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National SCIENCE Challenges

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Impact-based forecasts and warnings

There is a growing need in Aotearoa New Zealand to improve communications relating to various hazards that pose threats to people, property, and infrastructure. Impact-based forecasts and warnings (IBFWs) offer a way to design and communicate warnings that are more meaningful and relevant to people.

The goal of Impact-Based Forecasts and Warnings (IBFWs) is to communicate what the hazard may DO, and not just what the hazard may BE. Designing and developing an IBFW system can be daunting, so we have developed this policy brief sheet to introduce key definitions and concepts for IBFWs and provide a starting point for anyone who wants to setup an IBFW system in Aotearoa. IBFW systems should be co-developed by multiple agencies involved in hazard monitoring and forecasting, disaster risk reduction, and emergency response and preparedness.

KEY POINTS

- The thresholds for IBFWs are based on expected impacts rather than hazard attributes.
- The likelihood and magnitude of impacts change over space and time.
- To issue IBFWs we need to combine knowledge of the hazard (s) with knowledge about people, buildings, and lifelines.
- Actionable advice provided alongside IBFWs can improve their effectiveness.

What makes IBFWs different to traditional warnings?

IBWFs are used to tell people what kind of impacts they can expect from the hazard, and where and when they are likely to occur, rather than just describing the physical characteristics of the hazard.

Another distinguishing feature of IBFWs is that thresholds or triggers for the warnings are based on the expected impacts, rather than the physical characteristics of the hazard (such as rainfall amounts or wind speeds). This is because the level and likelihood of impacts can change over space and time due to changes in environmental conditions and in people's behaviour throughout the day, week, and season (Figure 1).

IBFWs can be more meaningful to people and can help them to make more informed decisions on how best to protect themselves. Research has shown that IBFWs are more effective when action advice is also provided in the warning, so that warning recipients know what to do with the information they've been given.

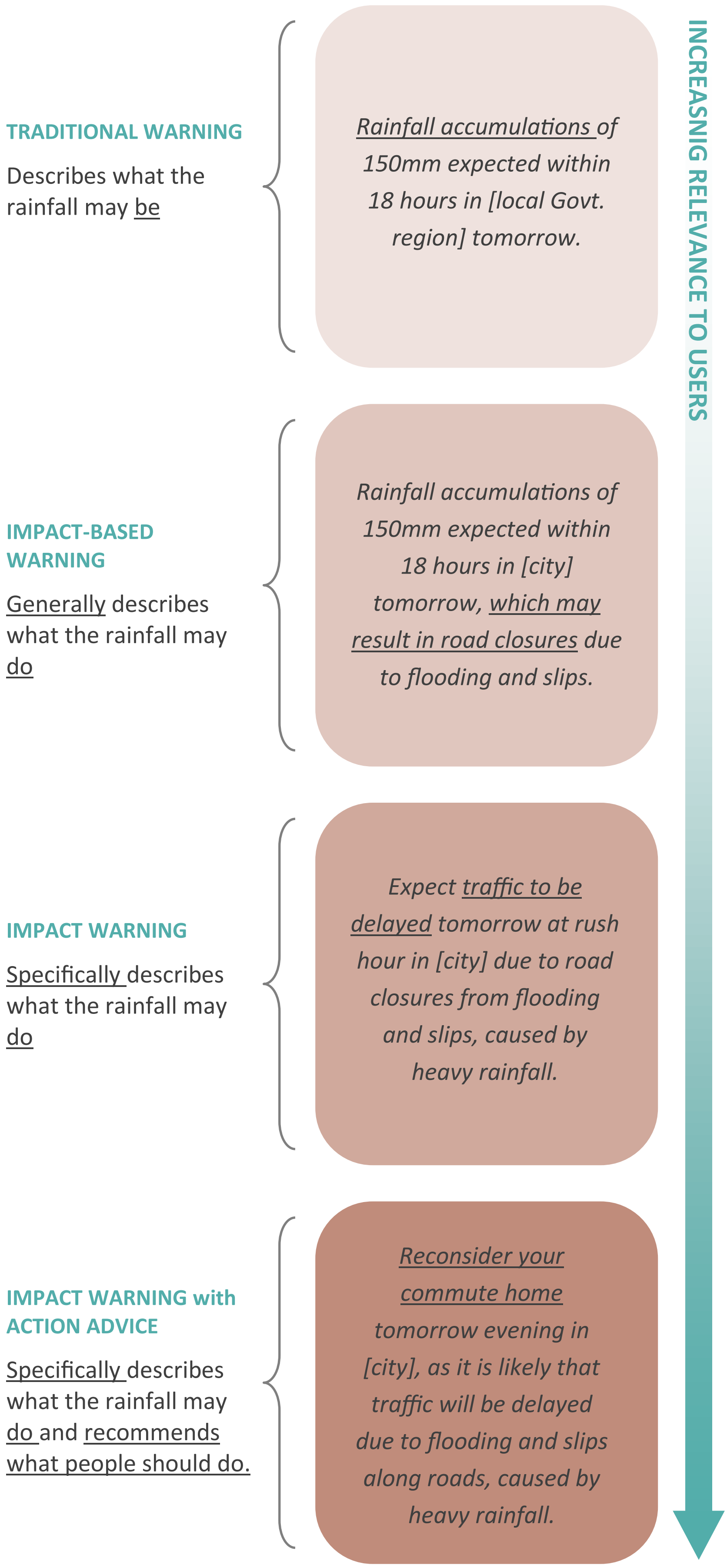

Figure 1. Comparison and examples of different types of warnings.

What are the possible approaches for developing an IBFW system?

There is a range of possible approaches to take when producing an IBWF system (Figure 2), from producing hazard-centric forecasts, to dynamic multi-hazard or impact forecasts using quantitative modelling. Qualitative approaches utilising tools such as risk/impact matrices and dialogues with partners and stakeholders can also be used. An additional feature could be included, that delivers tailored forecasts for individuals according to their location, and relates to multiple hazards. They could personalise their preferences, such as using a check-box system on a website or app to indicate their interests or situation (such as farmer, horticulture, school, hospital), and receive related impact information and guidance as part of the forecast. The approach adopted depends on the resources and capacity required and available, as well as the hazard and context. Thus, the system should be co-developed with the partners and users.

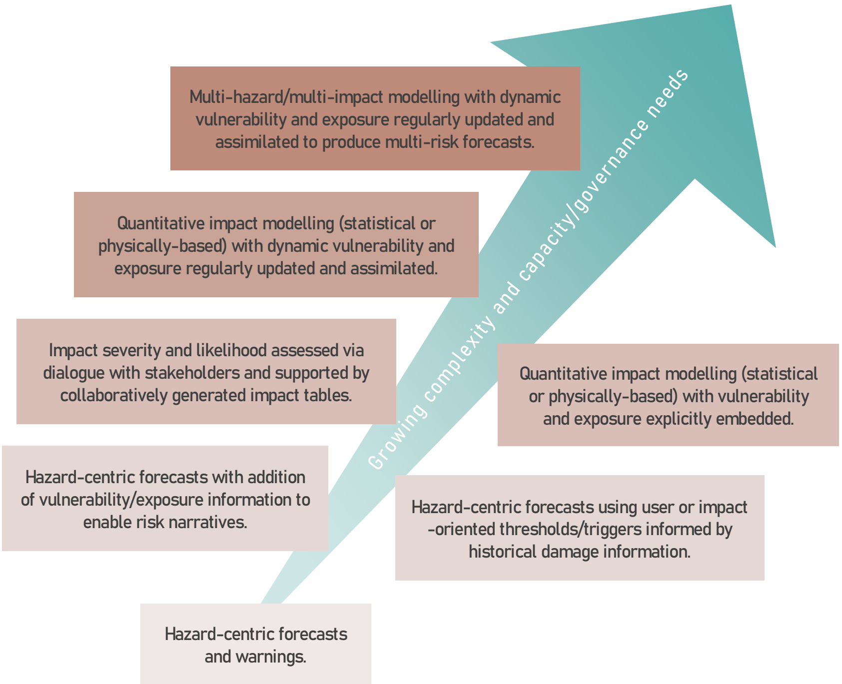

Figure 2. Spectrum of approaches for hazard and impact forecasting. Adapted from Robbins et al. 2022.

Co-development of IBFWs with the users and partner agencies

IBFWs should be co-developed with both the partner agencies who possess the required data and knowledge and/or have a role in warning communication and response, and the intended users. Examples of key IBFW partners and user groups are provided in Figure 3.

IBFW providers need a clear understanding of the range of users who can receive forecasts and warnings, make decisions, and take action based on them. Early engagement with users is critical. Some questions that should be answered through engagement include:

- what risks and impacts are users trying to reduce?
- What challenges do users face at the onset of and during a hazardous event?
- What forecast and warning information do users need to enable decision-making and action to reduce risk?
- What forecast and warning information, if any, is currently being used?
- What are the costs of action, and what would be the consequences of false alarms?

PUBLICS

- Individuals
- Communities (including at risk groups, schools etc.)
- Community leaders

GOVERNMENT

- National government departments
- Local government
- Public health

CIVIL PROTECTION

- Emergency responders
- Humanitarian and development agencies

BUSINESS

- Local, national, and multinational
- Agriculture, farmers

INFRASTRUCTURE

- Transport
- Telecommunications
- Utilities

Figure 3. Examples of key IBFWs user groups and partners. Adapted from the WMO Guidelines on Multi-Hazard Impact-Based Forecast and Warning Services: Part II (WMO, 2021).

What do we need in order to issue IBFWs?

To issue IBFWs, we need to combine:

- our understanding of the hazard severity and location,
- knowledge about the people, buildings, and lifelines (etc.) exposed to the impending hazard, and
- the vulnerability and capacities of the people, buildings and infrastructure exposed to the hazard.

This underlying information, shown in Figure 4, all contributes to the overall assessment of likely impacts, i.e., the risk. This information can be combined using different approaches as shown in Figure 2.

Once there is an idea of the expected level of impacts for an impending hazard, the warning level can be assigned using pre-determined thresholds, and the appropriate message can be communicated for the target audiences.

See p. 5 for more in-depth definitions.

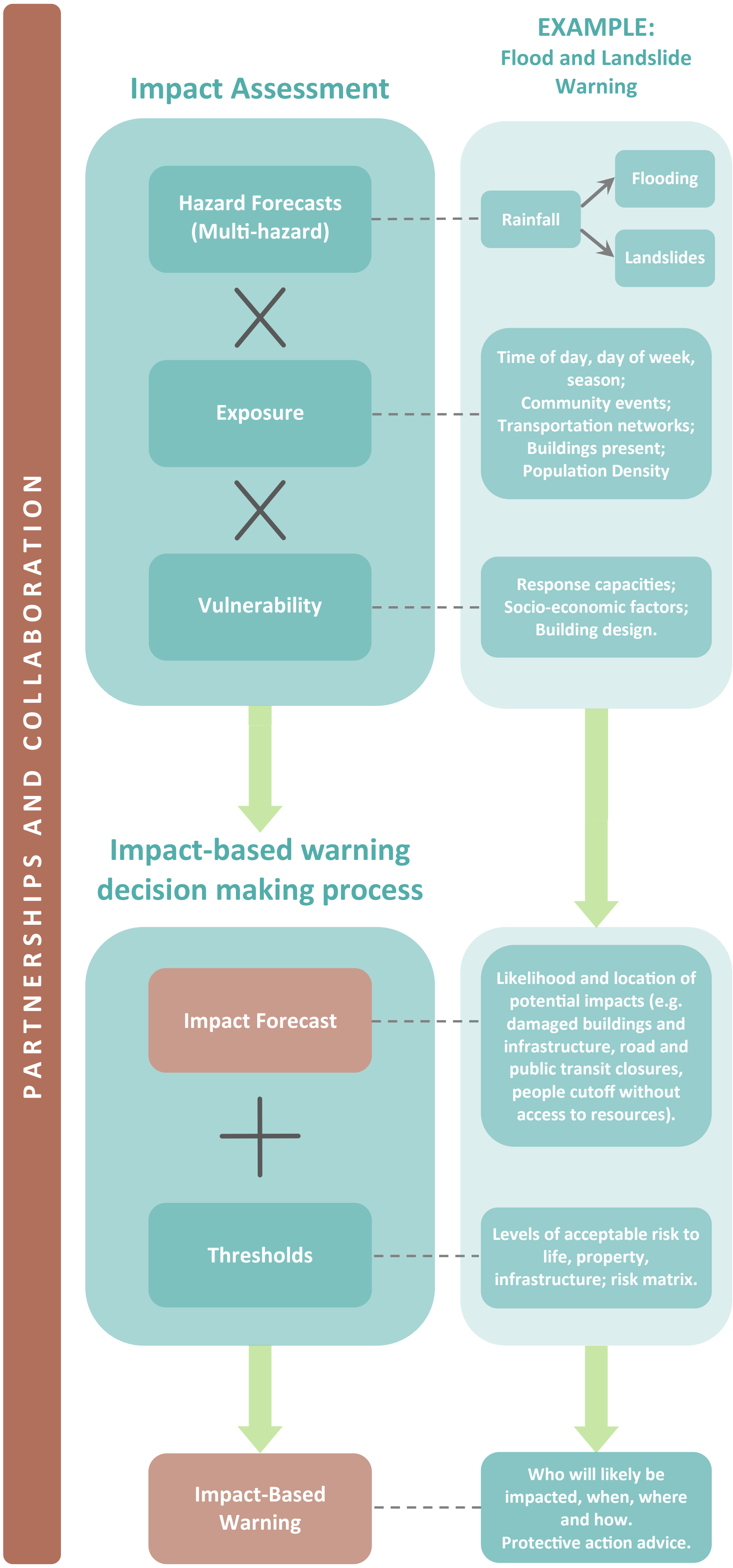

Figure 4. The IBFW process and components. The example provided in the diagram is for heavy rainfall that can result in flooding and landslides. Flooding and landslides are the secondary hazards that can be forecasted. The impacts are then forecasted based on the underlying vulnerability and exposure. The dark teal boxes indicate the inputs and the pale brown boxes are the outputs. The light teal boxes provide an example for flood and landslide impact-based forecasts and warnings. The dark brown box demonstrates the role and importance of partnerships and collaboration throughout the process.

Definitions of the elements of risk

HAZARD

- An event that has the potential to impact on human life, property, buildings, lifelines, and the economy (combined, these are referred to as elements at risk).
- The level of hazard depends on the event characteristics:
  - ⇒ Magnitude – how large is the event in terms of metrics such as volume (flood, volcanic ash), wind speed (storms), material displaced (landslides), energy produced (earthquakes, wildfire)?
  - ⇒ Duration – how long will the event last?
  - ⇒ Extent – what geographical area will potentially be affected?
  - ⇒ Speed of onset – will the onset be a few seconds to a few hours (e.g., earthquakes, local source tsunami, flash floods)? A few hours to a few days (e.g., storm winds, storm surge, river floods, frosts)? Or will it have a slow onset (e.g., drought)?

EXPOSURE

- Who and what may be affected in an area in which a hazard may occur, and where and when a person or asset (building, road network, power network, etc.) is in relation to the hazard.
- Exposure is a necessary determinant to risk and is dynamic: it changes over space and time as people move throughout the day.

VULNERABILITY AND CAPACITIES

- Vulnerability describes the characteristics and circumstances of elements at risk (e.g., human life and property) that make them susceptible to the damaging effects of a hazard.
- Vulnerability is determined by physical, social, economic, and environmental factors or processes.
- Vulnerability is situation specific, interacting with the hazard to generate risk. Therefore, like exposure, vulnerability may also be dynamic (i.e., time and space dependent).
- Capacities are the combination of all the strengths, attributes and resources available within an organisation, community or society to manage and reduce disaster risks and strengthen resilience.
- Capacity information can include risk mitigation and response plans, and agencies using disaster risk knowledge to inform their management practices.

IMPACT OR CONSEQUENCE

- The impact or consequence is the outcome of the hazard interacting with people and assets.
- Impacts are influenced by the exposure and vulnerability of the people and assets that are at risk to the hazard, and by the hazard characteristics.

RISK

- Risk considers the likelihood of the hazard occurring (which depends on the hazard characteristics described above), and the potential impact(s) on the natural, economic, built or social environments as a result of the hazard.

Further Information

This is a brief overview of key concepts and possible approaches for developing IBFW systems. It has been developed by Sara Harrison and Sally Potter from GNS Science with funding from Weather & Wildfire programme of Kia Manawaroa - Ngā Ākina o Te Ao Tūroa Resilience to Nature's Challenges National Science Challenge.

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