gap/difference between the desired and actual water level is high, the tap will be opened more. As the desired level of water is approached, the gap/difference reduces, so the tap is closed further, until it is fully closed when the water level reaches the desired amount.

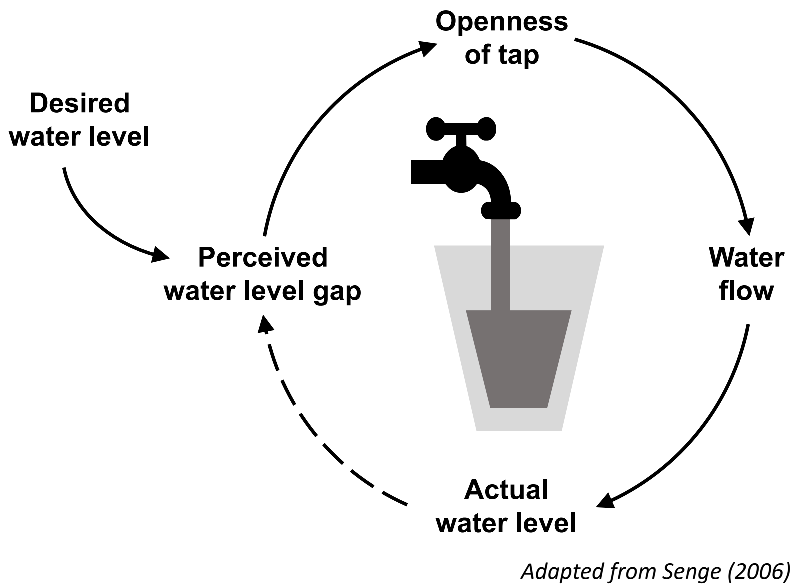


Figure 34: Example of a 'goal/gap' structure in a system map – filling a glass of water

How influence operates differently upstream and downstream of a change in flow

When a diagram is made up partly of variables and arrows of influence, as well as a visual bathtub analogy (stock and flows - as this report has), then the flows in or out of a stock themselves often form pathways of influence within feedback loops. When this occurs, the influence can be either same or opposite, depending on which way along the flow the influence is travelling.

When a flow forms part of a feedback loop and the influence is travelling with the flow (i.e. downstream), then that is a same influence. That is, if the flow were to increase (or decrease), then the stock to which it is flowing would also increase (or decrease), all other things being equal.

When a flow forms part of a feedback loop, outflows (drains) will always represent opposite relationships, while inflows (taps) will always represent same relationships. That is, an increase in an outflow reduces a stock, while an increase in an inflow increases a stock, all other things being equal.

The flow structure and the variable/arrow influence structure are compared in Figure 35.

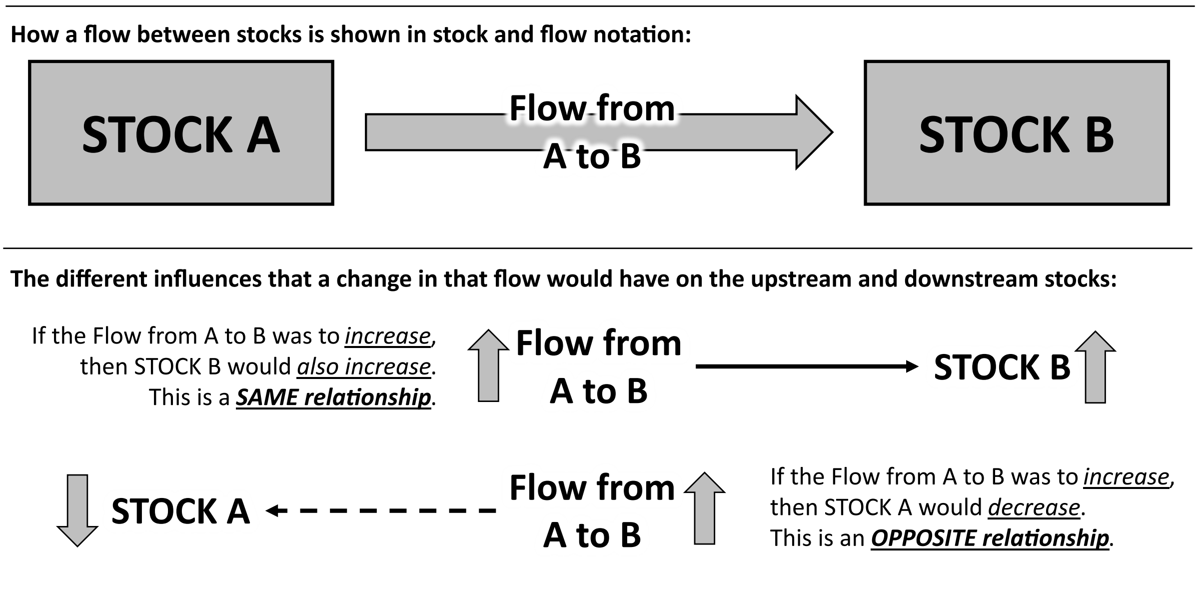


Figure 35: How influence operates differently upstream and downstream of a change in flow

Appendix 2. Infrastructure (wind & rain events) detailed causal diagram description

This overview distils the detailed causal diagram for increased intensity of wind and rain events on infrastructure, developed from the workshop discussions hosted in Wellington on 20th May 2025. The diagram provides a more nuanced and detailed representation than the overview presented in the main body of this report. The focus remains on how different factors interact, amplify, or balance each other over time, creating reinforcing and balancing feedback loops that affect infrastructure, communities, and the environment. It aims to clarify the relationships and feedback mechanisms shaping infrastructure resilience and cascading risks.

The feedback loops in the causal diagram are tabulated at the end of this description and are referred to throughout.

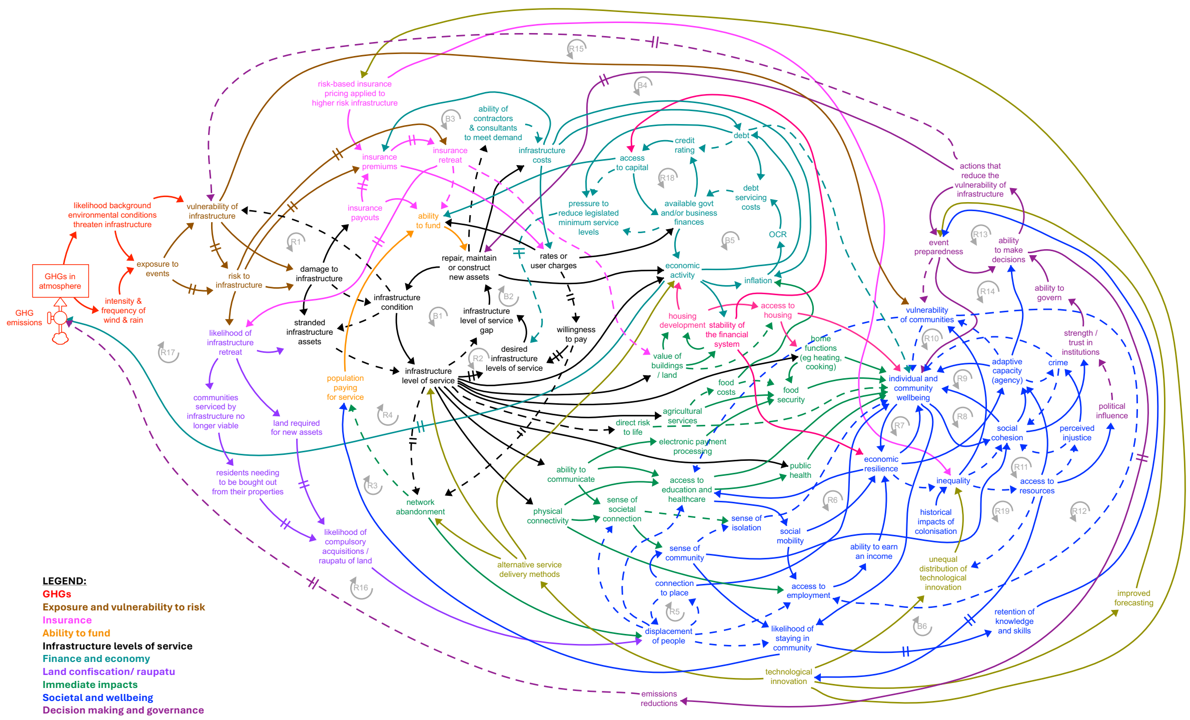


Figure 36: Infrastructure detailed causal diagram

Climate change and environmental pressures

On the environmental side of the diagram, the accumulation of GHGs *in the atmosphere* is represented as a stock, with *emissions* flowing into this stock. The level of this stock (amount of *GHGs in the atmosphere*) drives the *intensity and frequency of wind & rain events*, as well as *background environmental conditions* such as rising water tables and higher baseline winds.

As these pressures grow, they increase both *exposure to events* and *vulnerability of infrastructure*, raising the overall *risk*. Higher *risk* leads to greater *damage* during events, reducing *infrastructure condition* and, consequently, *levels of service*. Reduced *condition* also increases the *vulnerability of the infrastructure* (R1), exposing it to further *damage*.

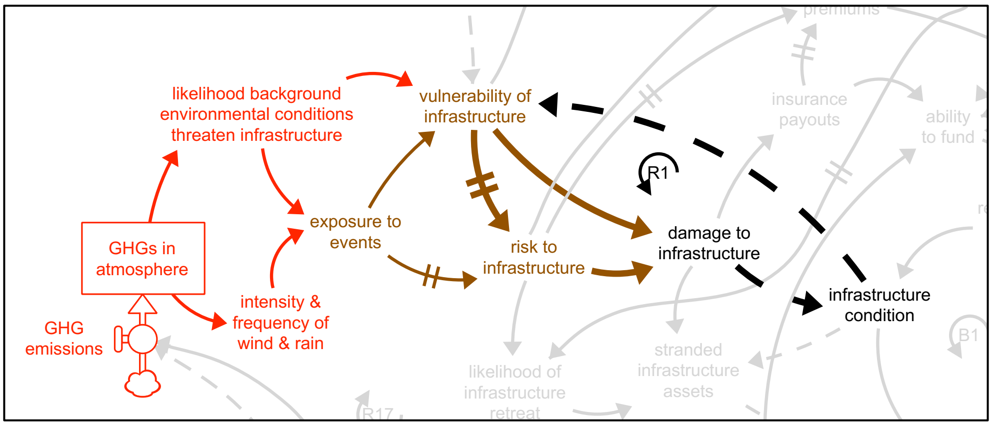


Figure 37: Climate change and risk to infrastructure

Infrastructure condition and levels of service

At the core of the diagram is the relationship between *infrastructure condition* and *levels of service*. When infrastructure is in good *condition*, *levels of service* are at a high level.

Higher *levels of service* reduce the *gap* between what is provided and what is desired - in other words, expectations are met. A smaller *service gap* means less *repair and maintenance* is required, as the infrastructure is operating as intended. This is the central balancing loop (B1) around infrastructure performance: *condition* supports *service delivery*, thereby reducing the *gap* and lowering the need for further *repairs, maintenance of new assets*.

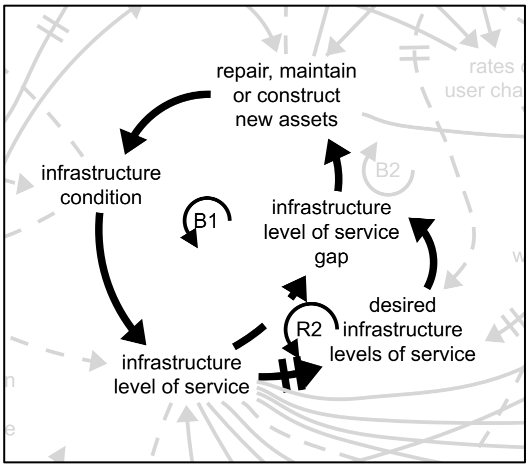


Figure 38: Infrastructure condition and levels of service

Alongside this is a reinforcing loop (R2) that adjusts *desired infrastructure service levels* over time. Sustained high service levels raise expectations, encouraging demands for even better infrastructure. Conversely, prolonged low service levels can erode expectations and encourage communities to accept lower service levels over time. These dynamics highlight how community expectations both inform and respond to infrastructure performance.

Insurance, funding, and infrastructure retreat

Risk and *damage to infrastructure* also affect economic factors such as *insurance payouts* and *premiums*. Increased *damage* leads to higher *insurance payouts*, raising *premiums* and sometimes causing *insurance retreat* - where insurers withdraw coverage from high-risk areas. *Insurance retreat* reduces *funding availability* for *infrastructure repairs and maintenance*.

Insurance retreat can lead to *infrastructure retreat*, where services in certain areas are reduced or eliminated. This may require *land acquisition for relocating infrastructure* or result in *stranded assets*. Both outcomes reduce *service levels* and community viability (by reducing the *likelihood of people staying in a community*).

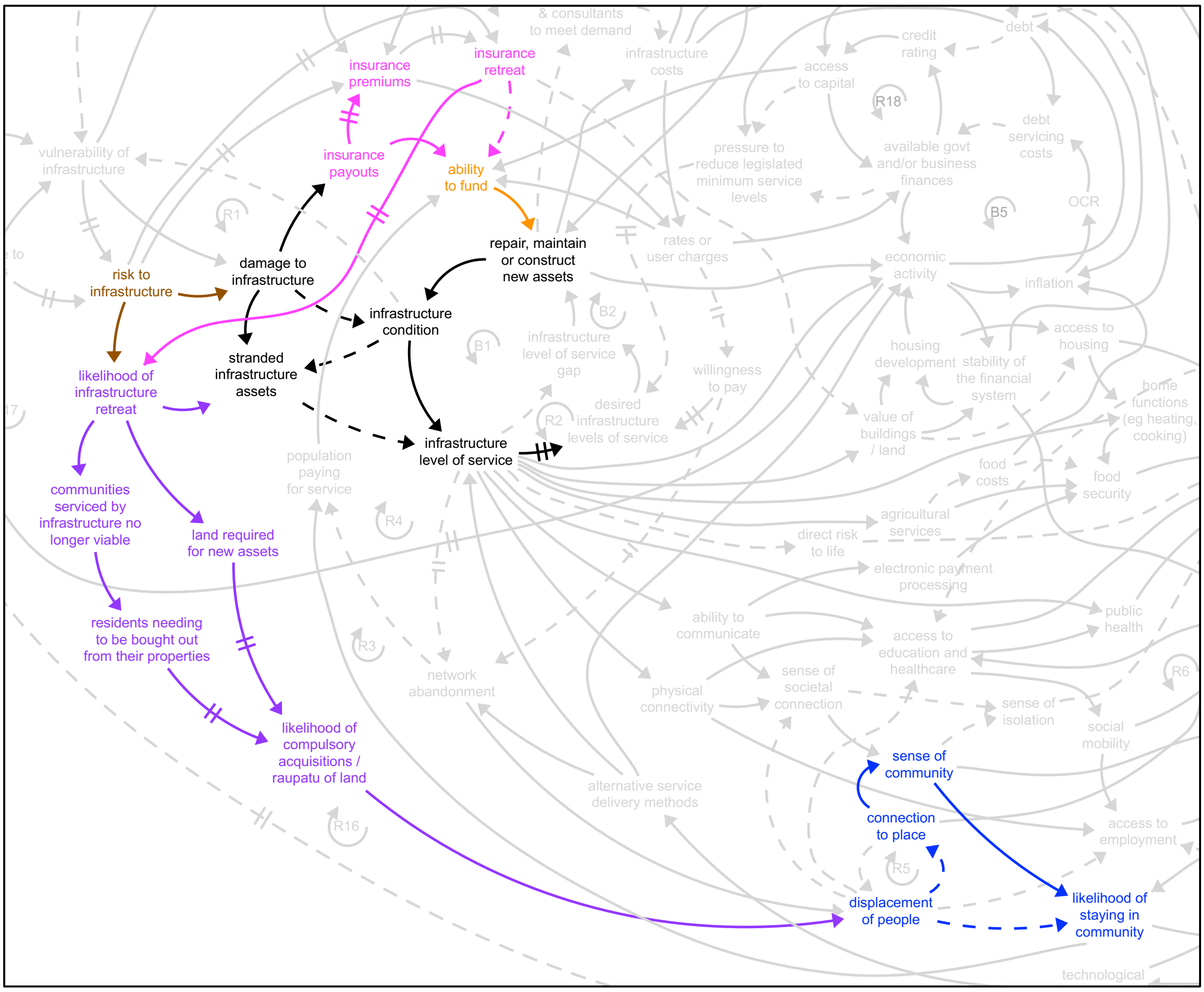


Figure 39: Insurance, funding and infrastructure retreat

Construction costs and willingness to pay

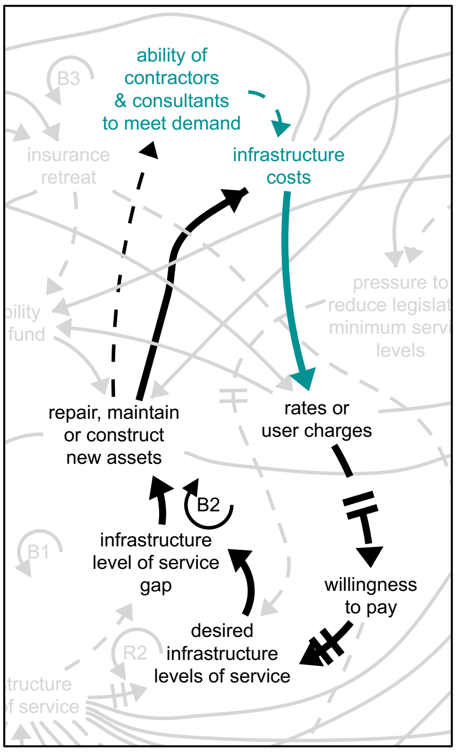


Figure 40: Construction costs and willingness to pay

Repairing and rebuilding infrastructure incurs significant *infrastructure costs*. As these rise, they translate into higher *rates and user charges*, which can reduce *willingness to pay*, subsequently lowering *desired service levels*. This dynamic can contribute to *a* reduction in *desired levels of service* through peoples' *willingness to pay* (B2), where users abandon infrastructure networks due to inadequate service or high costs, further reducing *funding* and *repair/maintenance* capacity.

Periods of concentrated *repair and construction*, such as after a disaster, also place pressure on *contractors, consultants, and builders*. Limited capacity within these skilled cohorts can drive costs even higher, further straining the funding system.

Construction costs and insurance retreat

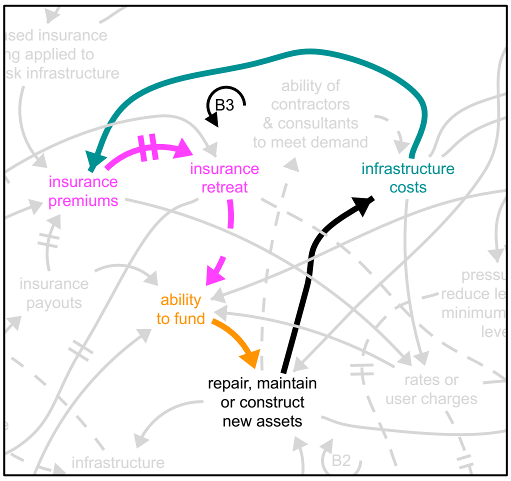


Figure 41: Construction costs and infrastructure retreat

Repairing and rebuilding infrastructure, and the *infrastructure costs* associated with it, also lead to higher *insurance premiums*, which may lead to *insurance retreat* in the longer term. This may reduce the *ability to fund* infrastructure repairs/rebuilds in the future, thereby creating the balancing dynamic (B3) shown in the diagram below.

Community abandonment and network abandonment

Reduced infrastructure service levels can lead to both community abandonment and network abandonment.

Community abandonment can result from disrupted *physical and communications connectivity*, impacting the *sense of community* and reducing the *likelihood that people stay in a community*. As people physically move away, the number of people paying for a service reduces, along with the ability to fund repairs/maintenance. This can spiral (reinforcing loop R3), resulting in further service reductions and more people leaving a community.

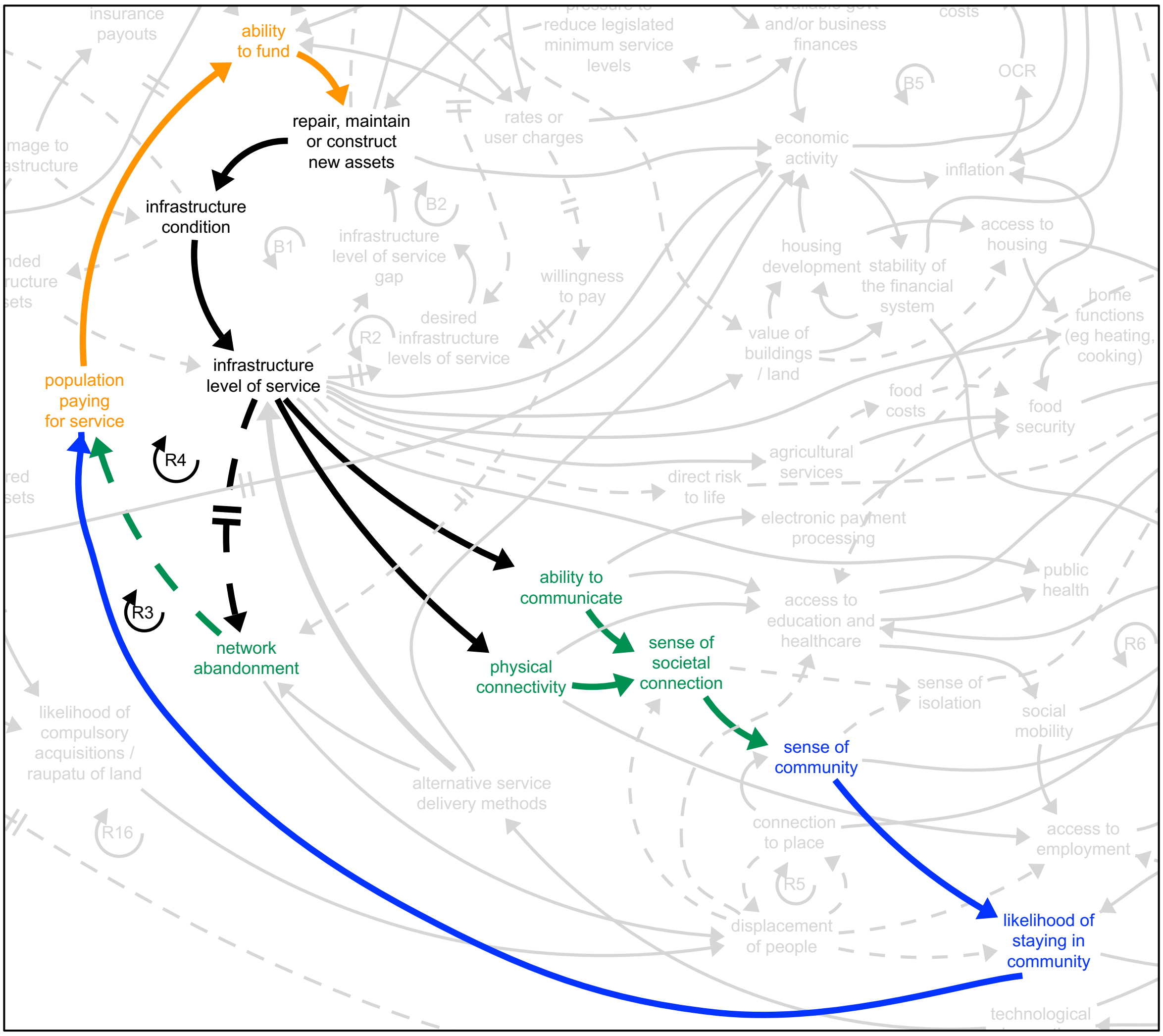


Figure 42: Community and network abandonment

A similar dynamic exists with *network abandonment*. This is when people abandon an infrastructure network (e.g. the electricity grid) because they can attain similar services elsewhere or via a different means. *Technological advances* can play a role here. They may remain physically as part of a community but not connected to networks of infrastructure. This results in a similar decline in the *population paying for a service* and the *ability to fund* infrastructure *repairs/maintenance*, resulting in continued decline in *services* (reinforcing loop R4).

Social and community impacts

Infrastructure service levels impact a wide range of community outcomes, including access to *food*, *healthcare*, *housing quality*, and *connectivity*—both physical and virtual. Declines in *Infrastructure levels of service* affect all of these areas, which cascade through to reduce *individual and community wellbeing* and *social cohesion*.

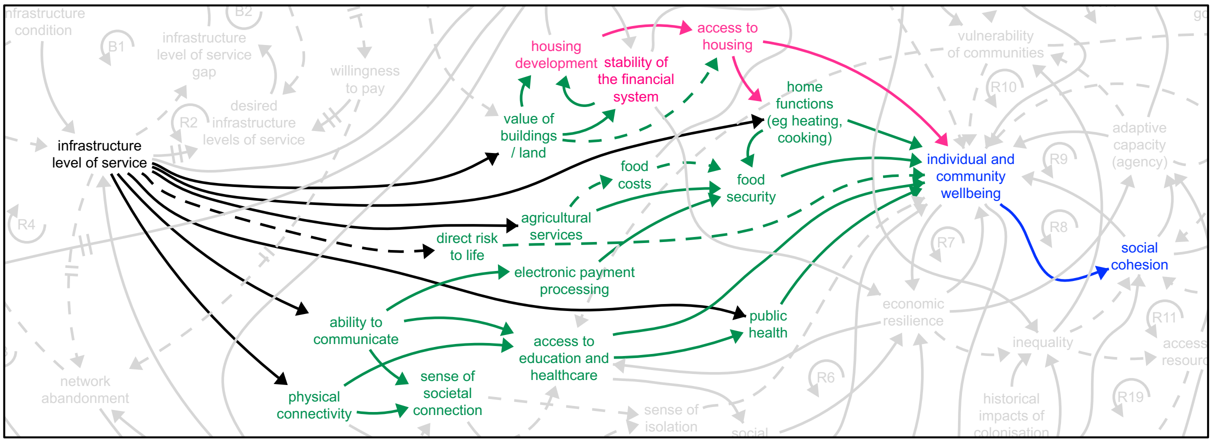


Figure 43: The impacts of reduced levels of service

They also feed into broader issues of *inequality*, as disparities in service provision and resilience widen gaps between groups. Greater *inequality* further reduces *social cohesion*, limits *access to resources*, and undermines *adaptive capacity*—the ability of communities to respond to challenges.

Conversely, strong social cohesion and adaptive capacity reinforce each other. Communities that retain knowledge, skills, and population are better able to make decisions, prepare for events, and recover. Infrastructure retreat or displacement, however, can disrupt these social foundations, eroding local identity and knowledge.

Historical *inequities*, including legacy impacts associated with *colonisation*, continue to influence these dynamics, creating lagging distributional effects that deepen *inequality* and *vulnerability*.

One key characteristic of these social factors worth noting is that they all tend to spiral or reinforce each other. Regardless of the level of detail, this is a key insight for policy-makers and decision-makers to be aware of. See reinforcing loops R5–R12.

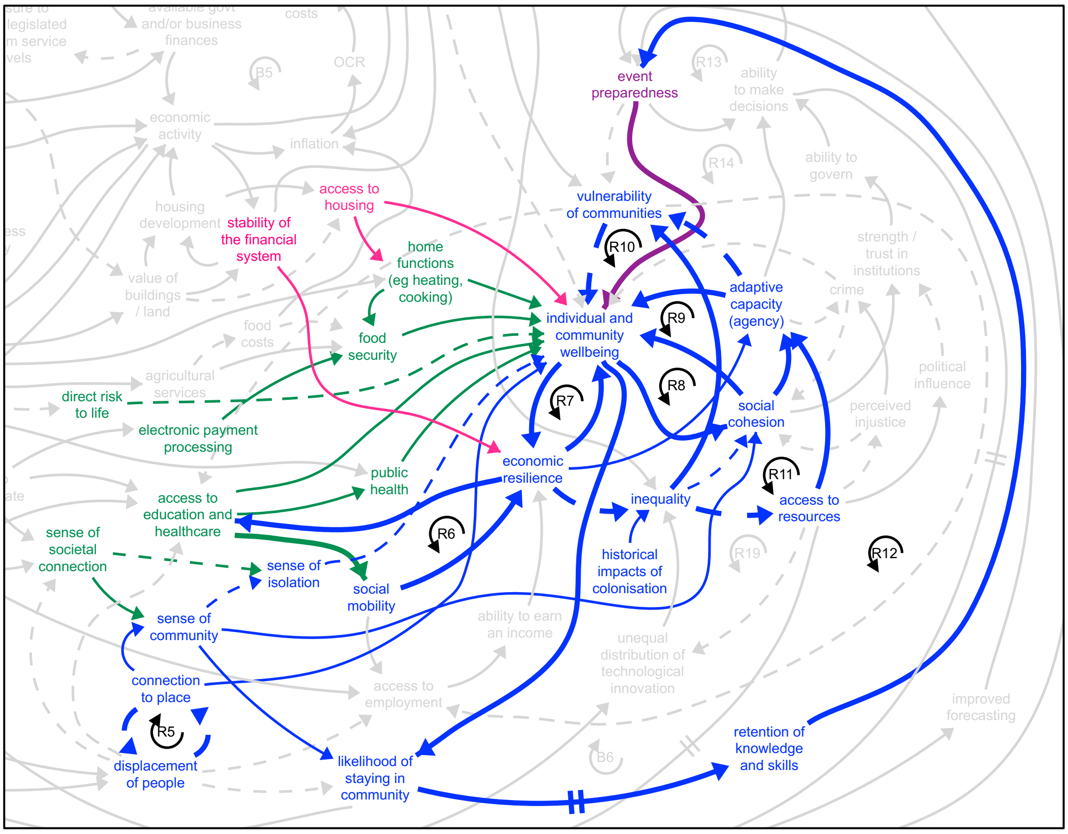


Figure 44: Social and community impacts

Governance and decision-making

Declines in *infrastructure condition* and widening *inequality* have political implications. *Perceptions of injustice*, weakened *trust in institutions*, and limited *access to resources* reduce confidence in governance and undermine the ability to make decisions.

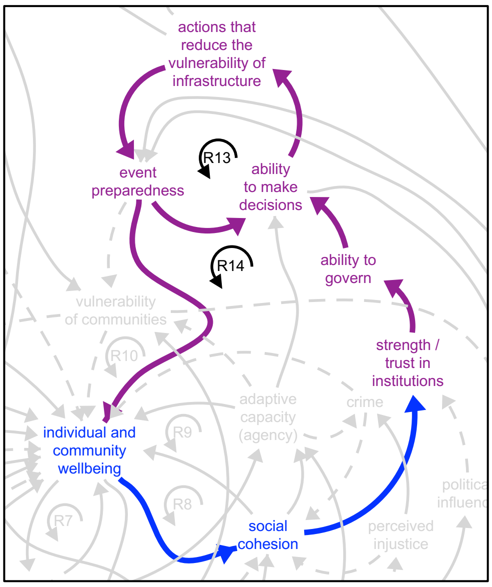


Figure 45: Wellbeing, social cohesion and ability to make decisions

Having strong decision-making capacity is central to resilience. When communities are able to plan and prepare effectively, they can reduce *vulnerability*, lower *risk*, and strengthen their long-term resilience. This forms several reinforcing loops. Better *ability to make decisions* reduces *vulnerability* and improves *preparedness* which in turn improves the *ability to make decisions* (R13). This also reinforces wellbeing and social cohesion (R14). Additionally, better *preparedness* reduces impacts (via *connectivity*, access to *food* and *health services,* etc.) when they actually occur, which in turn sustains the *ability to make decisions* (R15).

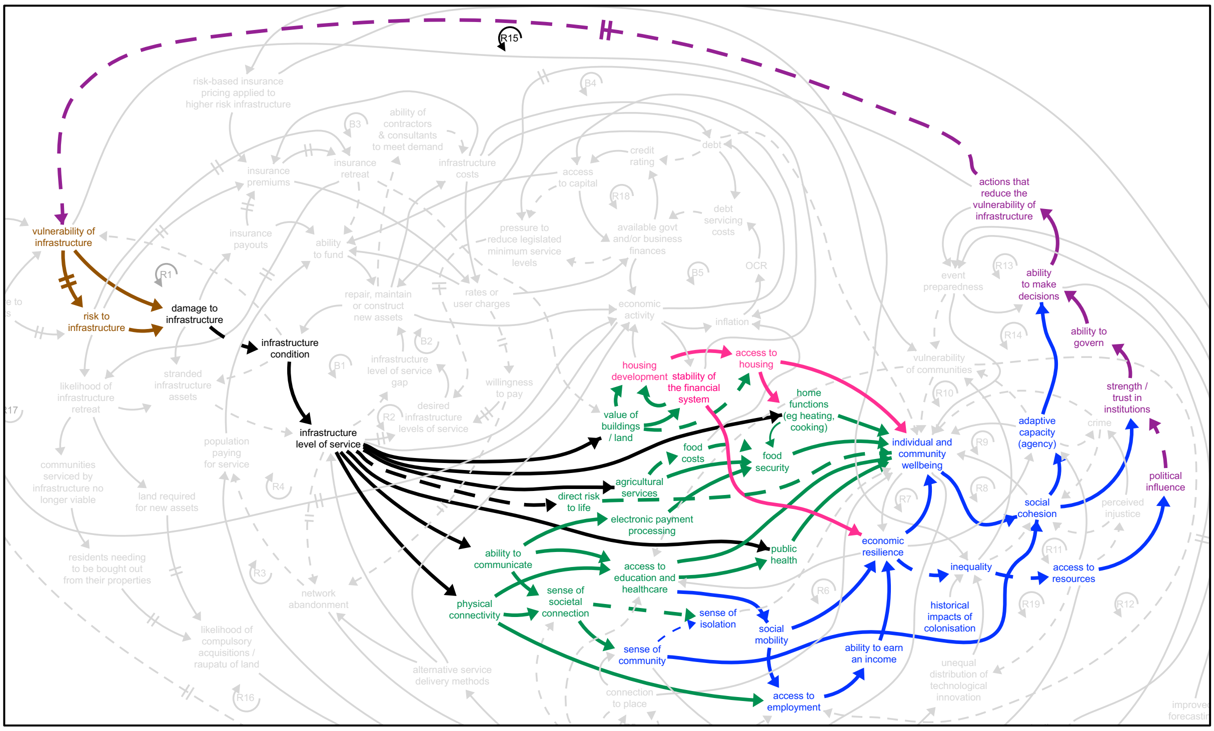


Figure 46: Ability to make decisions and vulnerability

A key insight here is that these may begin to spiral in an undesirable direction as a result of impacts from physical risks. Yet the ability to make robust decisions and be resilient to these risks may help reduce this exposure to begin with. This has implications for how to support decision-making as a pre-emptive response to risk impact.

A similar reinforcing loop to R15 is R16. Here, increased *risk* and *damage* to infrastructure reduces the *levels of service* provided by it, reducing *social wellbeing*, *cohesion* and the collective *ability to make decisions*. This further reduces the ability to proactively *reduce emissions*, which reinforces *GHG emissions*, the accumulation of *GHGs in the atmosphere*, the *risk to infrastructure* and, eventually, further reduces the *ability to make decisions*.

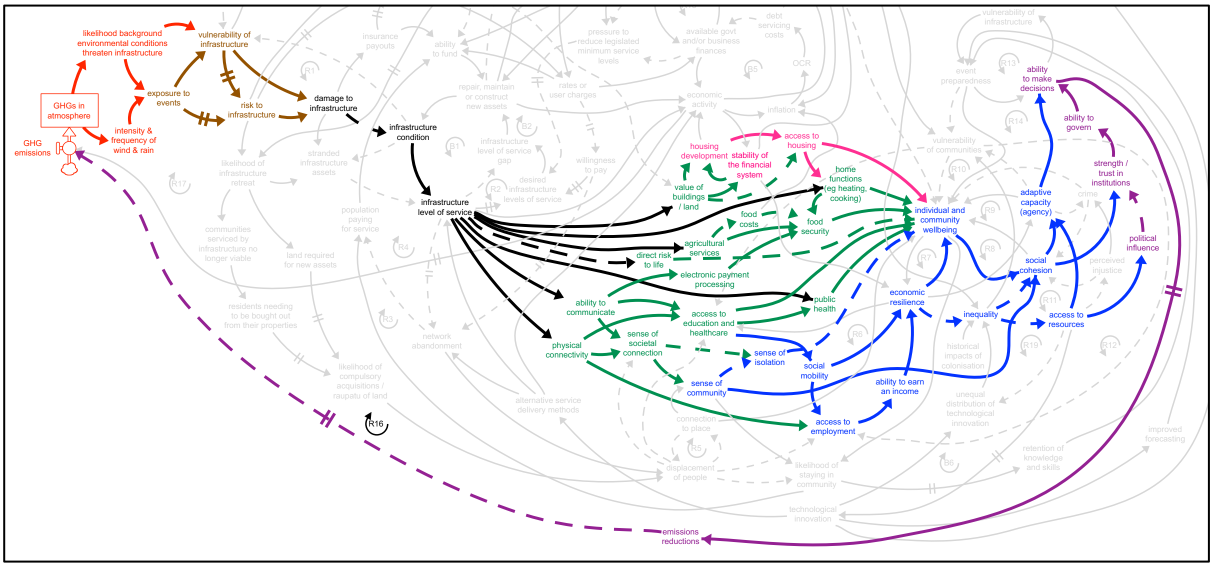


Figure 47: Ability to make decisions and emissions

Economic activity, emissions, and unintended consequences

Economic activity associated with *repairs and construction* is typically emissions-intensive, feeding back into the accumulation of *GHGs in the atmosphere* and worsening environmental pressures. This forms the reinforcing loop R17.

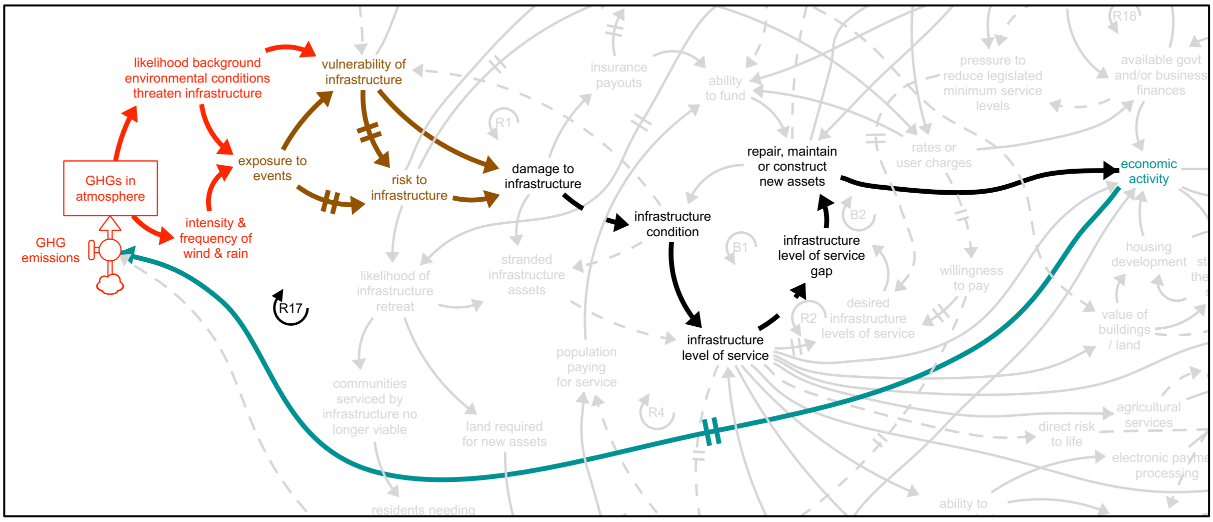


Figure 48: Economic activity and GHG emissions

Counterintuitively, when *wellbeing* and *adaptive capacity* erode, *economic activity* may decline, which reduces *GHG emissions*. This forms a balancing loop (B4) where emissions are reduced, but in a way that undermines resilience and prosperity.

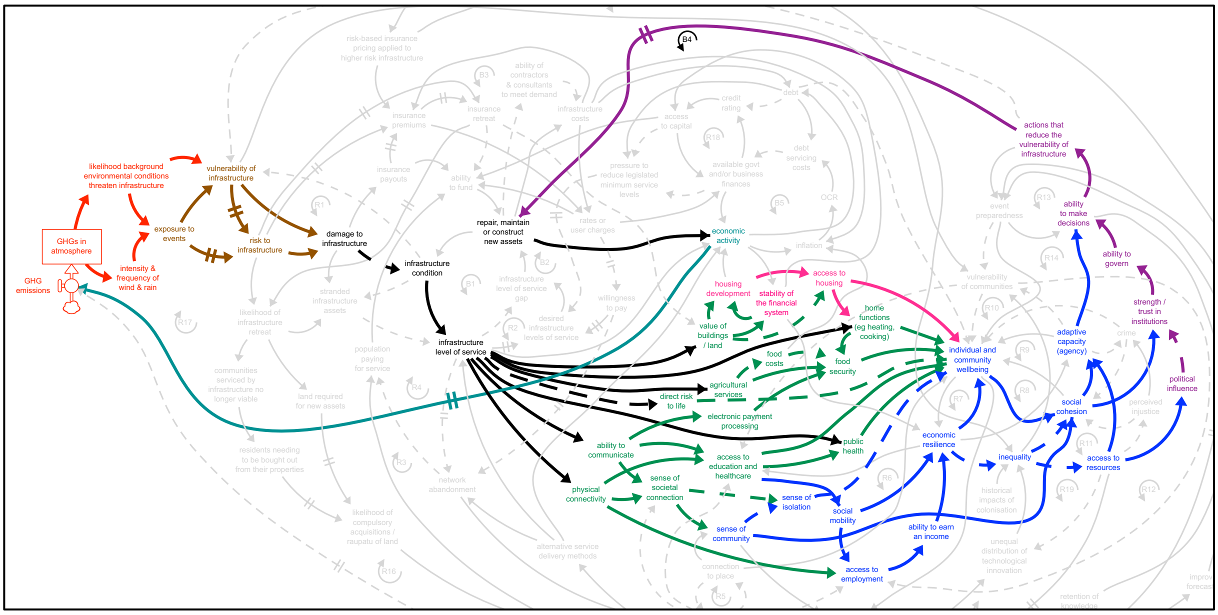


Figure 49: Ability to make decisions, economic activity and GHG emissions

Finance and debt dynamics

Financial factors, including *debt servicing* and *access to capital*, influence the *ability to fund* infrastructure to meet *desired levels of service*. *Credit ratings* and *access to capital* exist in a reinforcing loop (R18). Lower *debt* improves *credit ratings* and *access to capital*, enabling more *repairs and construction. However, increased spending can raise inflation, and in response, interest rates may rise*, increasing *debt servicing costs* in a balancing feedback cycle (B5).

If *access to capital* is reduced or constrained, and therefore *funding* to achieve the *desired levels of service* is not available, there may be increased *pressure to reduce legislated minimum service levels*. This would reduce the *desired levels of service* and is another way that expectations and reality may need to be adjusted to come closer into line.

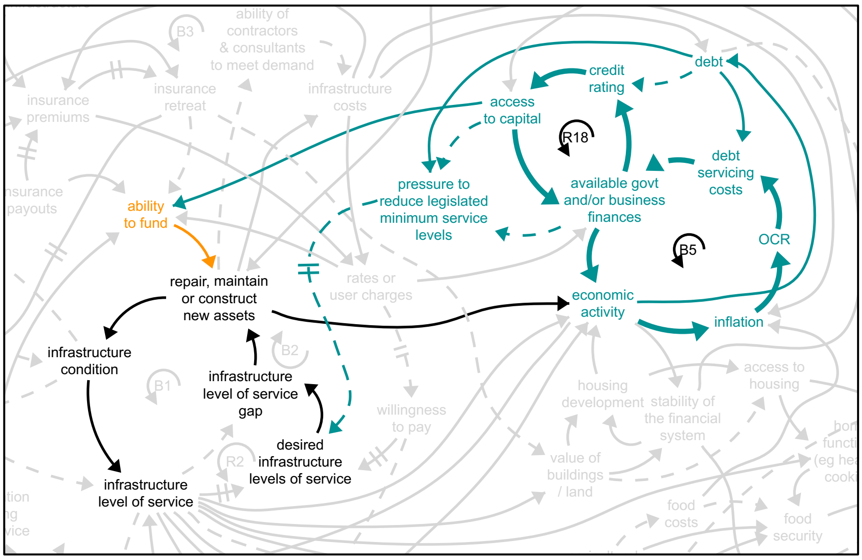


Figure 50: Finance and debt

Technical innovation

Technological innovation plays a dual role. Advances in *forecasting* and *event preparedness* can improve resilience. Additionally, new technologies may offer alternative service delivery methods, thereby reducing reliance on traditional networks. This can influence *network abandonment* and the associated *service levels* of the original infrastructure networks.

Technological innovation is involved in two important feedback loops. Firstly, *technological innovation* is unlikely to be equally distributed, which can increase inequality, thereby reducing access to resources and further reinforcing the unequal distribution of technology (R19). In addition, such *unequal distribution* and *inequalities* in the uptake of technology can limit some people's access to resources, which are what enable technological innovation in the first place (B6). Counter-intuitively, technology can result in inequalities, which can constrain its continued development in the longer term.

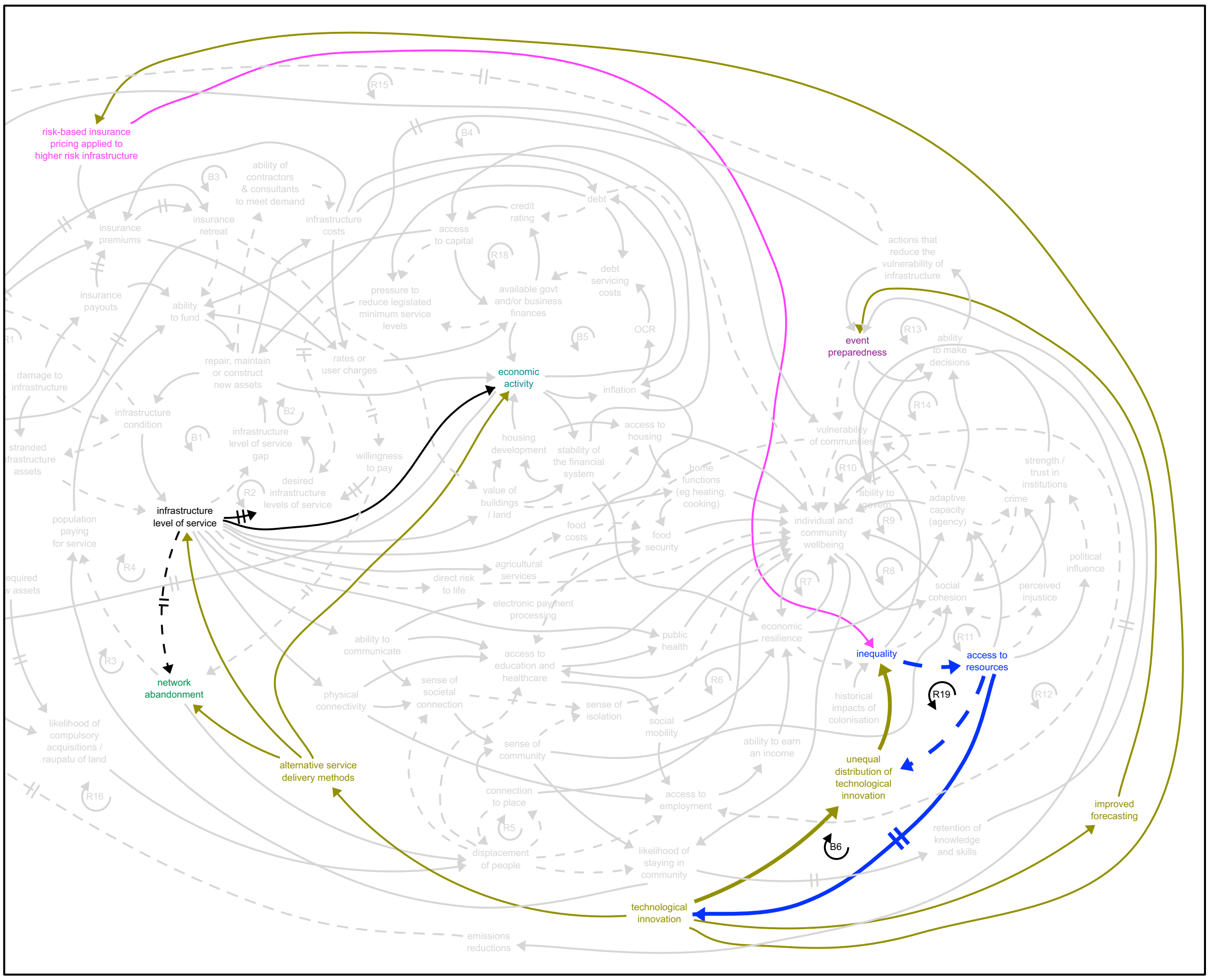


Figure 51: Technical innovation

Conclusion

In summary, the diagram captures the complex interplay of environmental, social, economic, and technical factors that drive infrastructure risks and community impacts. In particular:

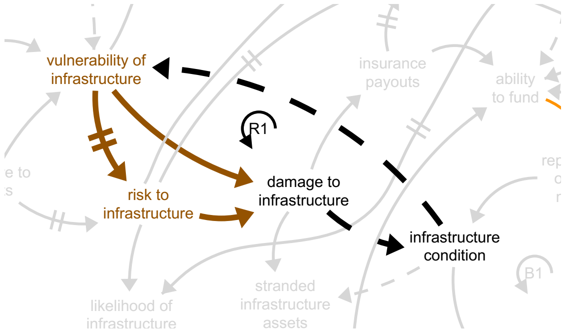
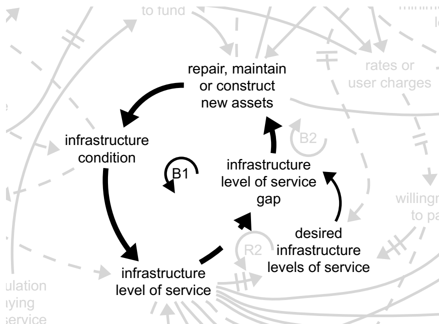
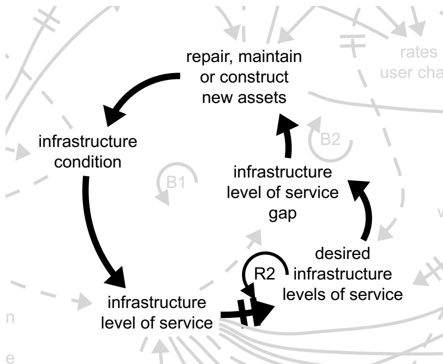
- Balancing loops act as forces of stability or resistance, aligning service provision with condition, funding, and willingness to pay.
- Reinforcing loops tend to amplify trajectories, whether toward resilience—through strong social cohesion and decision-making—or toward vulnerability, through inequality, retreat, and abandonment.
- External pressures can provide the exogenous influence that precipitates a series of cascading risks and feedbacks.

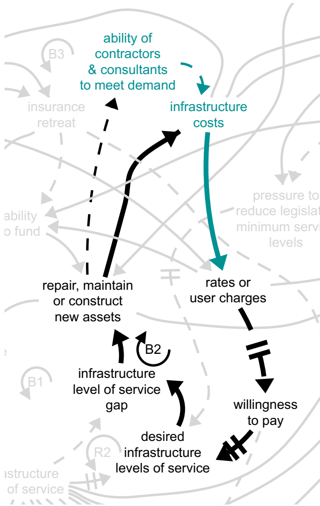
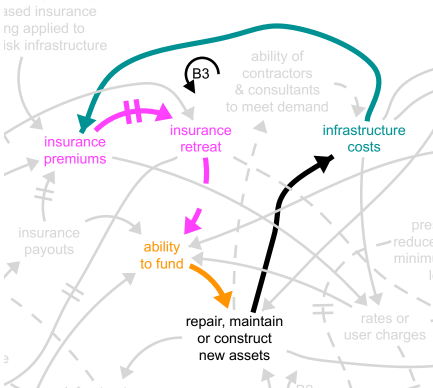
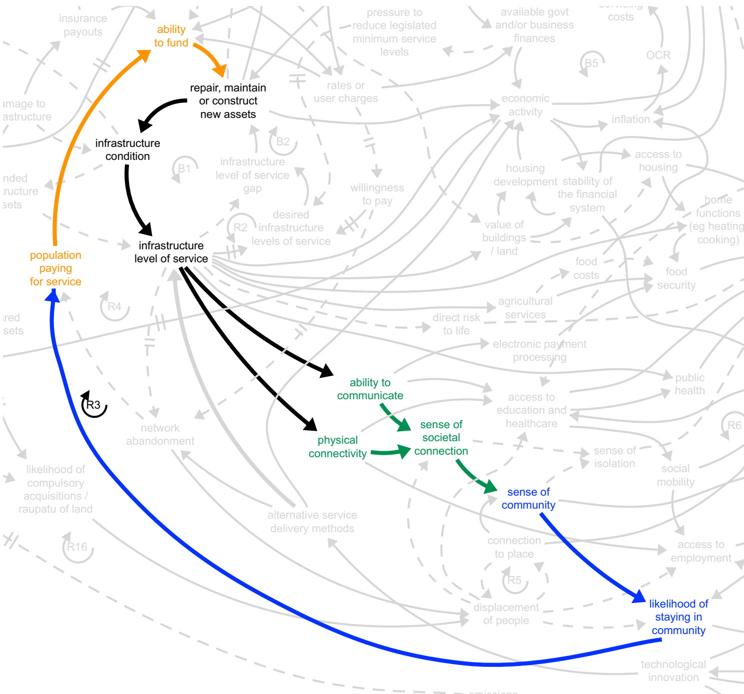
The diagram reveals that infrastructure resilience depends as much on social and financial systems as it does on physical assets. Addressing cascading risks requires integrated strategies that recognise these interdependencies and seek to strengthen both infrastructure and the communities it supports.

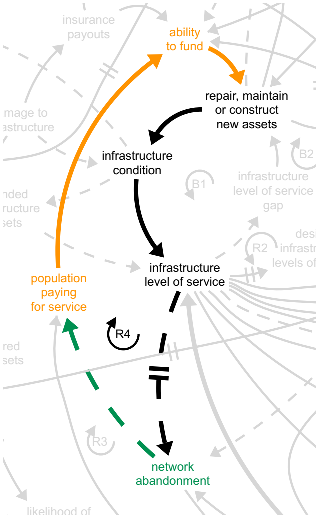
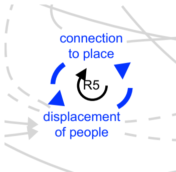
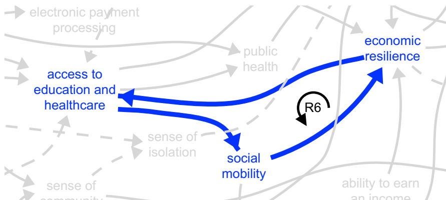
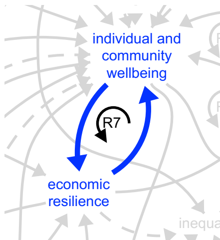
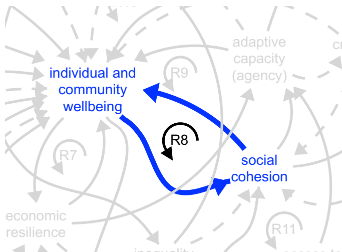
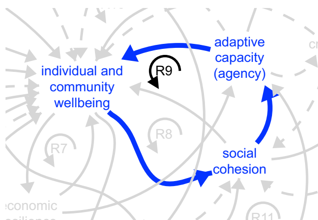
List of feedback loops in the detailed infrastructure diagram

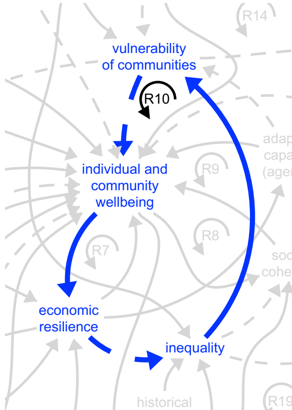
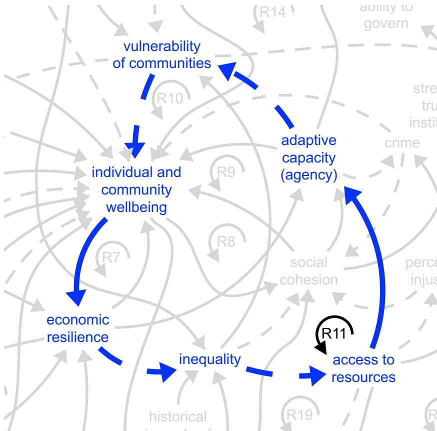
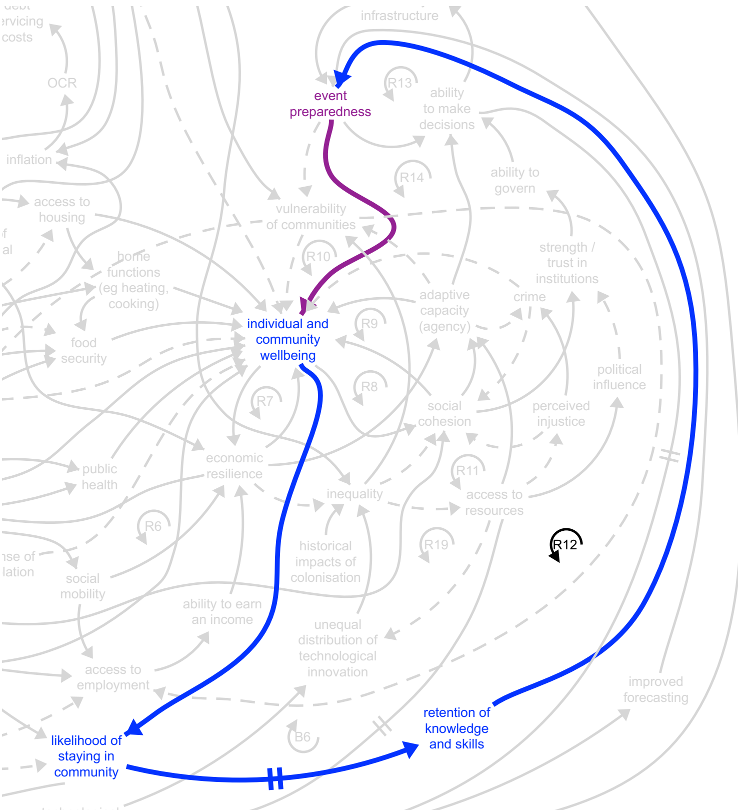
The table below lists images of all the feedback loops labelled in the detailed causal diagram for agriculture.

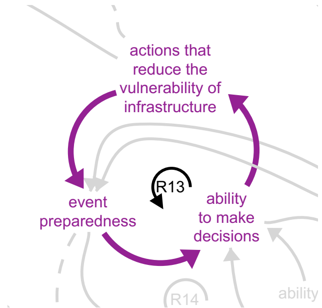
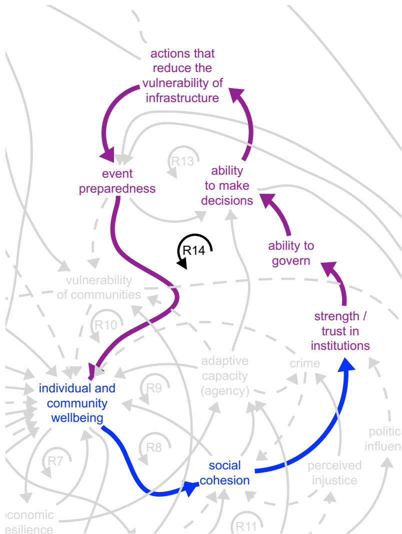
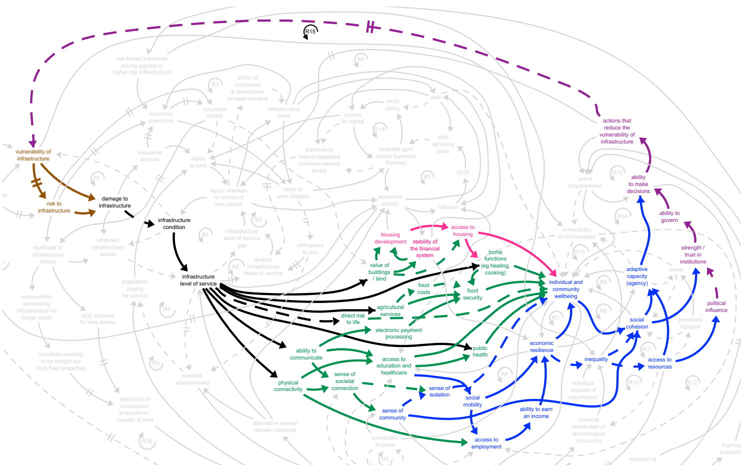
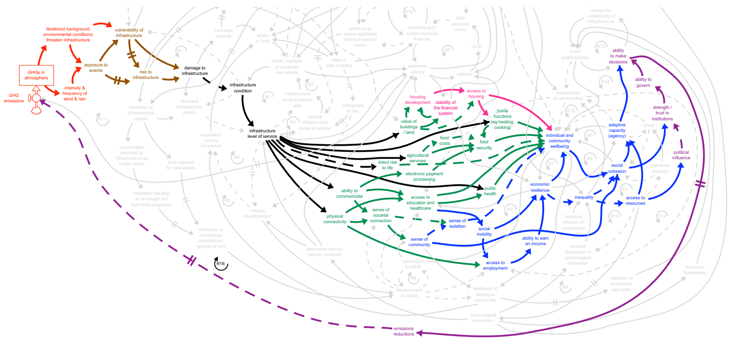
Table 1: List of feedback loops in the details infrastructure diagram

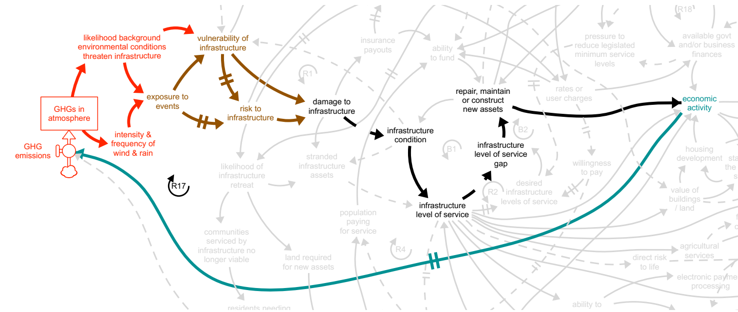
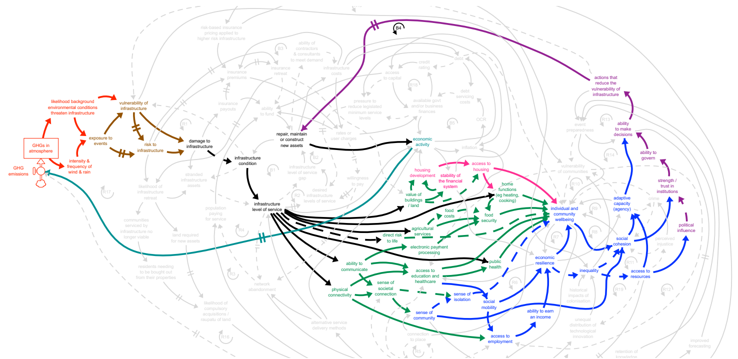
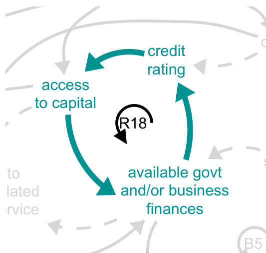
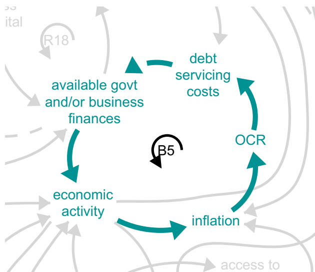
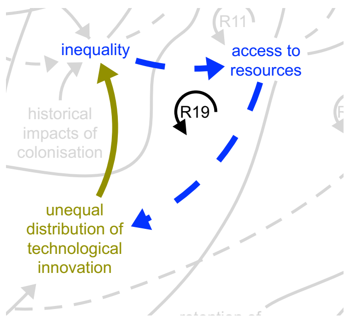
Label	Name	Feedback loop
R1	Infrastructure vulnerability and condition	
B1	Providing levels of service	
R2	Desired levels of service	

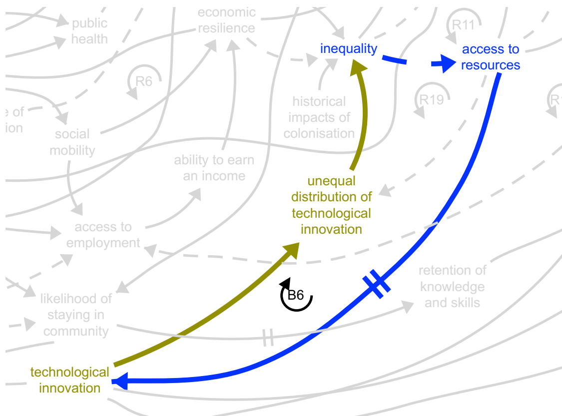
Label	Name	Feedback loop
B2	Willingness to pay for levels of service	
B3	Insurance retreat	
R3	Community abandonment	

Label	Name	Feedback loop
R4	Network abandonment	
R5	Displacement of people	
R6	Social mobility	
R7	Personal and economic wellbeing	
R8	Social cohesion	
R9	Social cohesion and adaptive capacity	

Label	Name	Feedback loop
R10	Inequality and vulnerability	
R11	Inequality and adaptive capacity	
R12	Skill retention and community preparedness	

<table>
<tr><th>Label</th><th>Name</th><th>Feedback loop</th></tr>
<tr><td>R13</td><td>Ability to make decisions</td><td>
</td></tr>
<tr><td>R14</td><td>Social cohesion and ability to make decisions</td><td>
</td></tr>
<tr><td>R15</td><td>Vulnerability and ability to make decisions</td><td></td></tr>
<tr><td>R16</td><td>Emissions, vulnerability and ability to make decisions</td><td></td></tr>
</table>

Label	Name	Feedback loop
R17	Emissions from infrastructure repairs and construction	
B4	Inability to make decisions and low emissions	
R18	Credit ratings	
B5	Spending, inflation and finance	
R19	Technological inequalities	

Label	Name	Feedback loop
B6	Technological innovation	

Infrastructure detailed causal diagram

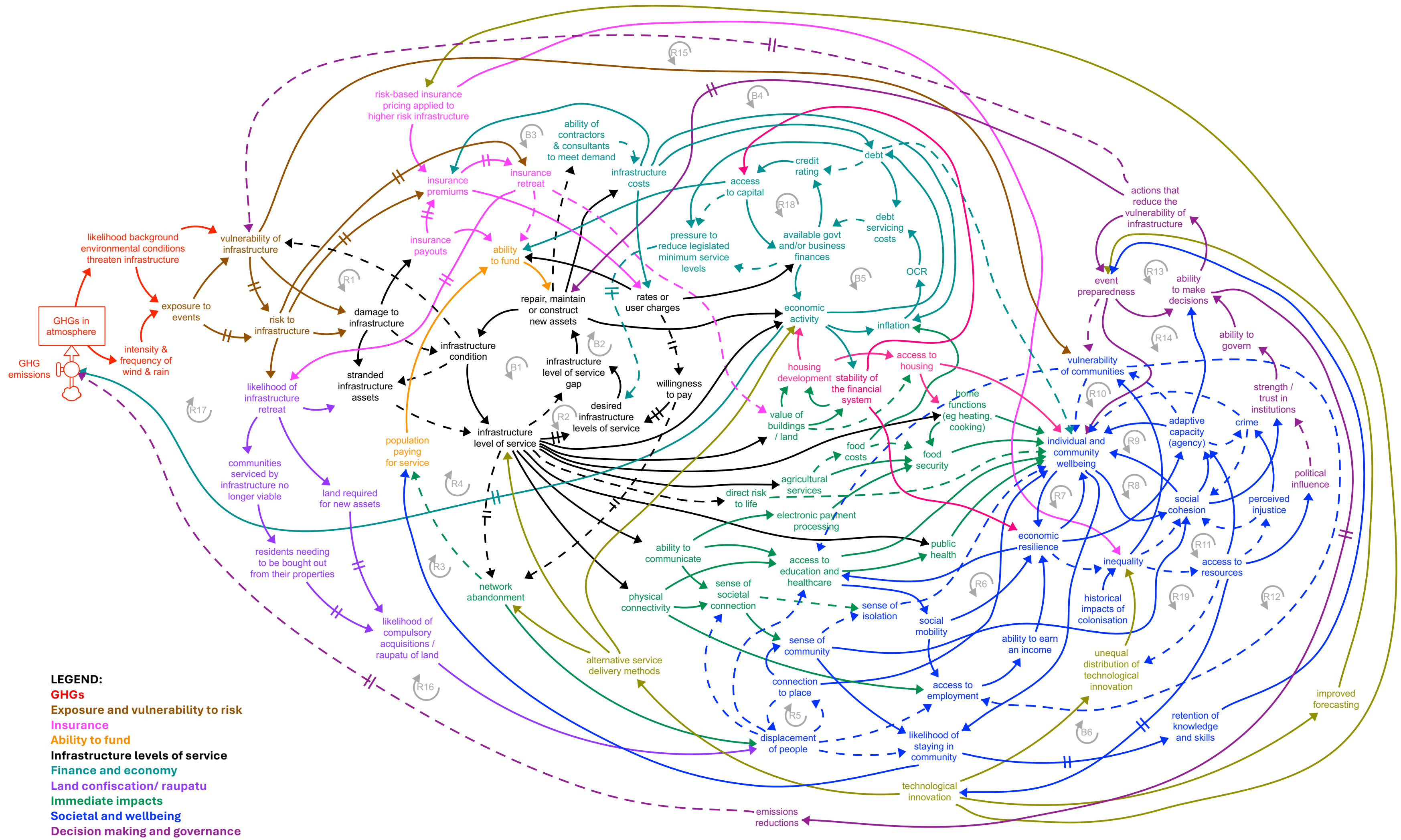


Figure 52: Infrastructure detailed causal diagram (large)

Appendix 3. Agriculture (drought) detailed causal diagram description

This overview distils the detailed causal diagram for drought impacts on agriculture, developed from the workshop discussions hosted in Wellington on 21st May 2025. Agriculture in New Zealand is deeply exposed to climate risks, particularly drought. The diagram provides a more nuanced and detailed representation than the overview presented in the main body of this report. However, the focus remains on interconnections between environmental processes, economic dynamics, social outcomes, and governance decisions. By examining these feedback mechanisms, the diagram helps identify both reinforcing spirals and balancing mechanisms that can stabilise the system.

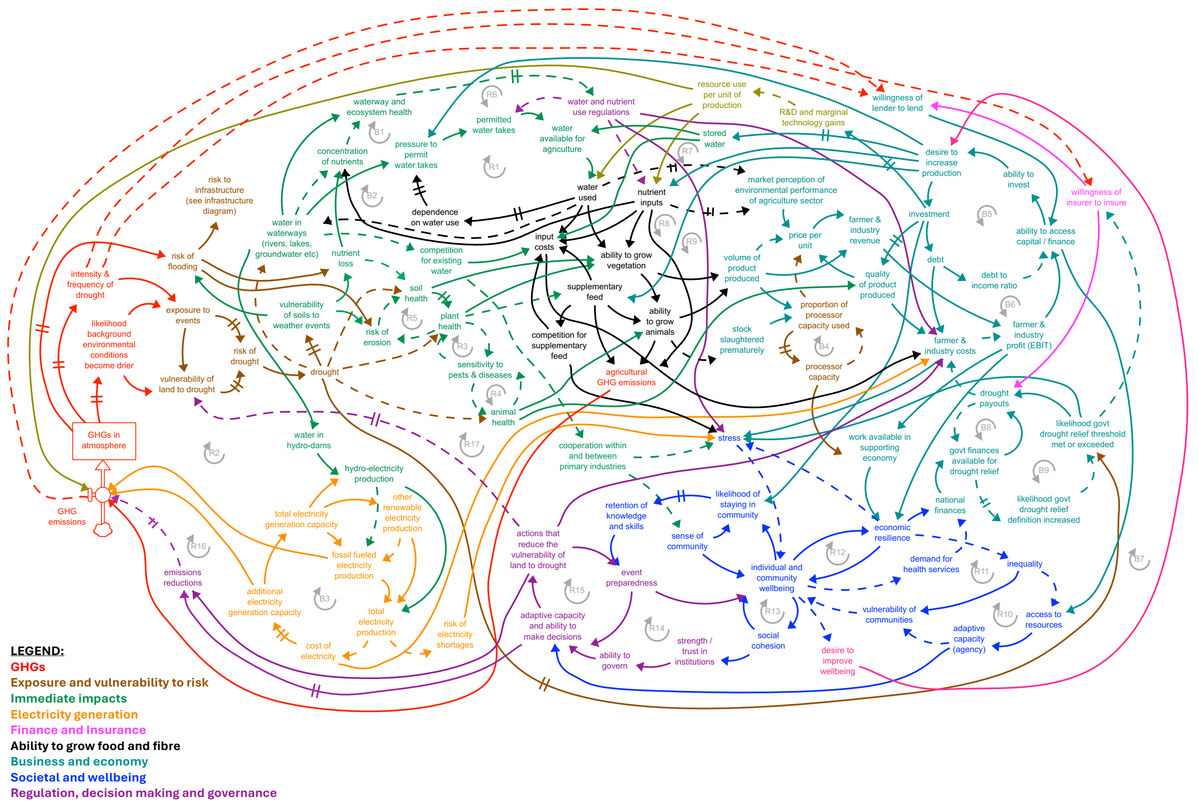


Figure 53: Agriculture detailed causal diagram

Climate drivers of drought

The accumulation of *GHGs in the atmosphere* is represented as a stock (bathtub), into which GHG *emissions* accumulate. Rising concentrations of GHGs intensify the *frequency and intensity of drought*, as well as the *likelihood that background environmental conditions will become drier*. These factors increase the *exposure* and *vulnerability* to the *risk* of *drought*.

GHGs in the atmosphere also increase the *risk of flooding*, which is a way that this causal diagram can link with the infrastructure causal diagram (as *flooding* is a *risk to infrastructure*).

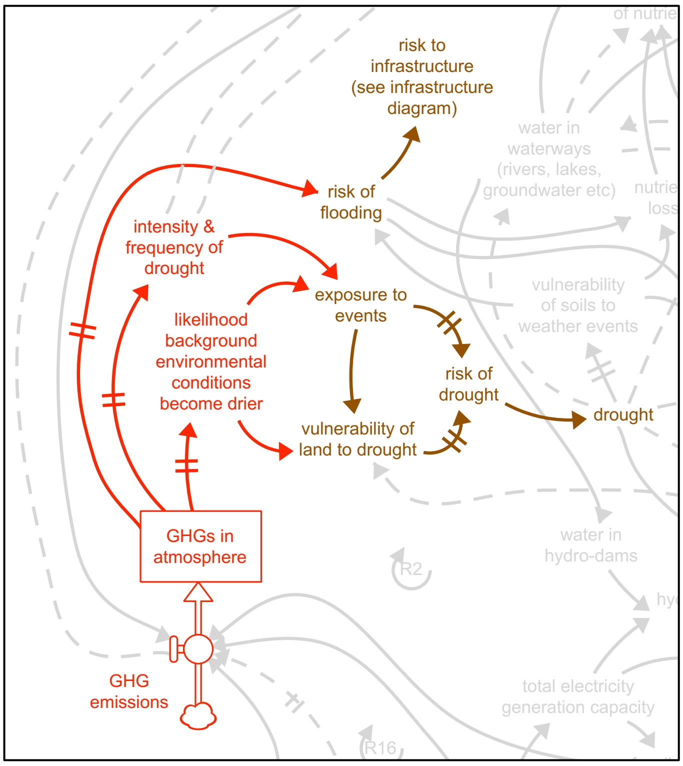


Figure 54: Climate drivers of drought

Agriculture, waterways, and irrigation

Drought reduces the amount of water in waterways (rivers, lakes, groundwater, etc), with several flow-on effects. Reduced water in waterways has a direct effect on waterway and ecosystem health, as well as increasing the concentration of nutrients in waterways.

Two balancing loops constrain how much water is extracted from waterways for human use. B1 constrains water use and is driven by *waterway and ecosystem health*. Here, if *waterways* are low and *ecosystem health* is low, this can (over time) increase *regulations* that reduce *permitted takes* and *water used*. The other is B2, which is driven by the perception that when there is *water in waterways,* it is perceived that there is more available for agricultural use. So, in times of plenty, this increases *pressure to permit water takes*, thereby increasing the amount of *water used* for agriculture. However, in times of drought when *water in waterways* is reduced, this reduces the *pressure to permit water takes*[4], thereby reducing the *water available for agriculture*.

At the same time, the reinforcing loop R1 means that *water use* encourages *dependence on water* for agricultural activities. This will lead to tension between these loops over time. *Stored*

[4] This same relationship holds that when there is plenty of water, there is pressure to extract because it may be seen to be 'surplus' and therefore available for human use. Conversely, when there is little water, it is understood that water needs to be retained for the water and there is less 'surplus' water available for extraction. This relationship is independent of the relationship between the likely need for water by farming activity during a drought.

water can alleviate some of this scarcity and tension in the short term, but it is likely to encourage further *water dependence* in the longer term.

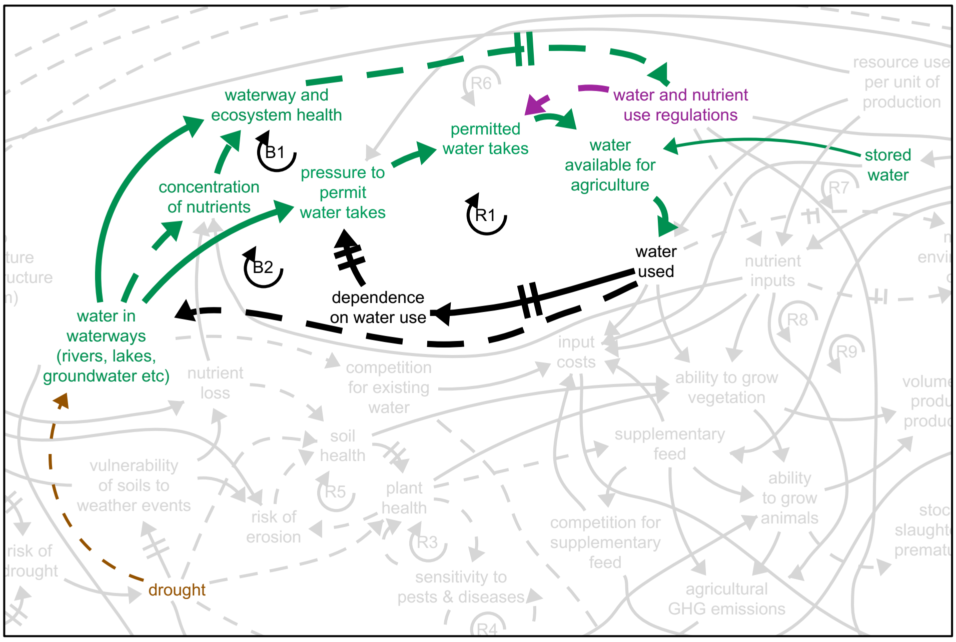


Figure 55: Agriculture, waterways and drought

Reduced water in waterways also increases competition for water, leading to higher costs and reduced cooperation within and between primary industries.

Electricity generation

Electricity generation is incorporated into a balancing loop (B3). Here, *total electricity production* is a result of the combined *hydro-electricity*, *other renewable*, and *fossil fuelled electricity production*. *Total production* influences the *price*, which in turn affects whether *additional electricity generation capacity* (of any kind) is added to the network. *Hydro-electricity production* requires *water in hydro-dams*, and the *total electricity production* informs the *risk of electricity shortages*.

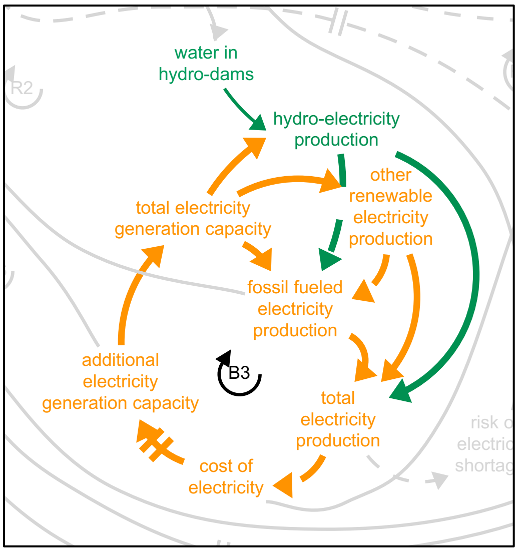


Figure 56: Electricity generation

Hydro-electricity and fossil fuel substitution

Drought can lead to reduced *water in hydro-electricity dams* and lower *electricity generation*, resulting in electricity potentially being generated from *fossil fuel-powered generation* to compensate. This results in a reinforcing loop (R2) that sustains *GHG emissions*, a contributing factor to the risk of drought.

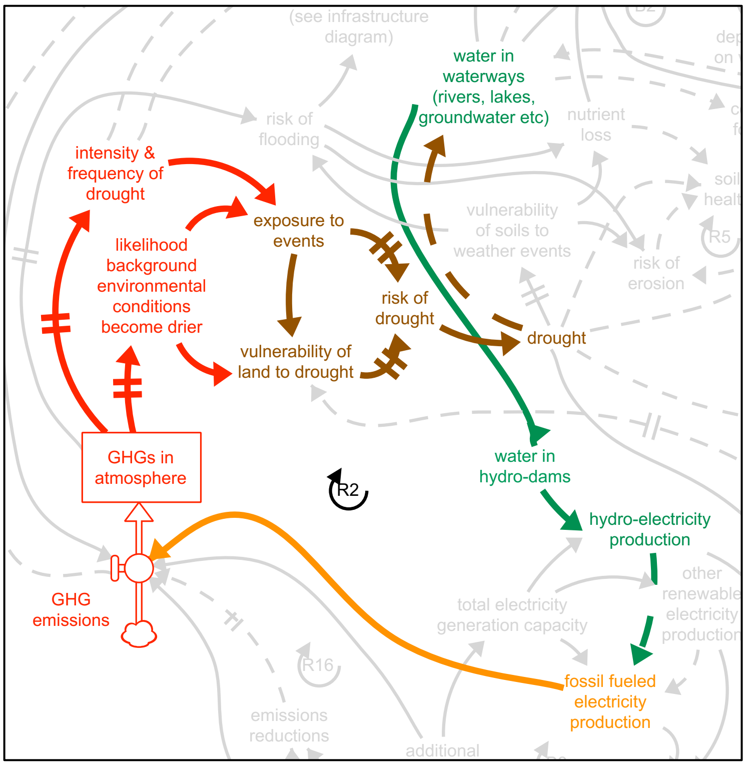


Figure 57: Hydro-electricity and fossil fuel substitution

Agricultural production

The effects of *drought* have other impacts outside of decreased water availability. Sustained drought results in reduced *soil health*, *plant health*, and *animal health*. This makes farms, gardens and orchards more susceptible to compounding risks such as *pests and disease*. These factors create a series of reinforcing feedback loops that risk increasing the vulnerability of plants and animals to further detrimental effects (see reinforcing loops R3 & R4).

Drought also increases the vulnerability of soils to weather events. Such as *nutrient loss* when the drought breaks (due to the release of a pulse of nutrients when it eventually rains) and an increased *risk of erosion* from wind and water. This further exacerbates the detrimental effects on ecosystem health. Reduced *plant health*, *risk of erosion* and *soil health* can spiral in a reinforcing loop (R5).

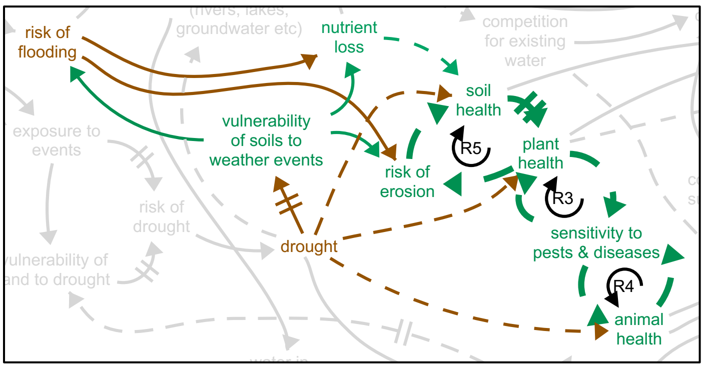


Figure 58: Soil, plant and animal health

Reduced *pasture/plant growth* and reduced *soil health* reduces the *ability to grow vegetation and animals*. For meat farmers, this can result in *stock being slaughtered prematurely*. Meat processors experience a surge in demand from such events, which lowers the *price per unit* for animals, reducing farmers' *revenue* and *profit*. For all processors (meat or otherwise), they will manage their *capacity* in response to demand and the *proportion of their capacity used* (balancing loop B4).

Farmers adapt by increasing supplementary inputs such as *fertiliser*, *feed*, and *irrigation/water used* (within the constraints of the *permitted water takes* contained in balancing loops B1 & B2 explained above). While this can temporarily sustain *production* and *revenue*, it also escalates *costs* and environmental impacts, including decreasing *water in waterways*, and increasing *nutrient loading* and *agricultural GHG emissions*.

Agricultural practices affect *market perceptions of environmental performance*. *Nutrient inputs* and *water use* can influence international markets and can affect the *price per unit*.

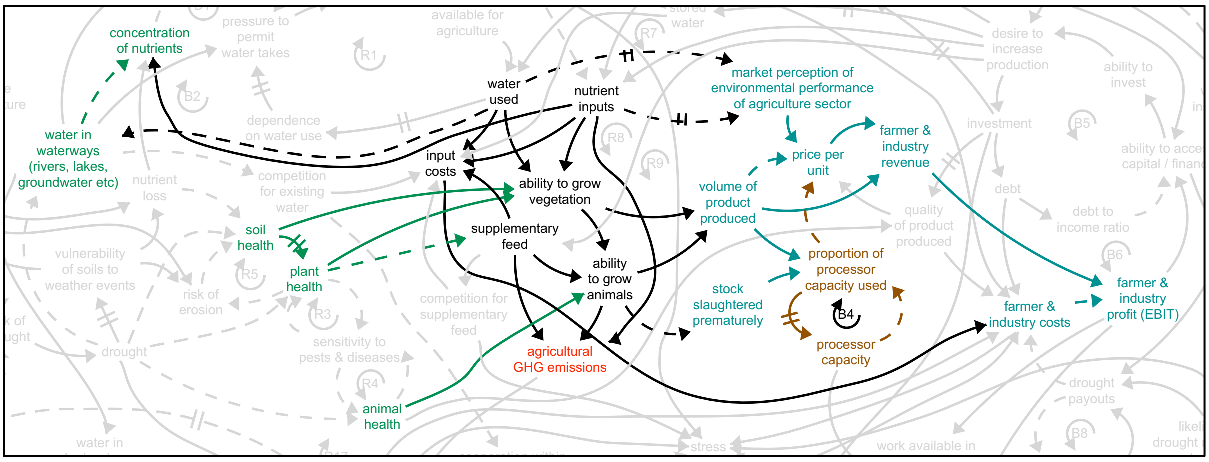


Figure 59: Agricultural production

Finance and capital

If the effects of *drought* lead to a reduction in *farm & industry revenue* and *profits*, this in turn reduces *access to capital/finance* and restricts *investment* and *expansion*. Major *investments* are often financed through *debt*, which increases the *debt to income ratio*, thereby completing a balancing feedback loop (B5) and restricting access to further *capital*. Additionally, increased *debt* raises servicing costs, which reduces *profit* margins, further restricting access to *capital* (balancing feedback loop B6).

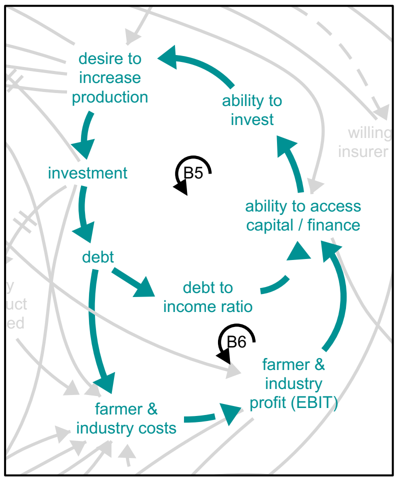


Figure 60: Finance and capital

The desire to increase production

Sustained *revenue*, *profit*, *access to capital* and the *ability to invest* encourage a *desire to increase production*. This is linked to four important reinforcing feedback loops. The pathways for these diverge from the *desire to increase production* to *pressure to increase water takes* (R6), *stored water* (R7), nutrient inputs (R8), and supplementary feed (R9). These are the main intervention pathways within agriculture. These pathways converge again through the *ability to grow vegetation*, the *ability to grow animals*, and the *volume of product produced*. From here, they all flow via *revenue*, *profit*, and *ability to invest*, returning to the *desire to increase production*.

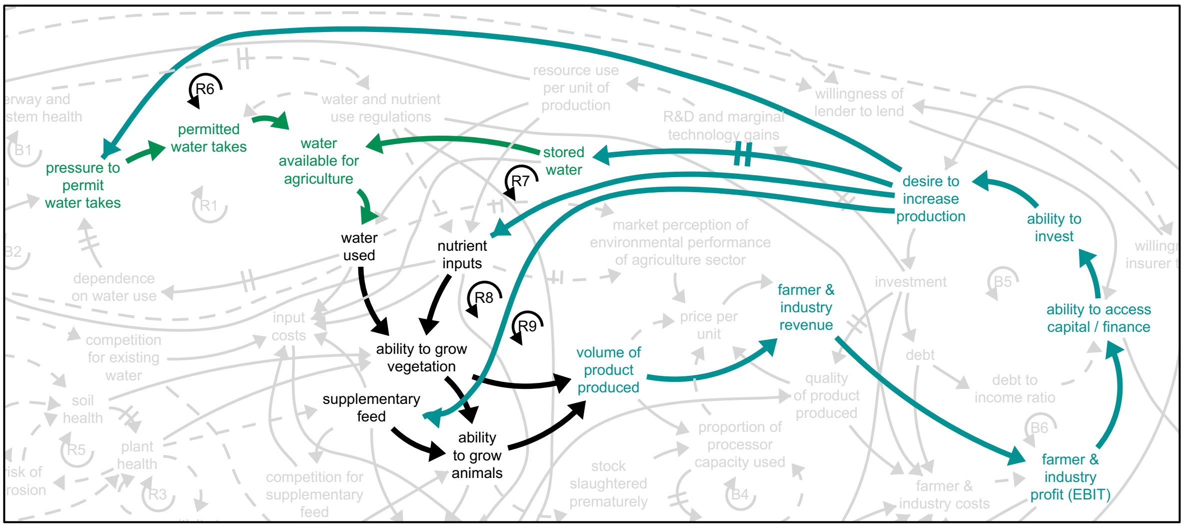


Figure 61: The spiralling of investment and return

In relation to *water use* and *nutrient inputs*, investment in *R&D and marginal technology gains* can reduce the *resource use per unit of production*. This can reduce the amounts of these inputs used, as well as reduce *GHG emissions*.

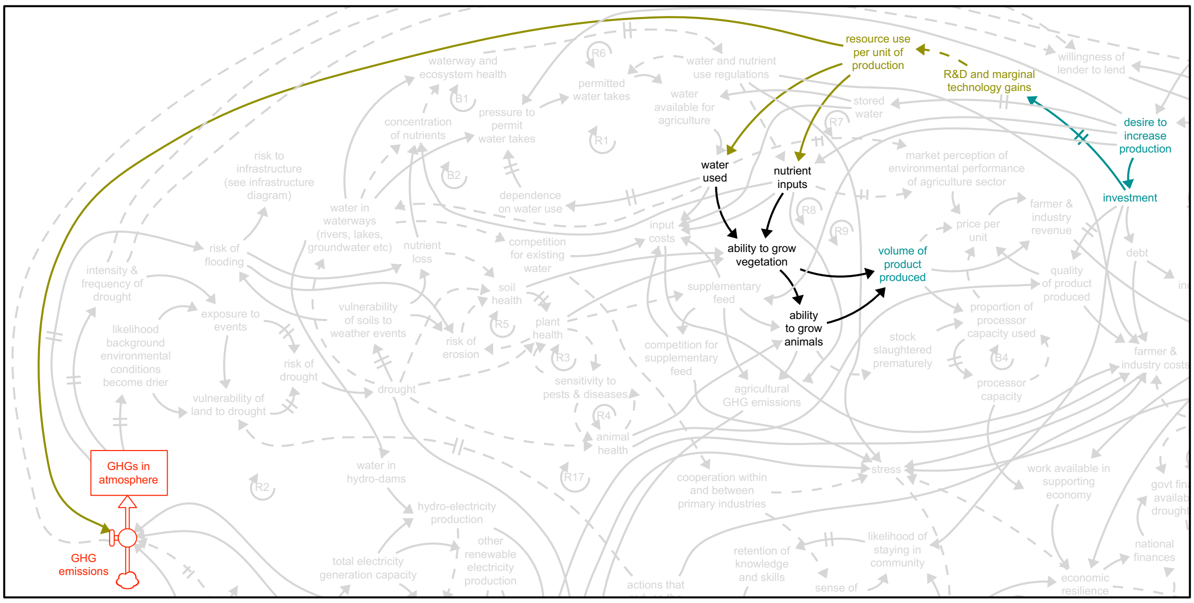


Figure 62: Investment, R&D and investment gains

The four reinforcing loops described above are all constrained by the balancing loop B7. This follows the same pathways as the reinforcing loops, through to *farmer & industry profit*. From here, an increase in profit increases *economic resilience* and reduces *stress*, both of which increase *wellbeing*. This reduces the *desire to further improve wellbeing*, which can constrain the *desire to increase production*. In short, agricultural production tends to increase to a point where *production* and *profits* are providing adequate *wellbeing* for farmers and communities. Where this point is will depend on the individual farmers and communities.

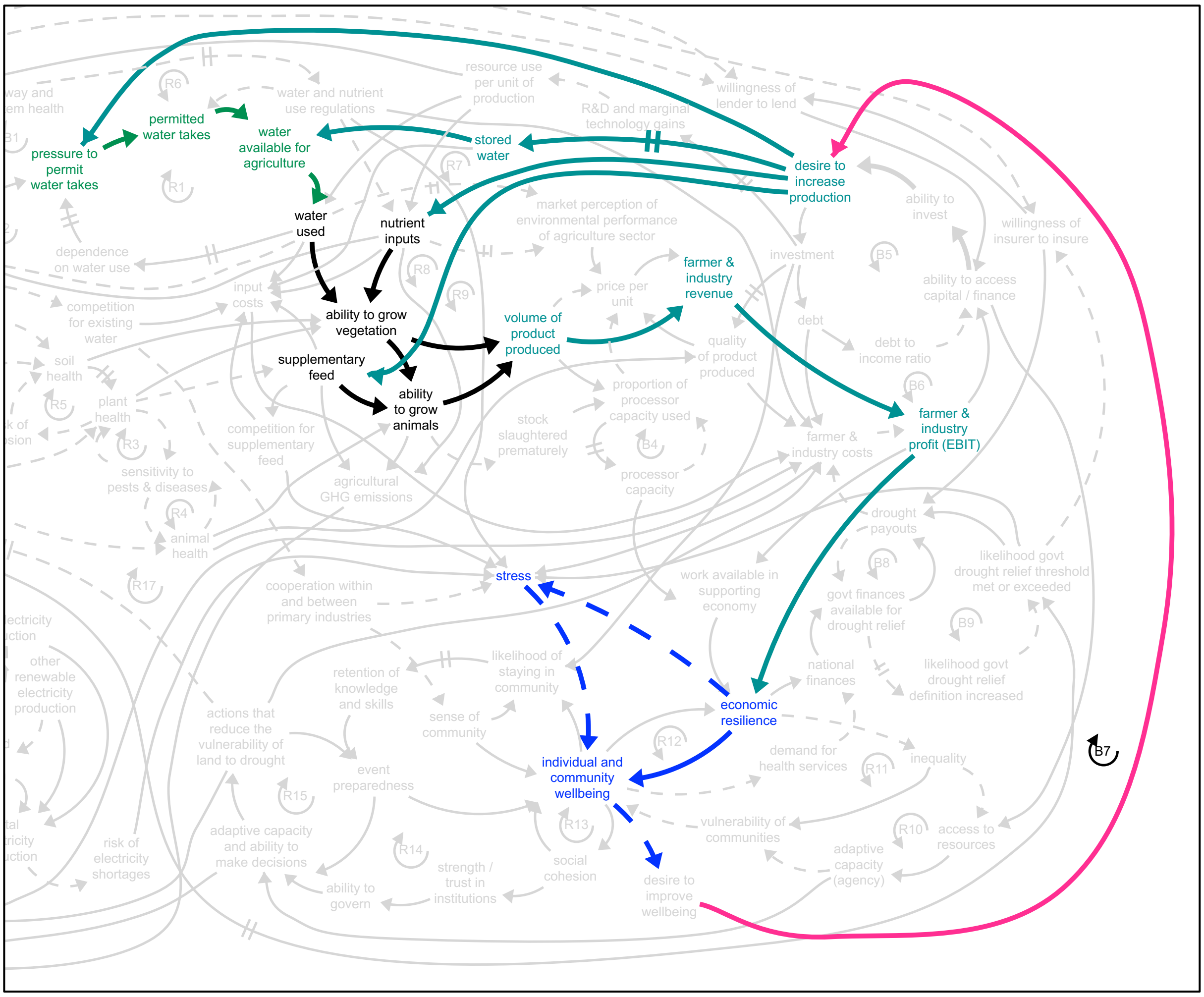


Figure 63: Agricultural activity delivering wellbeing

Insurance and lending retreat

As the *intensity & frequency of drought* increase, insurers face higher *payouts* and raise *premiums* or withdraw cover; in other words, their *willingness to insure* reduces. Lenders respond similarly, restricting credit to high-risk farms based on the *intensity & frequency of drought*, and the *GHG emissions* profile of farms. These processes limit *access to capital/finance* and reduce the *likelihood of drought payouts*. These limit adaptation options.

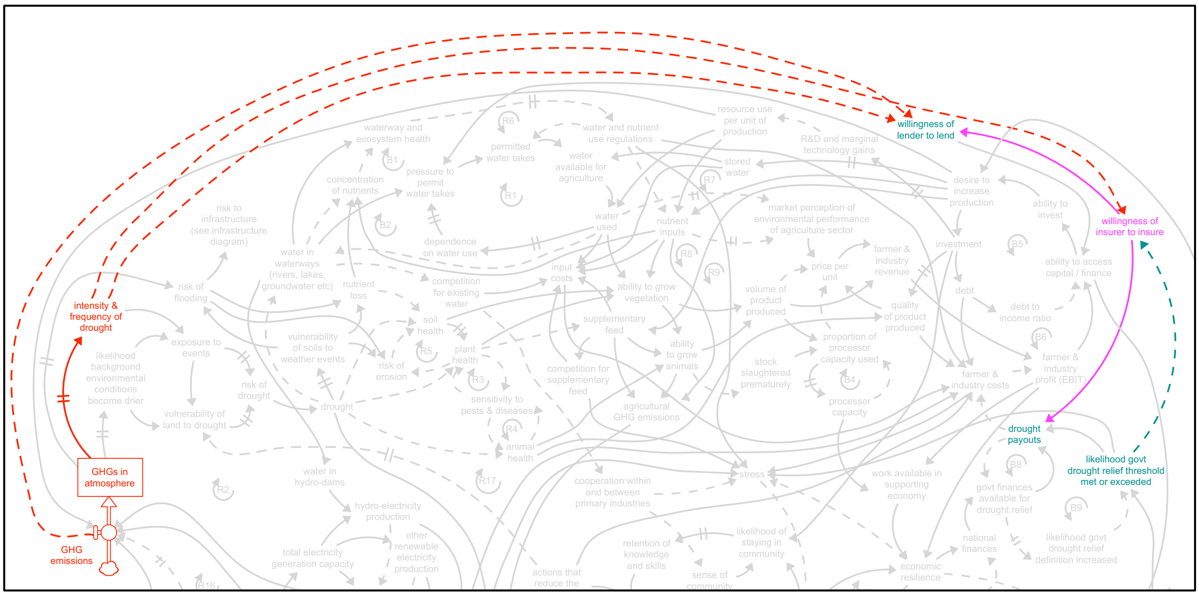


Figure 64: Insurance and lending retreat

Government drought payouts

The *government drought relief* is designed to support farmers through difficult times. Yet this is constrained (balancing loop B8) by *national finances* and the *government's finances available for drought relief*.

As the impacts of *drought* increase over time, the likelihood that the *government's drought relief threshold will be met or exceeded* also increases. Over time, this increases the likelihood that the *drought relief definition will be increased*, thereby making it harder for farmers to access *drought relief*. This creates a balancing loop (B9) in which state support diminishes compared to previously, as droughts become more frequent.

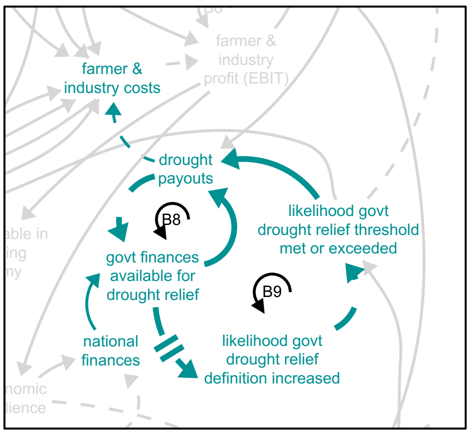


Figure 65: Government drought payouts

Rural economies and wellbeing

Agricultural *profits* sustain *rural jobs* and community *economic resilience*. Declining *profits* therefore reduce *local employment* and *economic resilience*, thereby spiralling several reinforcing feedback loops in an undesirable direction. This can lead to *inequality* widening as some groups bear disproportionate burdens, reducing their *access to resources* and increasing their *vulnerability*, which further weakens their *wellbeing* and resilience. See reinforcing loops R10-R12.

Economic resilience also contributes to individual and collective *stress*, along with increased *costs*, *competition*, *uncertainty*, *regulations*, and a reduction in *cooperation within and between primary industries*. This leads to poorer *wellbeing* among farmers and communities, which can reduce the *likelihood of people staying in the community*. This reduces the *retention of knowledge* and reduces the community's ability to be *prepared for the next event*.

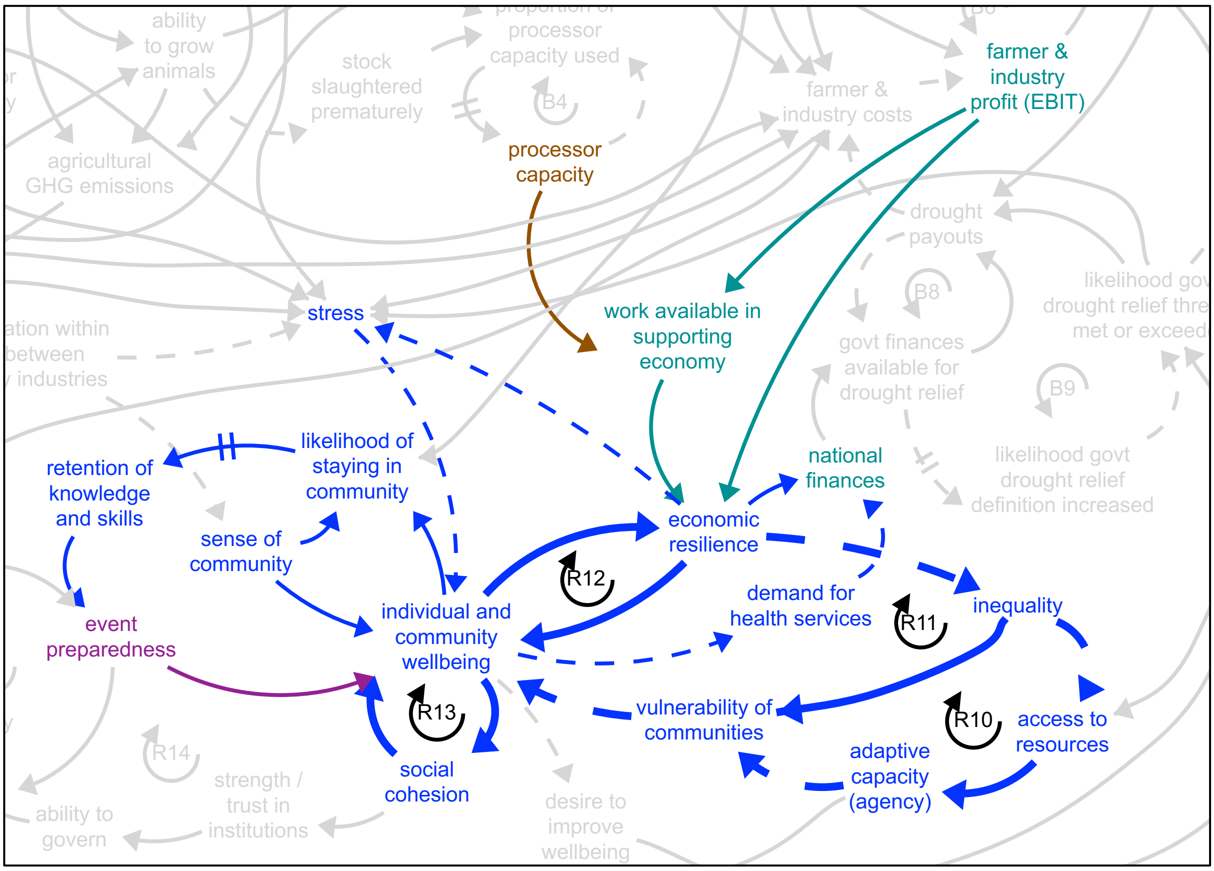


Figure 66: Rural economies and wellbeing

Adaptive capacity and decision-making

Individual and community wellbeing spirals with a sense of *social cohesion* (R13), and both spiral with *adaptive capacity and ability to make decisions*—the ability to respond collectively to challenges (see R14 & R15). Communities with higher *social cohesion* maintain *population*, *institutions*, and *decision-making capacity*, which in turn supports better *drought preparedness* and resilience by improving both mitigation and adaptation efforts.

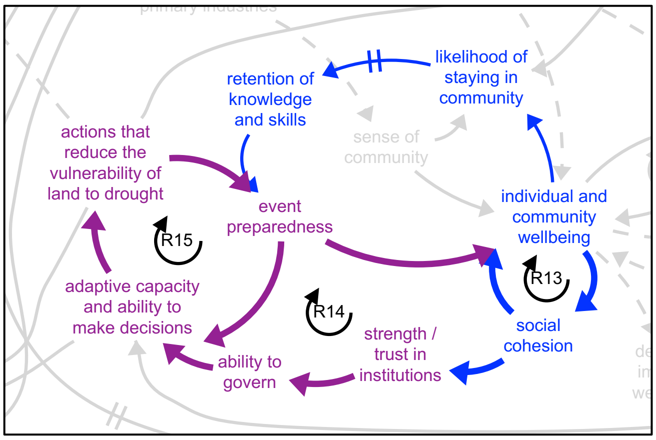


Figure 67: Wellbeing and adaptive capacity

Adaptive capacity and *ability to make decisions* are linked with mitigation efforts (*emissions reductions*) in reinforcing loop R16. Good levels of *adaptive capacity* can, over time, constrain *emissions,* which in turn limit the *impacts of drought* on agricultural activities, thereby further strengthening adaptive capacity. Conversely, continued *GHG emissions* will increase *drought impacts* in agriculture, reducing *adaptive capacity* and reducing the likelihood of *mitigation*.

Adaptive capacity and *ability to make decisions* are also linked with adaptation efforts (*actions that reduce the vulnerability of land to drought*) in reinforcing loop R17. Good levels of adaptive capacity can, over time, increase *actions that reduce vulnerability of land to drought*, which can limit the impacts of drought on agricultural activities, thereby further strengthening adaptive capacity. Conversely, continued *GHG emissions* will increase *drought impacts* in agriculture, reducing *adaptive capacity* and reducing the likelihood of *adaptation actions*.

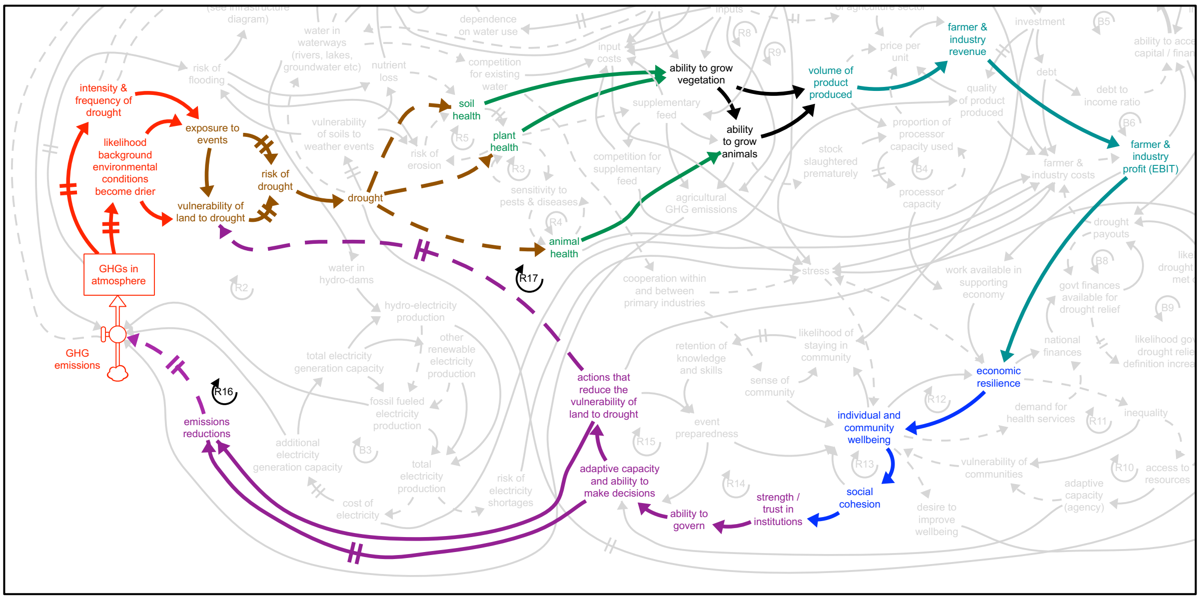


Figure 68: Adaptive capacity, decision-making and GHG emissions/vulnerability

Conclusion

In summary, the diagram illustrates how the effects of drought can cascade through various sectors, thereby linking factors such as climate change, financial systems, agricultural practices, and community wellbeing.

In particular:

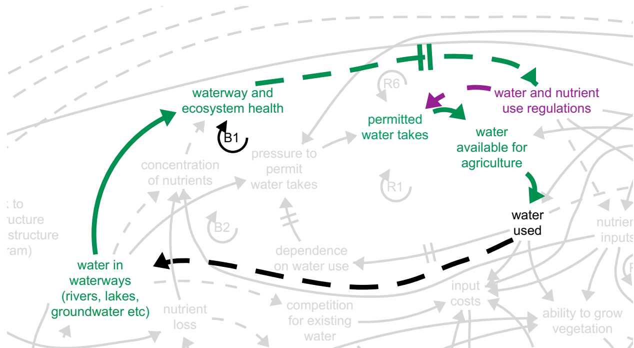
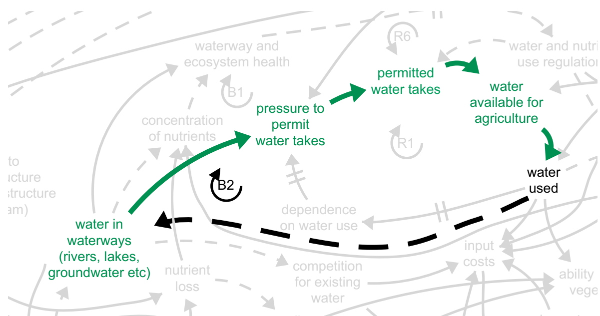
- Balancing loops provide stabilising forces through regulation, desired wellbeing, finance limits, and efficiency gains.
- Reinforcing loops can drive spirals of decline, especially where emissions, costs, and vulnerability dominate.
- Drought provides an exogenous influence that may initiate a series of cascading risks, driving many of these feedback loops.

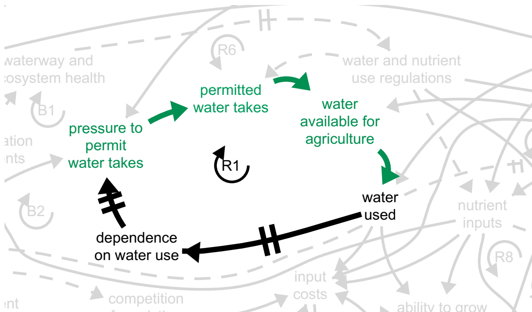
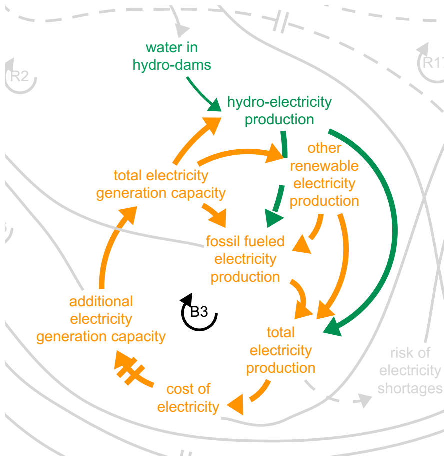
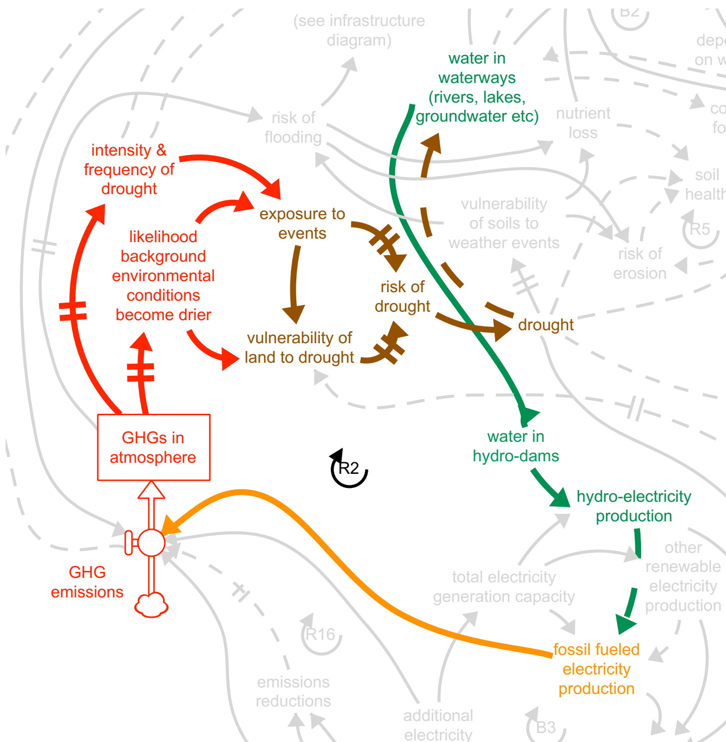
The diagram reveals that the long-term resilience of agriculture depends as much on social cohesion, governance, and adaptive capacity as on physical resources. Addressing cascading risks requires integrated strategies that recognise these interdependencies and seek to address them collectively as opposed to a siloed approach.

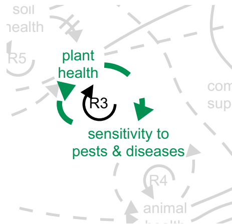
List of feedback loops in the detailed agriculture diagram

The table below lists images of all the feedback loops labelled in the detailed causal diagram for agriculture.

Table 2: List of feedback loops in the detailed agriculture diagram

Label	Name	Feedback loop
B1	Managing water extraction for ecosystem health	
B2	Managing water extraction for agricultural use	

Label	Name	Feedback loop
R1	Agricultural water dependence	
B3	Electricity generation	
R2	Hydro-electricity, fossil fuel generation and GHG emissions	

<table>
<tr><th>Label</th><th>Name</th><th>Feedback loop</th></tr>
<tr><td>R3</td><td>Plant health and disease</td><td>
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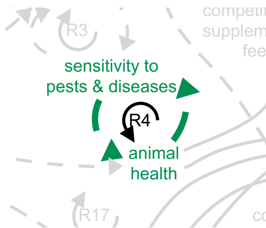
<tr><td>R4</td><td>Animal health and disease</td><td>
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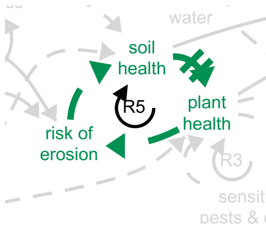
<tr><td>R5</td><td>Risk of erosion</td><td>
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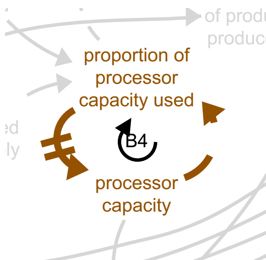
<tr><td>B4</td><td>Processor capacity</td><td>
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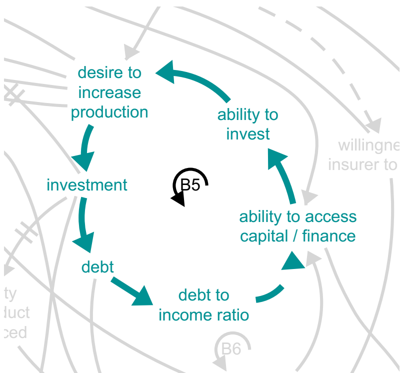
<tr><td>B5</td><td>Investment and access to capital/finance</td><td>
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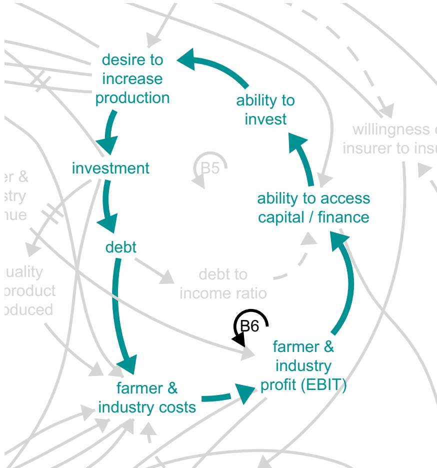
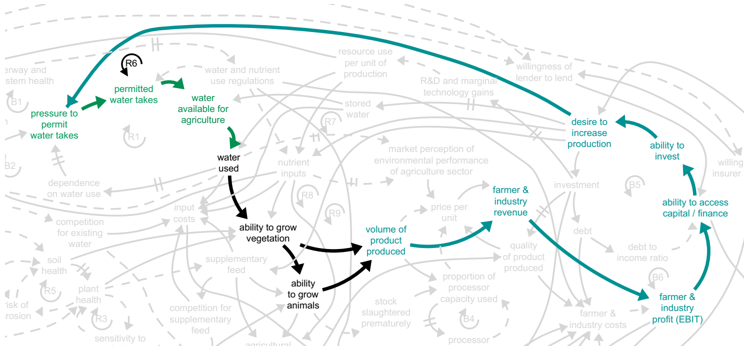
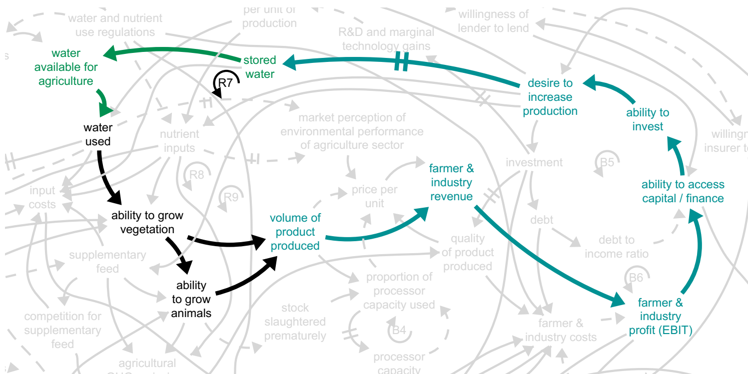
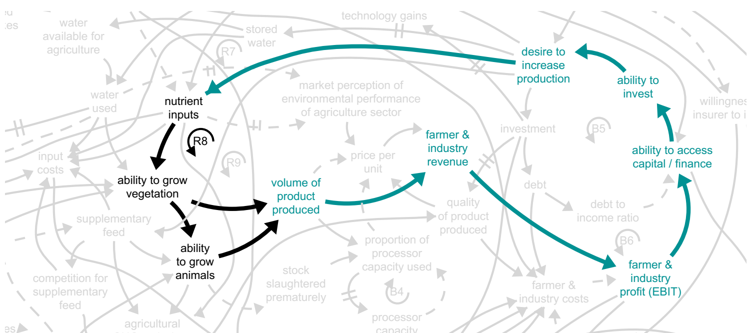
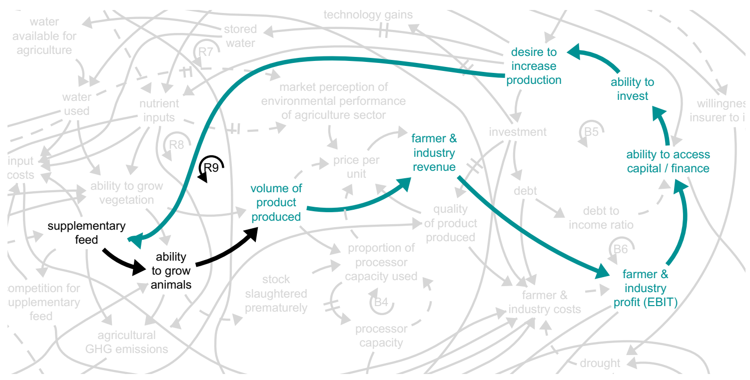
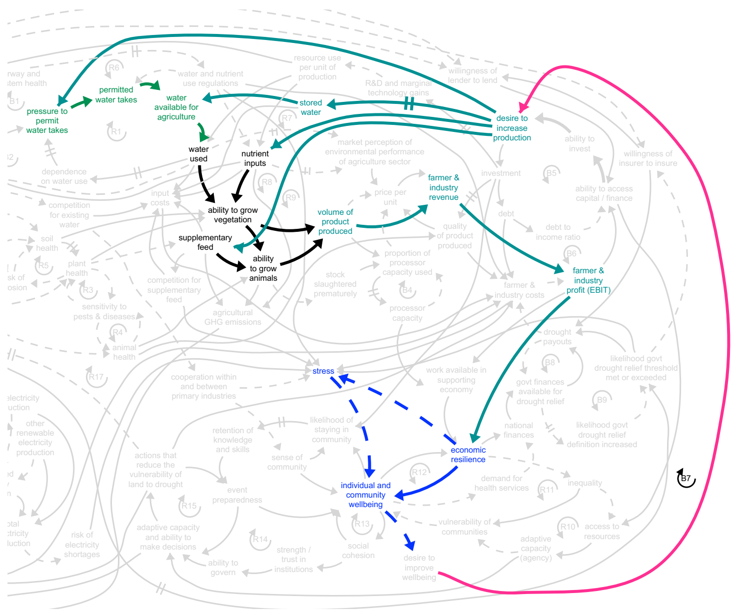
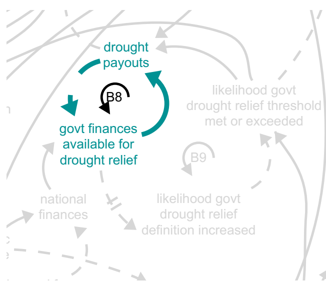
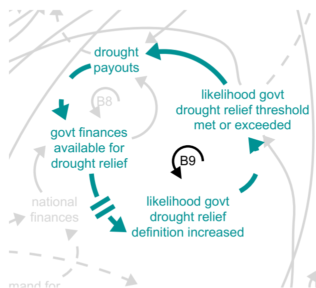
Label	Name	Feedback loop
B6	Debt servicing costs	
R6	Investment, permitted water takes and profit	
R7	Investment, stored water and profit	
R8	Investment, nutrient inputs and profit	

Label	Name	Feedback loop
R9	Investment, supplementary feed and profit	
B7	Increased production achieving desired wellbeing	
B8	Drought payouts	
B9	Changing drought relief payout threshold	

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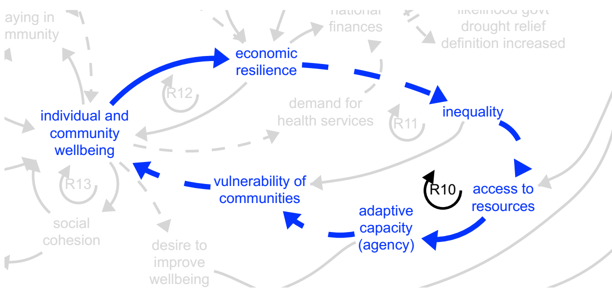
<tr><td>R10</td><td>Inequality and access to resources</td><td>
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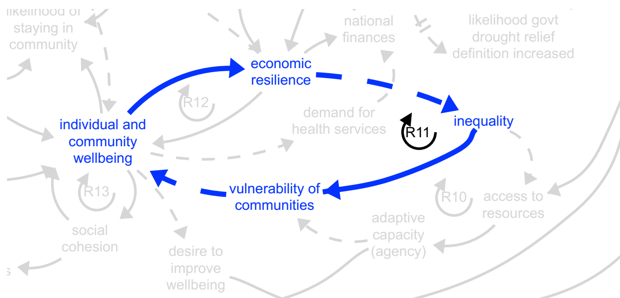
<tr><td>R11</td><td>Inequality and vulnerability</td><td>
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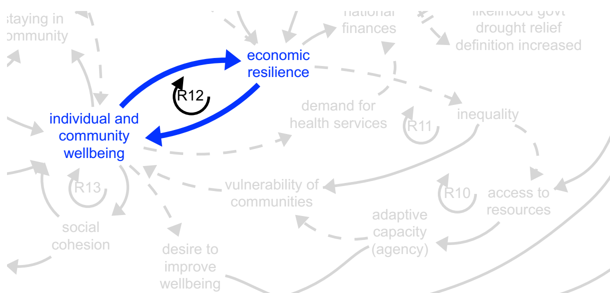
<tr><td>R12</td><td>Economic resilience and wellbeing</td><td>
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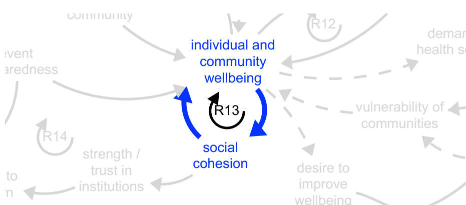
<tr><td>R13</td><td>Wellbeing a social cohesion</td><td>
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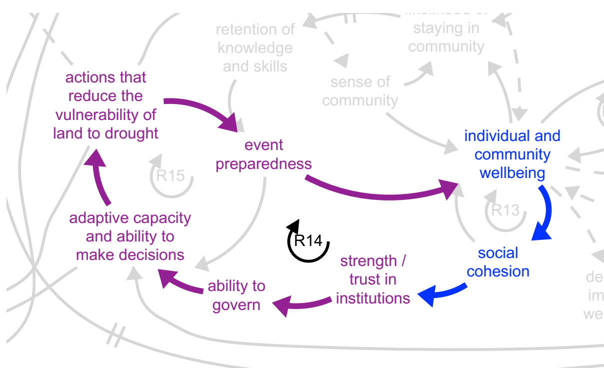
<tr><td>R14</td><td>Wellbeing, social cohesion and adaptive capacity</td><td>
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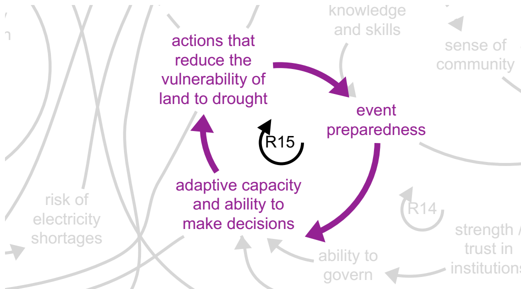
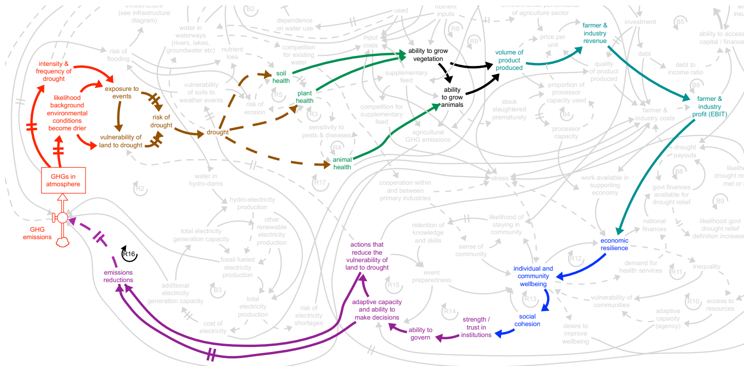
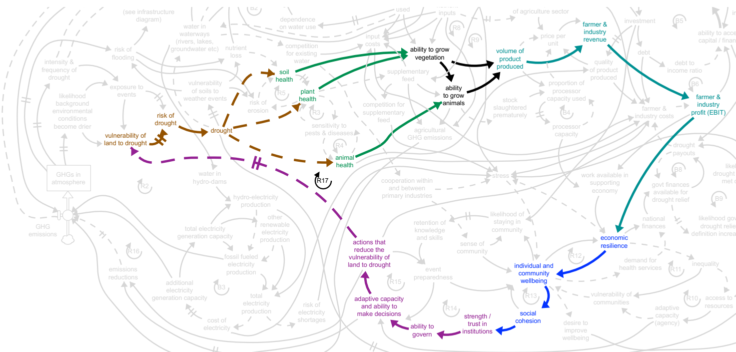
Label	Name	Feedback loop
R15	Adaptive capacity and event preparedness	
R16	Adaptive capacity and mitigation	
R17	Adaptive capacity and adaptation	

Agriculture detailed causal diagram

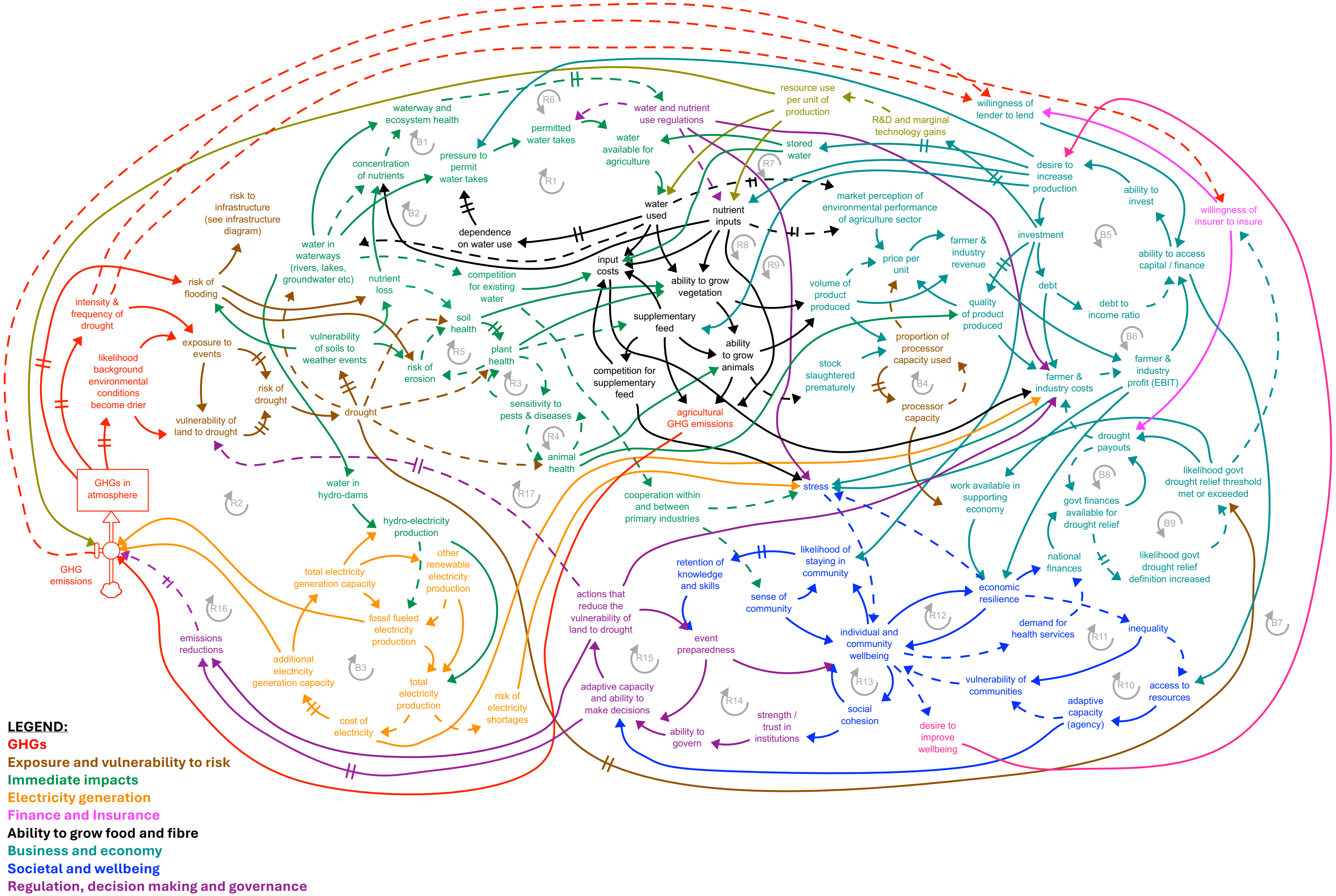


Figure 69: Agriculture detailed causal diagram (large)