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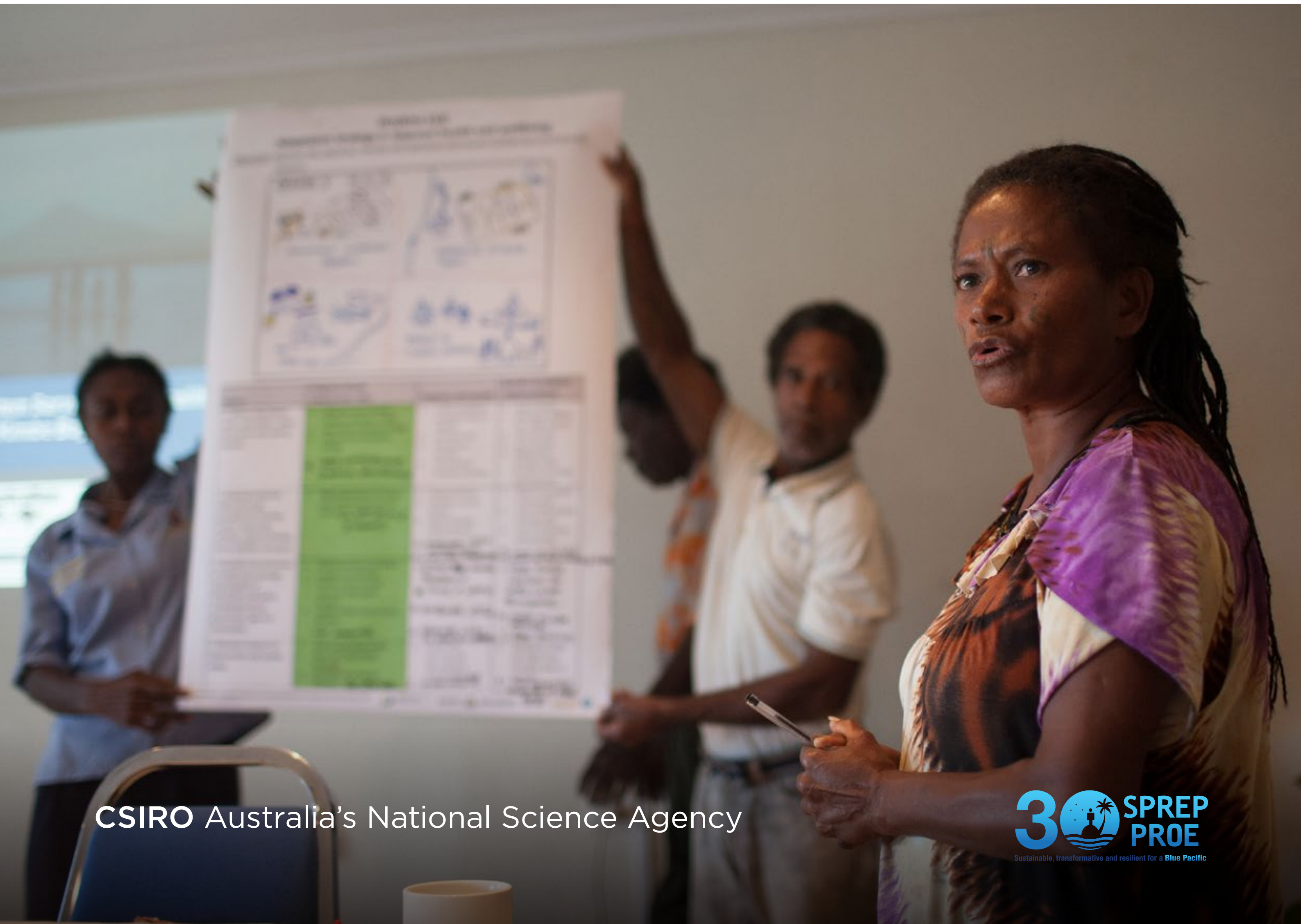
Knowledge Broker Support Program

Volume 1 – Foundation – Systems thinking module

The Knowledge Broker Support Program (KBSP) was funded by the Australian Department of Foreign Affairs and Trade, through the Australia Pacific Climate Partnership.



CSIRO Australia's National Science Agency

SPREP PROE
Sustainable, transformative and resilient for a Blue Pacific

Citation

Cosijn, M., Meharg, S. Grigg, N., Busilacchi, S., Barbour, E., Nadelko, A., Skewes, T., Taboada, M.B., Hayes, D. and Butler, J.R.A., 2023, Knowledge Broker Support Program Volume 1 – Foundation Modules, CSIRO, Canberra, 72 pp.

Cover photo: Knowledge broker in action. Photo by Tom Greenwood, 2017. Photo below by Tom Greenwood.

Systems thinking

This module gives you a glimpse of systems theory and helps prepare you to make decisions in complex contexts.

At the end of the module, you should be able to:

1. **Understand systems thinking, including drivers and pressures.**
2. **Understand how to navigate uncertainties and risks in systems.**
3. **Know how to make better decisions as a knowledge broker in a complex world.**

What is a system?

"A system is a set of things... interconnected in such a way that they produce their own pattern of behavior over time."
— Meadows, 2008

A system is composed of related and dependent elements which, when they interact, form a unitary, complex whole.

It also may not always be clear what the system boundaries are. Often we have to define this based on what we are looking at, but there are always (or nearly always) external influences and drivers that can affect the system we are interested in.

An example of a system is the human body. Another example is an agricultural system composed of biophysical aspects (e.g. soil, water, crops, livestock, climate, etc.) underpinned by social-political and economic components.

Systems approaches aim to understand how a whole system works and interacts with other systems.

Knowledge brokers need to understand the system in which they operate to identify key issues and solutions that can help the system change to a more desirable state.

A complex world in constant change

The world is a complex system, and globalisation has made everyone and everything more connected than ever before. Wherever you work and whomever you work with, you will be highly connected to other levels of the system, such as the province, the nation, the region and the world, through transport, trade, internet communications and information flows.

Consequently, our world has become more dynamic and unpredictable because something that happens in one part of the system will rapidly affect another. We increasingly face systems challenges that cannot be solved in piecemeal and incremental ways. The COVID-19 pandemic is a clear example of this, as is climate change.

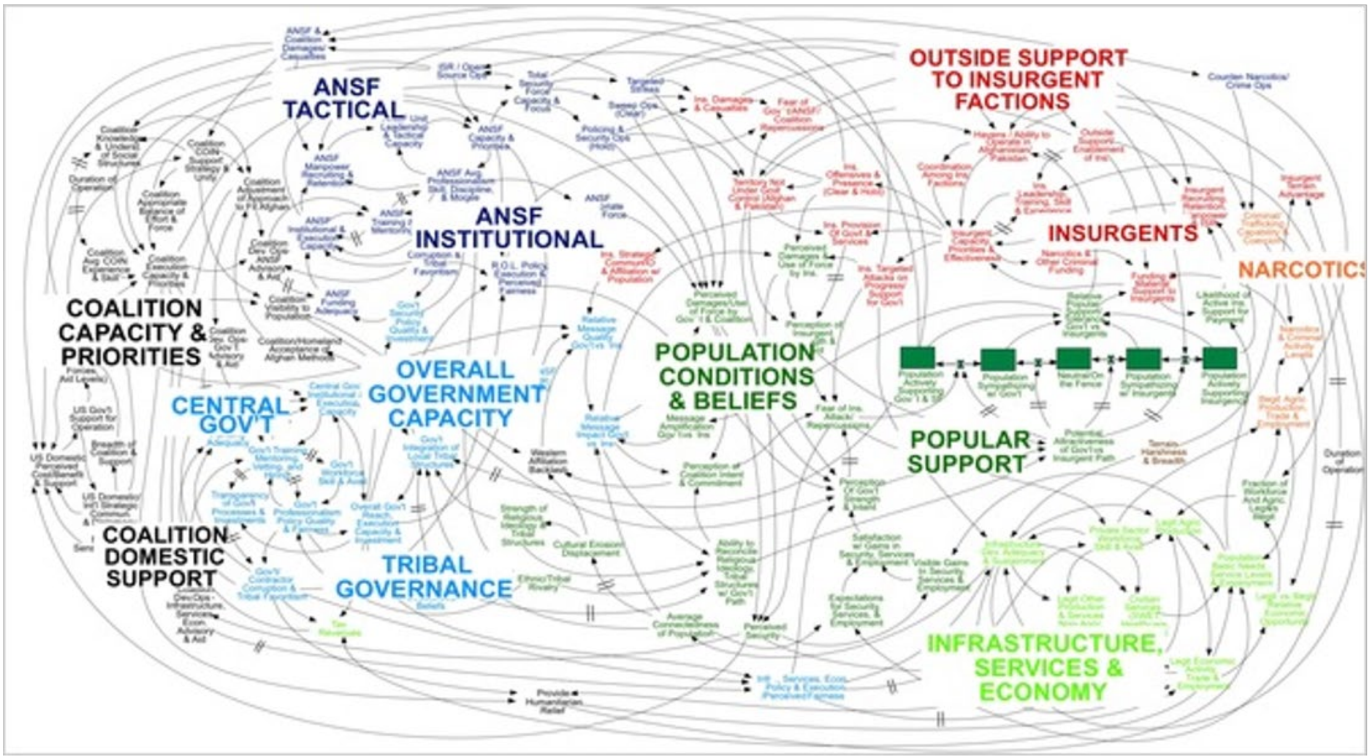


Figure 20 A description of a complex system – a visual representation of elements of war in Afghanistan highlighting the complexity of the issues. Sourced from Duncan Green (2016)

Systems thinking

Systems thinking is a way of understanding the world, which takes account of complex relationships between the various systems. It helps articulate the problem, and our assumptions and identify possible intervention points. It expands the range of choices and possibilities, especially if it is used in multi-stakeholder processes.

> **"Systems thinking explicitly recognises that we are a part of the system that we seek to understand and influence. It provides tools to assess and discuss causes, influences and interactions, and identify barriers to and opportunities for change."**
>
> Definition by: The Australian Government, Department of Home Affairs. 2019. Climate and Disaster Risk: What they are, why they matter and how to consider them in decision making. 3 Guidance on Vulnerability.

Identifying and understanding your system, drivers and pressures

When understanding your system, there are three aspects knowledge brokers need to think about:

1. The boundaries of your system.
2. The system context.
3. The drivers and pressures on your system.

Understanding the boundary of your system

An important first step is identifying the part of the system you are interested in (i.e. defining boundaries). This definition could be a location, a community, a town, a province or a region. While that is the focus of your interest, you must recognise that it is interconnected to other levels of the system above and below.

The boundaries should not be too narrow since this can restrict the identification of solutions. However, if too large, the system concerned may be unmanageable. The boundaries can be expanded as new systems issues emerge.

> "Draw the boundaries of the system in a way which makes system change a viable activity" — Leadbeater & Winhall, 2020

You must also understand the **formal** and **informal** processes underpinning the system.

- Formal aspects are often well articulated through policy, rules and regulations.
- Informal aspects such as cultural norms are often important at a local community level (see the **Governance Mapping Tool** (KBSP Manual Vol 2), which can help you map informal and formal decision-making arrangements).

Understanding the system context

By better understanding the context you are operating in and seeing the connections between things, you can identify intervention points where it may be possible to create significant change.

Knowledge brokers need a good understanding of the systems they are working in and the context, including the social, political, economic and environmental aspects.

Within systems, there is both content and process complexity that influence the context and can be described as follows:

Content complexity

Problems are 'multidimensional'. They are interrelated and have feedback loops so that one event or issue is related to another such that the more the first changes, the more the other one becomes acute or improves.

Process complexity

Many stakeholders are involved in a system, creating issues and generating solutions. Stakeholders have different viewpoints, values and objectives, which often are at odds with each other.

It is important to understand how people interact with their system. People or the environment are not considered in isolation. Understand what has happened historically, as this can impact how the system works, the drivers and pressures, and how decisions are made.

Decisions that need to be made and solutions that are generated are often complex, involving an understanding of the system and requiring deep collaboration with multiple stakeholders. Systems solutions are also often emergent, requiring ongoing engagement processes that build trust, transparency, adaptability, and learning.

For projects or programs, you need to think about:

- **Where** are you working and why?
- **Why are you interested** in doing this project, **why are others** interested?
- **Who** needs to be involved, including decision makers, key actors in the system? When thinking about who should be involved also think about what you can do to address power imbalances and ensure a diversity of participants.
- **What** do you need to do, and **when** and **how** would it be best to do it?

Systems drivers and pressures

You need to identify the drivers of change that are acting upon your system of interest, and which will potentially shift or change your system in the future.

The drivers may be emanating from the same level of the system (e.g. local population growth), or from levels above (e.g. national land clearing policy, climate change, global pandemics).

Drivers are the factors that cause change. e.g. changes in climate, population, technology, economics.

Pressures are the more immediate factors that affect the environment. e.g. urbanisation, food productions, mining.

Source: Australian State of the Environment (2011)

There are many systems drivers which, as a knowledge broker, you may need to understand to help you support communities to make decisions about their future.

It is important to consider multiple drivers of change in systems.

This module focuses on **climate change** and **population growth**, which are the primary drivers of future change for communities in the Pacific and other regions of the world.

Climate pressures

Usually, a "Business as Usual" emissions scenario, where the following pressures can be analysed:

- Temperature increase
- Rainfall change (annual and seasonal)
- Storm intensity
- Sea level rise
- Ocean acidification

Human pressures

Population growth and density is one of the most common drivers that causes pressures such as:

- Harvesting of natural resources (water, timber, fisheries, etc.)
- Land-use change from building infrastructure
- Natural resource use (e.g. firewood)
- Pollution

COCONUT RHINOCEROUS BEETLE – IMPACTING FOOD SECURITY AND LIVELIHOODS

An example of a driver is the recent arrival from South-east Asia of the Coconut Rhinocerous beetle (*Oryctes rhinoceros)* in the Pacific. It is rapid damaging and destroying coconut, betel nut, sago and oil palm, bananas, sugarcane and tree ferns impacting food security and livelihoods of many families across the region. The loss of coconut palms in coastal areas is also resulting in increased erosion as these trees are vital for erosion protection. Previously it was controlled by a virus and cooler temepratures. As temperatures increase with climate change so the range and rate of spread of the beetle will be even faster.

Knowledge brokers from Australian and Pacific research institutions are working together with communities and government to develop strategies to control the bettle's spread and minimise the impact.

CYCLONES

Cyclones have always been a part of life for most of the countries in the Pacific (pressure). High winds and increased wave levels can be devastating in terms of the damage and destruction of infrasture, housing, crops and coastal resources like mangroves and coral reefs. While communities have found ways to adapt, these events severely impact their ability to meet basic living standards and feed themselves. Women, children and the elderly are the most vulnerable.

As sea temperatures increase with climate change (driver) cyclones are becoming more frequent and more intense, causing even more damage and stressors for communities, with some households never recovering between events. Households are becoming increasingly vulnerable and unable to build sustainable livelihoods.

EXTERNAL DRIVERS AND IMPACTS ON FOOD SECURITY – UKRAINE RUSSIAN WAR

Often drivers can come from outside of the Pacific and compound existing pressures. An example is the Ukraine Russian war which started in 2022 while the impacts of the COVID-19 pandemic were ongoing. This war resulted in a rapid increase in costs of fertilisers and fuel due to the embargo against Russian exports and the difficulties in shifting goods out of Ukraine. In addition, Ukraine and Russia produce 25% of the world's wheat. The net result has been difficulties for farmers to obtain fertilisers compounded by increased costs due to rising fuel prices.

These issues have challenged food production systems around the world, including in the Pacific, with many areas reducing production. Rising fuel costs have also created challenges for transporting agri-food commodities from rural to urban areas. The cost of wheat products has also increased substantially. The net result is that urban and even rural communities are spending an increasing proportion of their incomes to meet basic food needs or reducing food consumption. The long term implications are still unclear, but this has the potential to adversely impact on nutrition of households, which was already decreasing in many places due to changes in food access due to lockdowns during the height of COVID-19 pandemic. It is clear that overlapping drivers in the system are challenging food security.

REFLECTION QUESTION – What are the main drivers of change for your system of interest, and how might these shift by 2030, 2050 and 2100?

Compiling information on drivers and pressures can be difficult, but it is important for planning adaptation

Useful things to consider when analysing drivers of change are:

Time slices

Definition – intervals of time you want to present back to your stakeholders.

Generally, CSIRO has found that 2030 (not too far in the future) and 2050 (about a generation) are useful time-slices to consider. Sometimes 2100 is also informative but is often highly uncertain, and considered as too far into the future, and therefore not as relevant.

Future scenarios for drivers and pressures

Because climate change is uncertain, having multiple future scenarios of climate pressures is useful. Perhaps the most useful scenario is the 'worst case' or 'Business as Usual' scenario, which assumes that global greenhouse gas emissions are not mitigated (see the module on Climate Information for more on how to access climate data and scenarios).

Population growth is uncertain and may vary depending on growth rates and migration. Again, future scenarios based on different possible growth rates will be useful. The 'Business as Usual' scenario usually is based on the current growth rate and, therefore, not as relevant.

Population growth pressures

Population growth is a significant driver of a system, which increases pressures on natural resources such as utilisation, pollution, and land use.

Natural resource utilisation

Many natural resources will have a finite yield that can be harvested, and overharvesting will reduce its status and yield. The population cannot grow indefinitely across a finite ecosystem. There is a limit to the population that the ecosystem's natural resources can support. This limit is called the carrying capacity.

Pollution

Pollution is another population-driven pressure. Pollution increases as the population grows, negatively impacting the volume and quality of goods and services the ecosystem can provide.

Land use

Land use also intensifies and changes as the population grows. To support an increasing population, land within the ecosystem is converted to housing or infrastructure, which can reduce the amount of land available for agriculture or the remaining native ecosystems, or both.

Population data sources

There two sources of population data that CSIRO has used for projects in the Pacific region: national censuses and the United Nations World Population Prospects.

EXAMPLES OF NATIONAL CENSUS DATA

PNG National Statistical Office:

https://www.nso.gov.pg/statistics/population/

Solomon Islands National Statistics Office:

https://www.statistics.gov.sb/statistics/social-statistics/population

The data available from individual country censuses varies, but reports may include historic population data as well as population projections. Data is collated at different levels, depending on how the census was conducted, and may be available for national, provincial, local government or ward areas. Unfortunately, not all data is necessarily available at all spatial or projected scales.

INTERNATIONAL POPULATION STATISTICS

World Population Prospects – United Nations Population Division of the department of Economic and Social Affairs:

https://population.un.org/wpp/DataSources/

The UN dataset is at national level only and includes historic population data that have been compiled from census reports from countries across the globe. It also includes population projections at national level based on fertility, mortality and migration modelling. These projections can be somewhat uncertain.

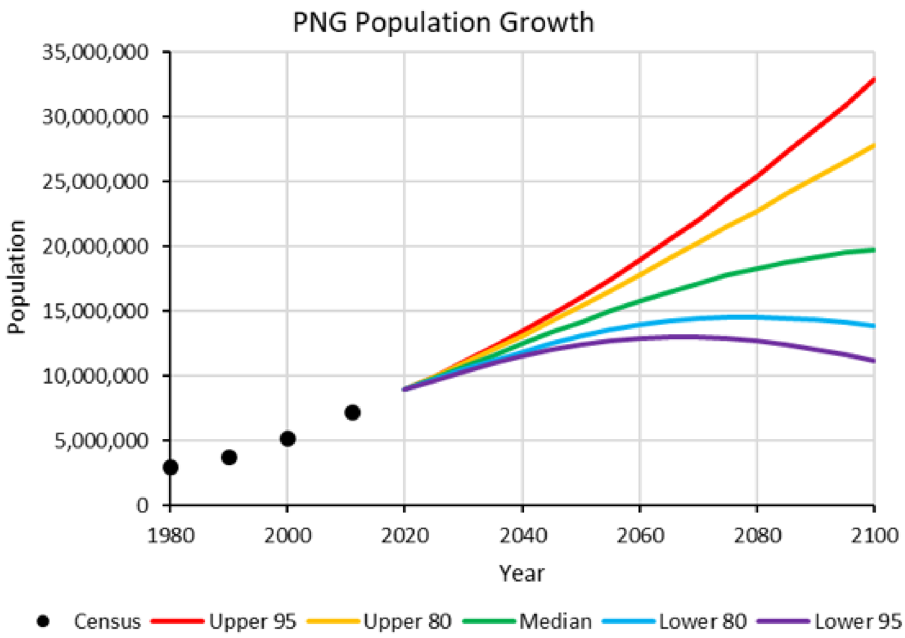


Figure 21 Historical and projected population growth in Papua New Guinea (1980-2100). The graph shows Papua New Guinea's historic population and probabilistic population projections from the UN dataset. The projections show there is great variability and therefore uncertainty across the range of probabilistic percentiles. Source: United Nations Probabilistic Population Projections based on the World Population Prospects 2019

Estimating population projections

Where your case study is at a spatial scale where population projections are not available, these projections can be estimated.

Follow these steps for a way to do it:

STEP 1 CALCULATING THE POPULATION GROWTH RATE

Beginning with historic population data from national census reports, the historic growth rate can be calculated as the change in population over time.

It is subjective which data intervals to include in this calculation and knowledge of the drivers of historic trends is helpful.

The population density growth rate is simply the population growth rate divided by the land area occupied by that population.

STEP 2 CALCULATING POPULATION PROJECTIONS

Beginning with historic population data from national census reports, the historic growth rate can be calculated as the change in population over time.

It is subjective which data intervals to include in this calculation and knowledge of the drivers of historic trends is helpful.

The population density growth rate is simply the population growth rate divided by the land area occupied by that population.

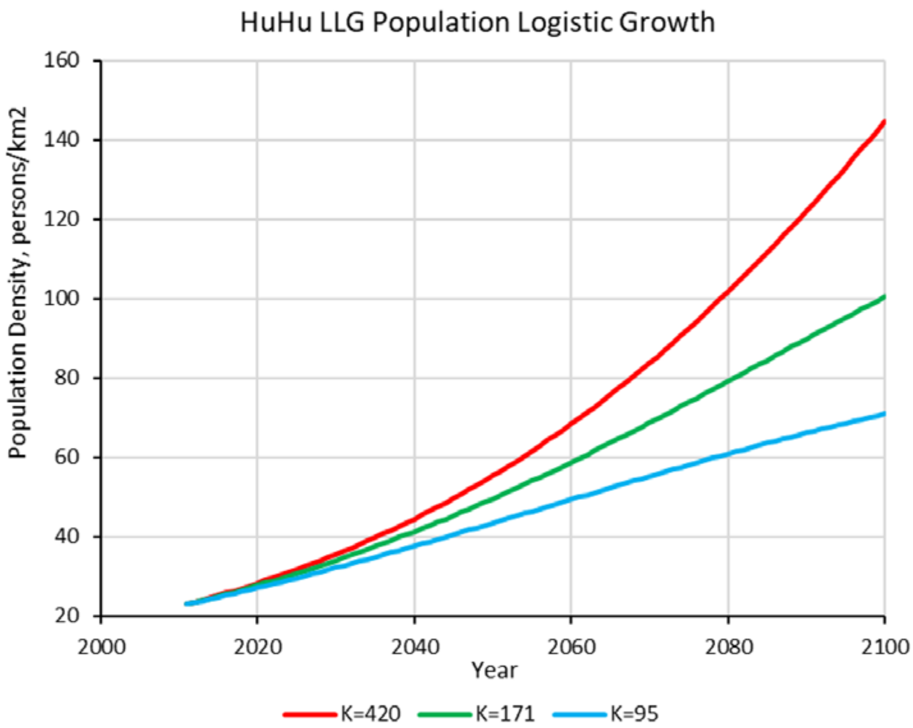


Figure 22 The graph shows population density projections to the end of the century used in the Huhu local-level government case study for three different carrying capacities. It is clear that future population densities are quite sensitive to the carrying capacity used to calculate them, leading to much uncertainty in these projections.

REMEMBER: You don't have to do this alone!

It is usually helpful to ask for input from specialists to get projections that will better suit your particular project.

Navigating systems

Uncertainty in complex systems

Operating in complex systems means encountering uncertainty. Knowledge brokers must be aware of existing and future uncertainty.

Uncertainty is increased where there are interactions from multiple drivers on your system of interest, such as climate change and population growth. It can be helpful to be aware of the different kinds of uncertainty or 'unknowns' encountered when making decisions

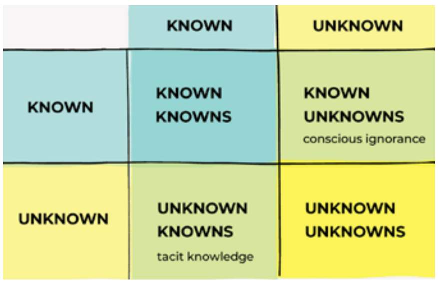


Figure 23 Types of unknowns.
Artwork by Dr Manuela Taboada, Queensland University of Technology

Embracing uncertainty

There are many types of unknowns.

Sometimes an important role for a knowledge broker is to help others understand uncertainty and complexity and what that means for decision-making.

Every situation will be different.

Even if there is a large amount of uncertainty, don't try and reduce the uncertainty, or try to pick the most likely future. Instead, focus on insights most likely to hold true despite the uncertainty.

Help people understand the assumptions behind the information you present on drivers and pressures, including climate projections.

KNOWN KNOWNS are the things you know you know about.	For example, you know that your water tank is filled from rain falling on your roof and how much rain falls on your roof if you measure it with a rain gauge.
UNKNOWN KNOWNS are the things you don't realise that you know or find very hard to explain to others.	For example, some people know how to foster a sense of trust and safety in the people around them, and yet they may never have tried to break down all the steps involved so that they could explain in detail to others how they do it. Even if they try to teach others, other people may never be able to do it as well.
KNOWN UNKNOWNS are the things that you know are deficiencies.	For example, climate scientists know a lot about the uncertainties in climate change. They can tell us about the unknown parts of the science, and often they can give sophisticated descriptions of the probability of different outcomes. This allows us to plan based on what is likely or unlikely, even though we don't know everything we would like to know.
UNKNOWN UNKNOWNS are the things that catch you out because you are not prepared for the fact that you do not know about them, and you only find out about them after they have impacted you. When thinking about future risks, you always have these unknown unknowns in mind.	For example, before the COVID-19 pandemic, people knew that pandemics were possible, so the possibility of future pandemics was a known unknown, but everyone learnt things about the pandemic's impacts that never occurred them to think about. During the pandemic, many people left the cities and returned to their villages or home towns, causing pressure on village resources. Some people have not anticipated this, while this was a natural response during crisis for others.

Navigating uncertainty

When navigating uncertainty, focus on things that people care about instead of trying to find a simple answer to future uncertainty.

For example, if you are being asked...

... *"All those possible futures are confusing – can't we just pick the most likely?"*

Possible consequences might be ...

You risk locking in decisions for only one future. These may be maladaptive in other futures that are equally or more likely.

Try asking this instead ...

"Can we identify what we really care about and look after those things no matter what future is ahead of us?"

... *"All this uncertainty is getting in the way of us making decisions – what can we do to reduce it?"*

Possible consequences might be ...

You risk not taking useful actions now.

Some uncertainties are not reducible.

Try asking this instead ...

"What decision-making processes will help us make future-ready decisions even when there is high uncertainty?"

... *"The complexity is confusing – please simplify it and tell us what we need to know?"*

Possible consequences might be ...

A simpler story doesn't make the complexity go away.
You risk reducing your options and making decisions based on assumptions that will not hold in many circumstances.

Try asking this instead ...

"What practices will help us accept and engage with complex realities rather than seek to simplify and avoid them?"

Image by Tom Greenwood

Risk in a complex system

When considering uncertainty in systems, you also need to consider risk.

The IPCC defines **"risk"** as "the **potential for adverse consequences** where something of value is at stake and where the occurrence and degree of an outcome is uncertain".

It is also often defined as the likelihood of a hazard and impact. There are two types of risk: **perceived risk** and **actual risk.**

Perceived risk can drive behaviour.

Understanding **actual risk** can help determine the most appropriate response.

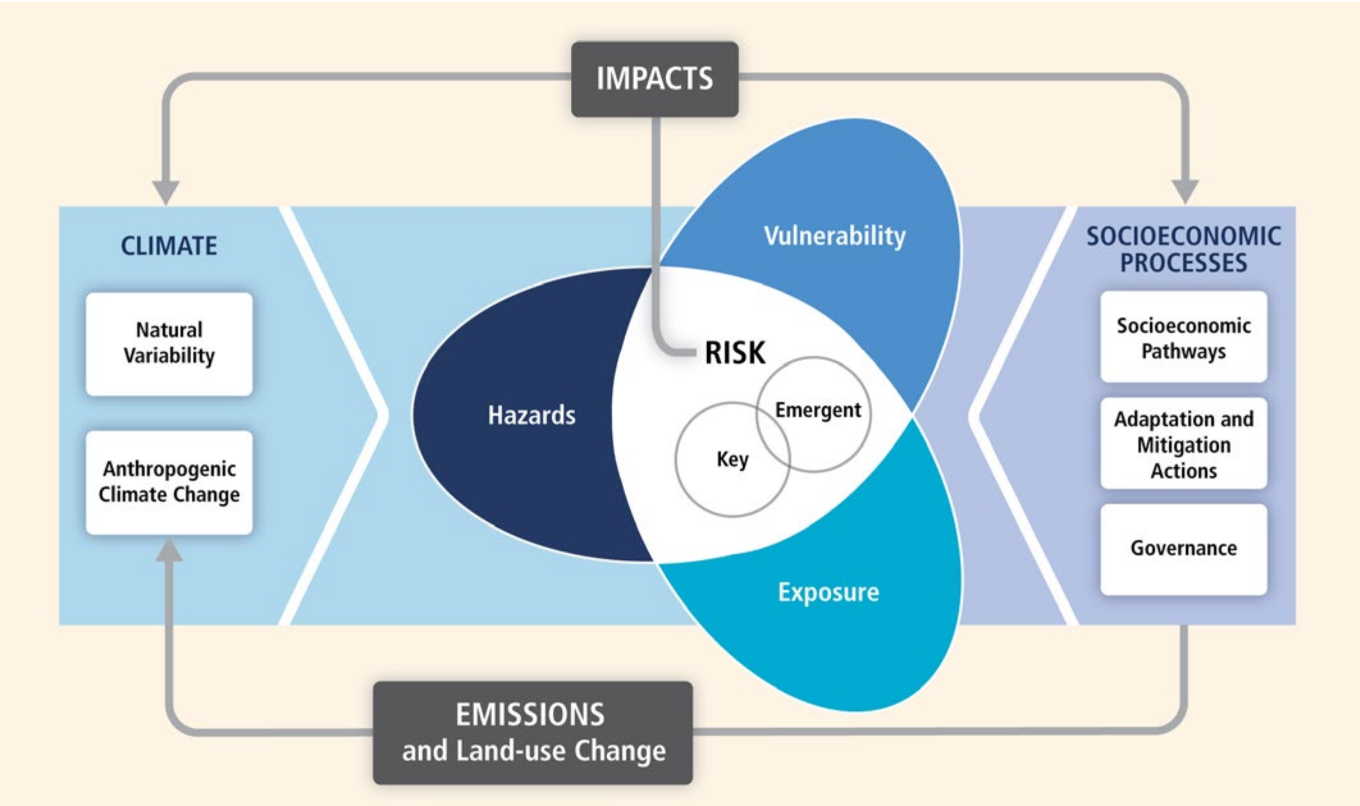


Figure 24 Risk Management Strategy Source: Figure 19-1 from Oppenheimer, M., M. Campos, R. Warren, J. Birkmann, G. Luber, B.C. O'Neill, and K. Takahashi, 2014: Emergent risks and key vulnerabilities. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1039-1099.

When considering the impacts of climate change, there is the potential for adverse consequences due to a specific climate hazard and potential adverse consequences due to adaptation or mitigation responses to that hazard.

The adverse consequences might be on lives, livelihoods, health and well-being, ecosystems, economic, social and cultural assets, services (including ecosystem services), and infrastructure.

In a complex system, other drivers will also interact with climate change, leading to other 'emergent' risks.

When knowledge brokering, you will find some key risks to things that your communities care about, as well as emergent risks, which are harder to anticipate.

EXAMPLE 1: CHANGES IN RAINFALL

Changes in rainfall can adversely affect the availability of surface water for drinking.

In many locations, women and girls are responsible for collecting drinking water. The net result is women and girls have to spend increased labour and time fetching water for household use. For girls, this can reduce their ability to attend school.

At a household level, this can also result in water rationing, impacting hygiene and reducing meals cooked, resulting in declining nutrition.

EXAMPLE 2: BUILDING A SEA WALL

A policy to build sea walls in anticipation of sea-level rise could have adverse economic consequences and cascading impacts because sea walls are expensive. It could have adverse health impacts if water cannot drain away, resulting in stagnation.

Be broad in your thinking about risk. Think not only of the climate-related hazards but also of emergent risks that arise from our social responses to perceived risks.

Risk management strategies

In risk management, it can be helpful to recognise some of the different kinds of unknowns that we are dealing with in complicated and complex systems. The table below describes three challenges: complexity, uncertainty and ambiguity, and the associated risk management strategies.

CHALLENGE	RISK MANAGEMENT STRATEGY	DESCRIPTION
Complexity	Use best available knowledge to inform how to limit exposure and reduce vulnerability to hazards.	Complicated web of causal relationships where many intervening factors interact to affect the outcome of an event or activity.
Uncertainty	Improve capacity to cope with uncertainty and surprise (e.g. adaptation planning, building capacity for flexible responses, building buffers for absorbing shocks).	Lack of reliability or confidence in our understanding of cause-effect relationships.
Ambiguity	Participatory processes for resolving conflict and ensuring fair consideration of concerns when developing and implementing options they have ownership of solutions.	Conflicting views about the interpretation of risk and its acceptability.

Making decisions in a complex world

Living in such a complex world requires us to use systems thinking if we want to successfully navigate complex contexts where uncertainty and risk might make decision-making harder.

By better understanding the context you are operating in and seeing the connections between things, you will be able to identify intervention points, discover your own assumptions, formulate relevant questions, and hopefully prevent undertaking maladaptive activities.

In this section, you will find two approaches that might help you frame your decision-making process.

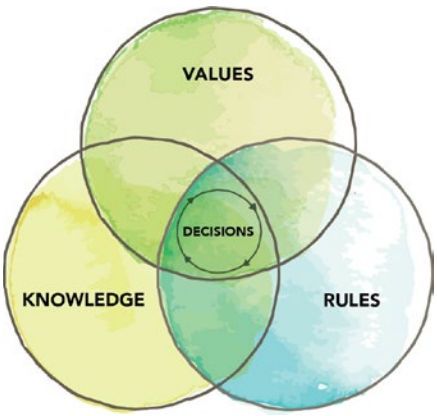


Figure 25 Values, rules and knowledge. Source: Gorddard et al (2016).
Artwork by Dr Manuela Taboada, Queensland University of Technology

Values, rules and knowledge

Understanding the values, rules and knowledge (VRK) involved in a certain context can be of great help when making complex decisions. According to this framework, decisions should be made based on the relationships between these three components.

- **VALUES We need to want the outcomes**
- **RULES We need to be allowed to implement the option to achieve the outcomes.**
- **KNOWLEDGE We need the knowledge to choose and implement an option.**

We often have good methods, precedents or personal experience for helping us choose among options in the central space (decision-making).

AN AUSTRALIAN EXAMPLE...

In Australia, we sometimes have a water supply problem due to drought. One way to improve this supply problem is to recycle water for drinking.

The knowledge for how to do this is well understood, in fact countries like England and Singapore have been doing it for years. The rules are in place to allow for the implementation of the recycling process, but the Australian public has concerns and doesn't share the value of recycling water. Work needs to be undertaken to better understand why and to potentially shift these values.

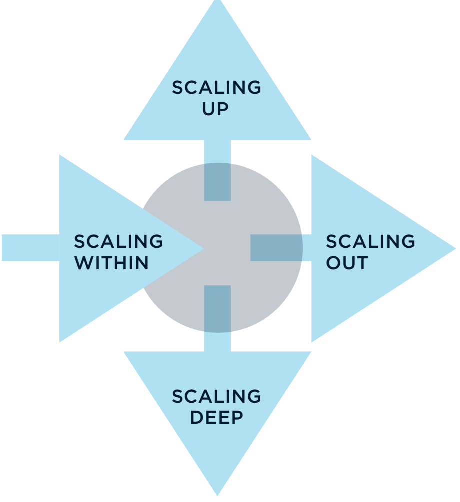


Figure 26 Scaling Up, Out, Deep and Within.
Design idea by Zelda Hilly

Scaling

For systemic change to occur, the impacts of projects and activities need to be durable and to diffuse across levels of the system. This is often referred to as 'scaling up', 'scaling out', 'scaling deep' and 'scaling in'.

It is often assumed that if a project is done well it will be possible to transfer any lessons to other contexts and scales, like producing a cake by using the same recipe. This assumption is often false because there are **four main ways to scale:**

- **SCALE UP This is achieved through laws and policy,** e.g., taxes or environmental protection rules.
- **SCALE OUT This is achieved through replication when your model is applied in other contexts or communities.** e.g. in agriculture, it is common for farmers to copy their successful neighbours or other successful communities.
- **SCALE DEEP This is achieved by changing cultural norms** e.g. in Australia a good example is smoking — after many years of heavy behavioural change campaigns, there are now far few people smoking in the country.
- **SCALE WITHIN This is achieved through you and your organisation** e.g. in CSIRO and science more broadly, there has been a challenge to get more women to participate, particularly in leadership roles. CSIRO is actively implementing One Sage (Science in Australia Gender Equity) to change this.

Different modes of scaling are crucial for achieving impact and benefit.
It is not always clear which will be the best scaling mode; often, it is not one single pathway.

Innovation brokering and climate change

Communities, community development and adaptation, are all part of a system. Due to globalisation, communities are tightly connected to drivers of issues from the global to the local level, but also between natural and human systems, resulting in complex and rapid change.

Climate change is one part of the system. When it interacts with other drivers, especially population growth, it generates high uncertainty about the future, with a range of complex risks and outcomes.

In these situations, brokers must deal with multiple issues when supporting decision-making about community adaptation and development. Also, many different stakeholders are often involved in decision-making, and the problems being addressed will require their different knowledge types to be integrated.

In complex decision-making contexts innovation brokers who can understand the system they are dealing with, the range of future uncertainties and risks, and facilitate decision-making about unknown futures, are required.

They will need a wide range of competencies, and in particular systems-thinking, future-thinking, critical-thinking, interpersonal skills, openness, creativity and comfort with ambiguity.

Rather than relying on one person to provide these skills, plus those of knowledge broker and knowledge translator or infomediary, it may be best to assemble a team of people with complementary skills who can work together.

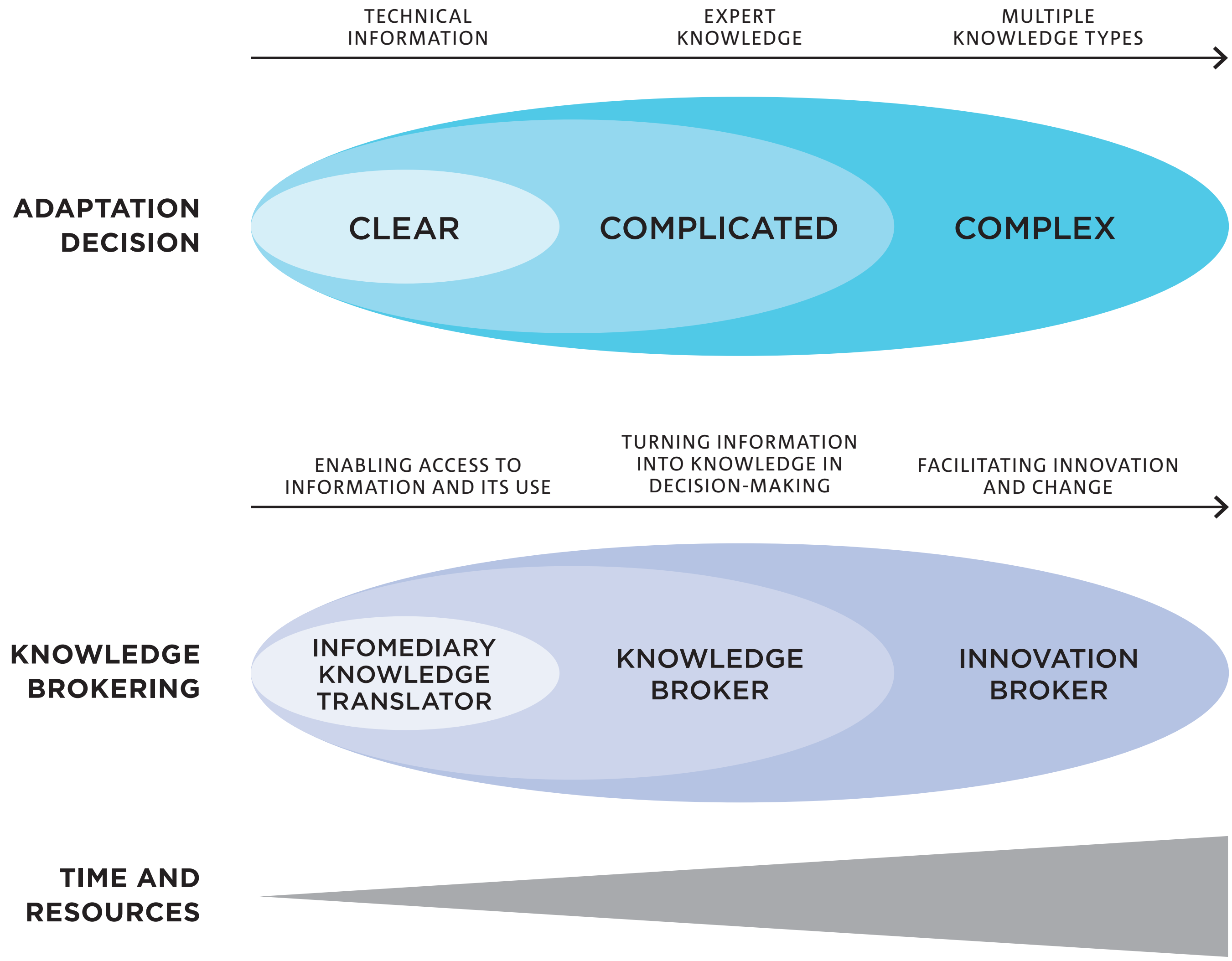


Figure 27 Types of knowledge brokers needed for clear, complicated, and complex adaptation decisions.

References and additional resources

If you would like to watch a YouTube video on this module, please see https://www.youtube.com/watch?v=htFmbUGmohA

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Acknowledgements

Michaela Cosijn (CSIRO): an innovation broker who works in international development programmes solving complex problems and enhancing livelihoods, with her work focused on agri-food innovation systems, gender integration, and climate adaptation.

Nicky Grigg (CSIRO): a research scientist who works in interdisciplinary teams on a diverse range of projects concerned with global change and social-ecological systems.

Seona Meharg (CSIRO): an integration scientist focused on the capacities and competencies needed for systemic change, and with experience in research evaluation and project management for transdisciplinary projects.

James Butler (CSIRO): a sustainability scientist with a background in agricultural economics, terrestrial, freshwater and marine ecology gained in southern Africa, Europe and Australia.

Emily Barbour (CSIRO): a research scientist in hydrology. Emily works on a diverse range of water issues focusing on collaboratively generating knowledge and tools to support decision making for complex environmental challenges.

Tim Skewes (Tim Skewes Consulting): an ecologist with a background in coastal fisheries and ecosystems, valuing ecosystem goods and services, and assessing the impacts of climate change.

Sara Busilacchi (Independent research scientist): research scientist with a background in fisheries science with a focus on social-ecological systems thinking for the sustainability of small-scale fisheries in a changing world using collaborative and participatory approaches.

Anthony Nadelko (CSIRO): a research technician who investigates the environmental interactions, resource use efficiency and sustainability of natural and human-made ecosystems.

Samantha Stone-Jovicich (CSIRO): an anthropologist with an interest in strengthening science's contribution to on-the-ground impacts and a focus on complexity-aware monitoring, evaluation and learning (MEL) frameworks and tools to critically assess current research approaches and practices and to foster experimentation with new ways of thinking and practice to better bridge science and meaningful, lasting social change.

"None of us, including me, ever do great things. But we can all do small things, with great love, and together we can do something wonderful." — Mother Teresa

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