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Qualitative Assessment of Complex and Interacting Climate Risks

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May 2023

Presented at the 2024 All Actuaries Summit

The Actuaries Institute acknowledges the traditional custodians of the lands and waters where we live and work, travel, and trade.
We pay our respect to the members of those communities, Elders past and present, and recognise and celebrate their continuing custodianship and culture.

Contents

Background

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Introduction to climate change risk

Risk = Hazard x Exposure x Vulnerability

Climate change risks can be quantified by hazard, exposure, and vulnerability

Traditionally, we focus on the climate change risks on the built environment i.e. properties and buildings

But many are recognising the need to expand this scope to include social, natural, and economic *domains* to get a holistic view of climate change risk

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Introduction to climate change risk

Four domains

Built Environment – the risk of physical damage to residential and commercial property, industrial facilities and public and private infrastructure

Social – the risk of loss or harm to human lives and communities

Natural – the risk of damage to the natural environment

Economy – the risk of disruption to the economy

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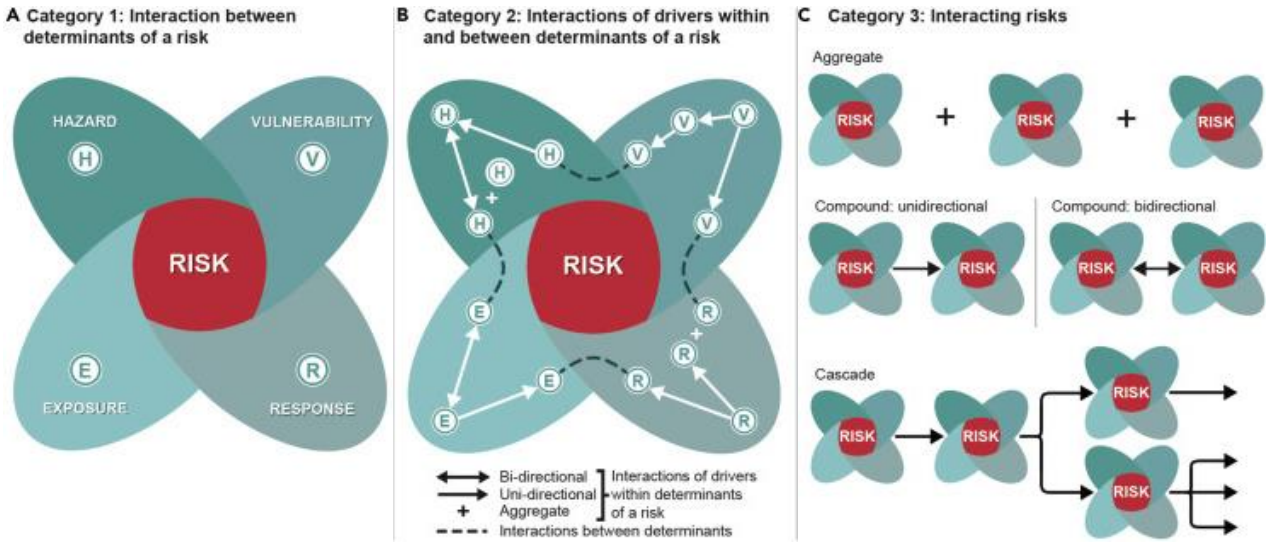
Framework for complex climate risk assessment

There are limitations to relying solely on a quantitative assessment as climate change risk is extremely complex.

The complex risk framework by Simpson et al., (2021) captures the complexity nicely. The diagram shows the three categories of *interaction*:

- Interactions between *determinants* of risk
- Interactions of *drivers* within and between determinants of risk
- Interacting risks (or *domains*)



Simpson, N. P., Mach, K. J., Constable, A., Hess, J., Hogarth, R., Howden, M., . . . Rober, D. (2021). *A framework for complex climate change risk assessment.* One Earth. Retrieved from https://doi.org/10.1016/j.oneear.2021.03.005

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Categories of interactions (1)

Example of interactions between *determinants* of risk

- Built risk depends on interactions between bushfire (*hazard*), roof and wall type (*vulnerability*), and the location of the building (*exposure*)

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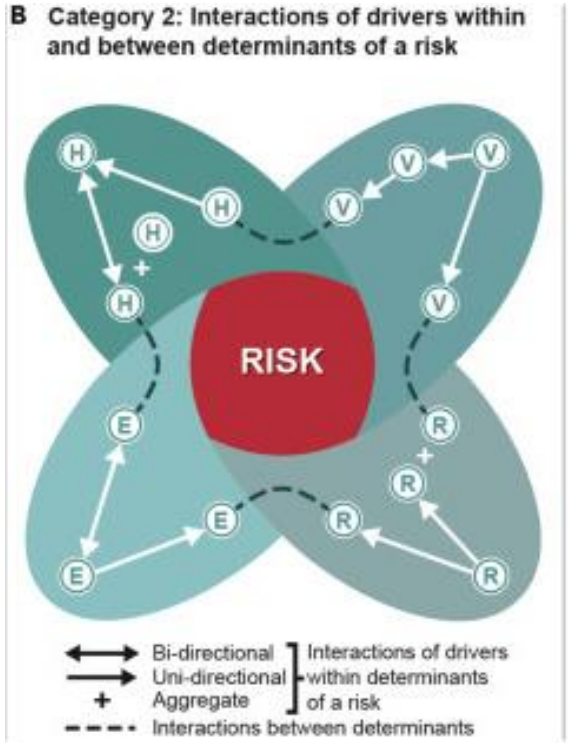
Categories of interactions (2)

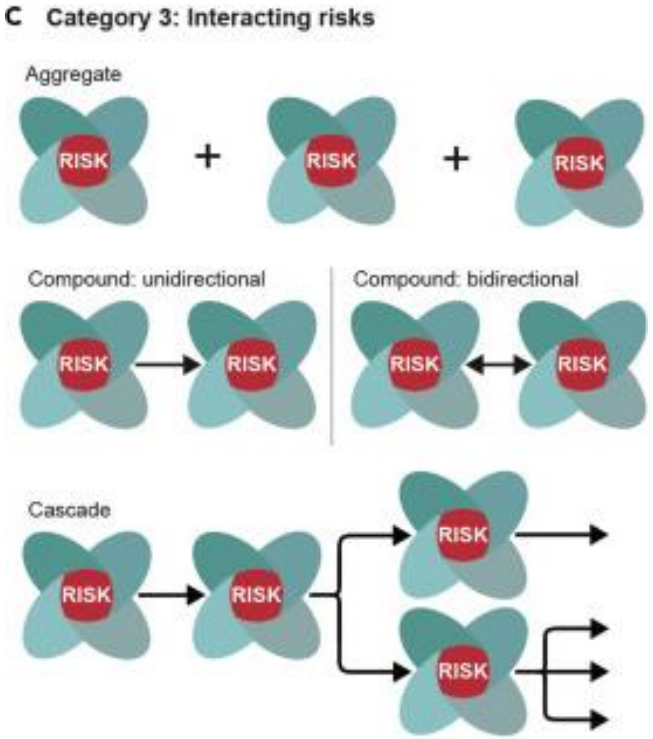


Example of interaction of *drivers* within and between *determinants* of risk:

- Burden of recovery and volunteering (*social vulnerability*) shifts to a small group of people (*social vulnerability*) as time passes by
- COVID compounded the impacts of bushfires (*hazard*) on people and hindered their recovery (*social vulnerability*). COVID lockdowns prevented community support and engagement for recovery (*social vulnerability*)
- Change in levels of vegetation (*natural exposure*) and bushfire threat level (*natural vulnerability*) are interlinked as increased vegetation can increase fuel loads

Simpson, N. P., Mach, K. J., Constable, A., Hess, J., Hogarth, R., Howden, M., . . . Rober, D. (2021). *A framework for complex climate change risk assessment.* One Earth. Retrieved from https://doi.org/10.1016/j.oneear.2021.03.005

Categories of interactions (3)



Examples of interacting risks (or *domains*):

- Power outages on transport network (*economic exposure*) impede communication and the ability to acquire food, medication (*social vulnerability)*
- Air pollution or poor air quality (*natural exposure)* causes heart and lung disease and puts the elderly and children at most risk (*social vulnerability)*
- Storms (*hazard*) decrease agricultural productivity, leading to decline community capital wealth (*social vulnerability*) and natural resources (*natural exposure*) which reduces quality of life (*social vulnerability*)

Simpson, N. P., Mach, K. J., Constable, A., Hess, J., Hogarth, R., Howden, M., . . . Rober, D. (2021). *A framework for complex climate change risk assessment.* One Earth. Retrieved from https://doi.org/10.1016/j.oneear.2021.03.005

Value for qualitative risk assessments

Quantitative Assessment

Pros

- Better for numerical representation
- Feed into cost-and-benefit frameworks more easily

Cons

- Numerical output does not give insight to drivers of risk and how they can be changed
- Computational complexity
- Fail to identify feedback loops caused by non-

Qualitative Assessment

Pros

- Can include interactions
- Can include non-linear effects
- More tractable for systems thinking and systemic impacts

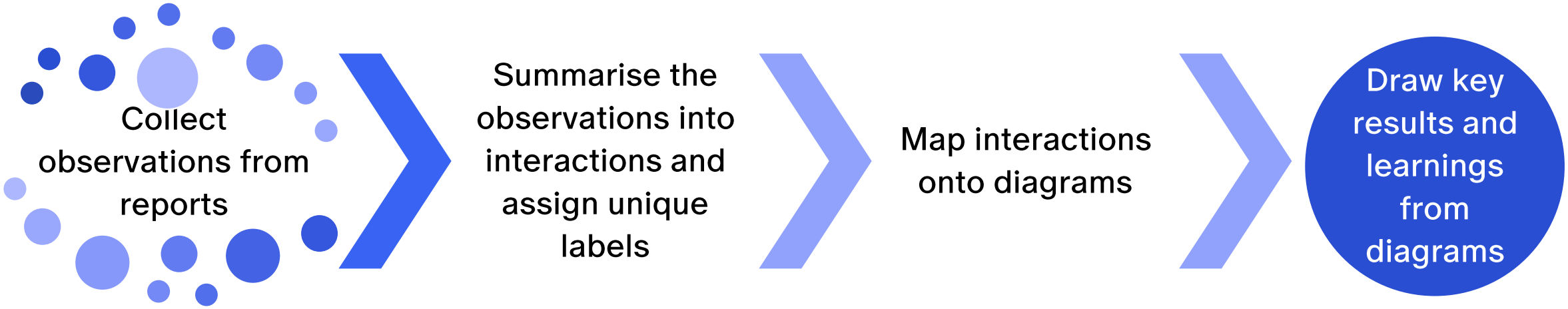
Cons

- Limited quantification of the relative size of risks
- Less ability to upscale

A qualitative risk assessment can help identify the interactions between hazard, vulnerability, and exposure that a quantitative assessment typically fails to capture

Methodology

- Data source: Community interviews and stakeholder reports; we chose to focus our analysis on bushfire and flood hazards as they have caused the most devastation to each domain historically – by no means an exhaustive list of all possible sources of climate risk interactions!
- Analysis: Identify recurring themes and interactions across various reports; Confidence in findings increases with repeated observations and thematic consistencies
- Process goes from data collection to data summary and finally data visualisation



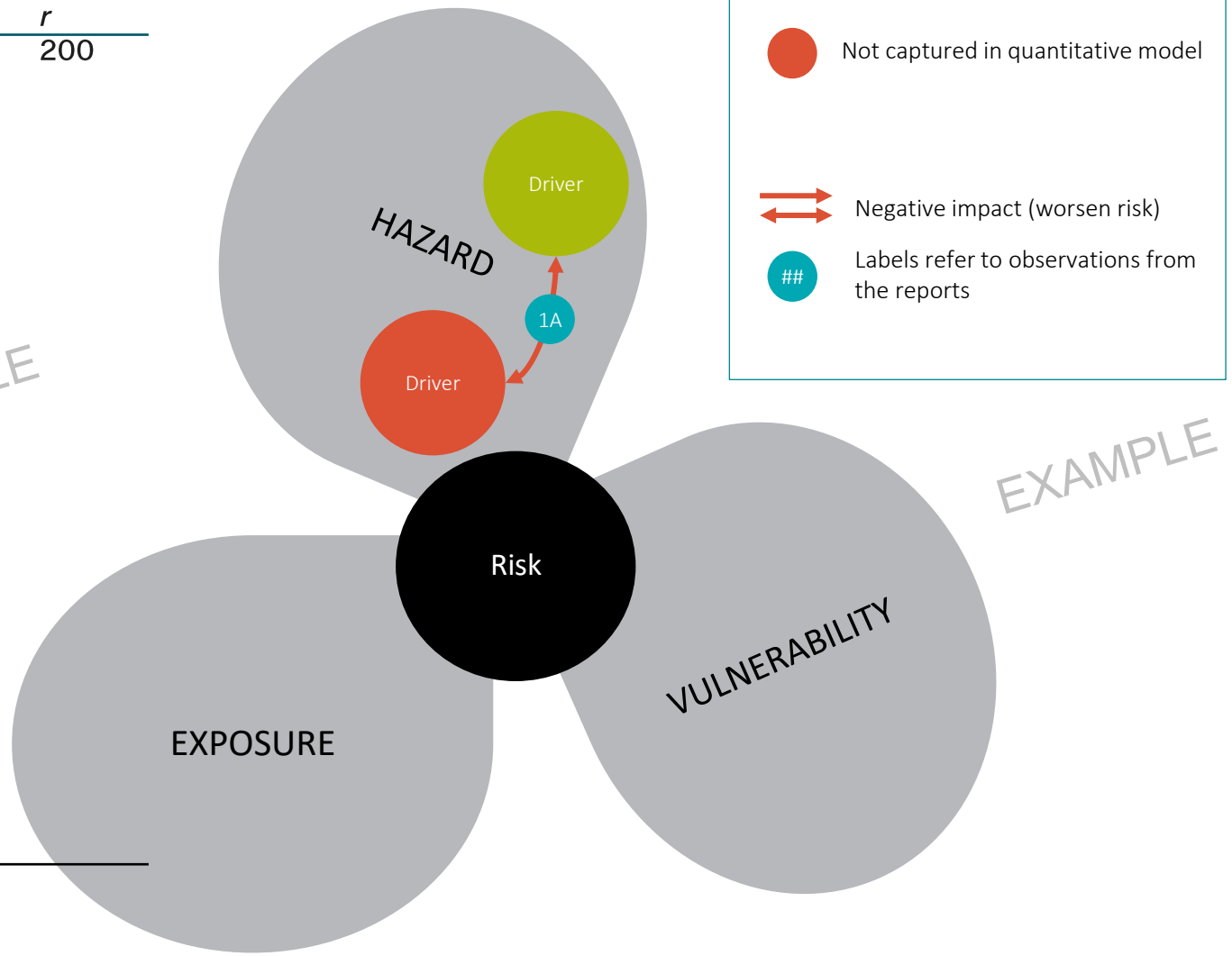
Referenced reports for qualitative assessment

	Report
A	Community experiences of the January – July 2022 floods in New South Wales and Queensland, Summary Report (Natural Hazards Research Australia , 2023)
B	Western Enabling Regional Adaptation, Central West and Orana region report (State of New South Wales and Office of Environment and Heritage, 2017)
C	Western Enabling Regional Adaptation, Far West region report (State of New South Wales and Office of Environment and Heritage, 2017)
D	Final Report of the NSW Bushfire Inquiry (Owens & O'Kane, 2020)
E	Black Summer – How the NSW Community Responded to the 2019-20 Bushfire Season: Research for the NSW Rural Fire Service (Whittaker J, 2021)
F	NSW Flood Inquiry Volume 1 Summary Report (2022)
G	Western Enabling Regional Adaptation, New England North West region report (State of New South Wales and Office of Environment and Heritage , 2017)

	Report
H	Western Enabling Regional Adaptation, Riverina Murray region report (State of New South Wales and Office of Environment and Heritage, 2017)
I	Bushfire-affected waterways (NSW Department of Planning and Environment , 2023)
J	Integrated Regional Vulnerability Assessment: North Coast of New South Wales, Volume 1: Assessment Report (NSW Government, Office of Environment and Heritage, 2016)
K	Urban Heat Climate Change Impact Snapshot (NSW Government Office of Environment and Heritage , 2015)
L	Sydney Air Quality Study Stage 2 Fact Sheet (NSW Government Department of Planning and Environment, 2023)
M	Understanding the experiences of women in disasters: lessons for emergency management planning (Australian Institute for Disaster Resilience, 2022)
N	Women's health-related vulnerabilities in natural disasters: a systematic review protocol (Riyad Fatema S, 2019)
O	Cultural Flows, A Guide for First Nations (Murray Darling Basin Authority, 2010)
P	10 Years Beyond Bushfires Report (Gibbs L, 2020)

Example output

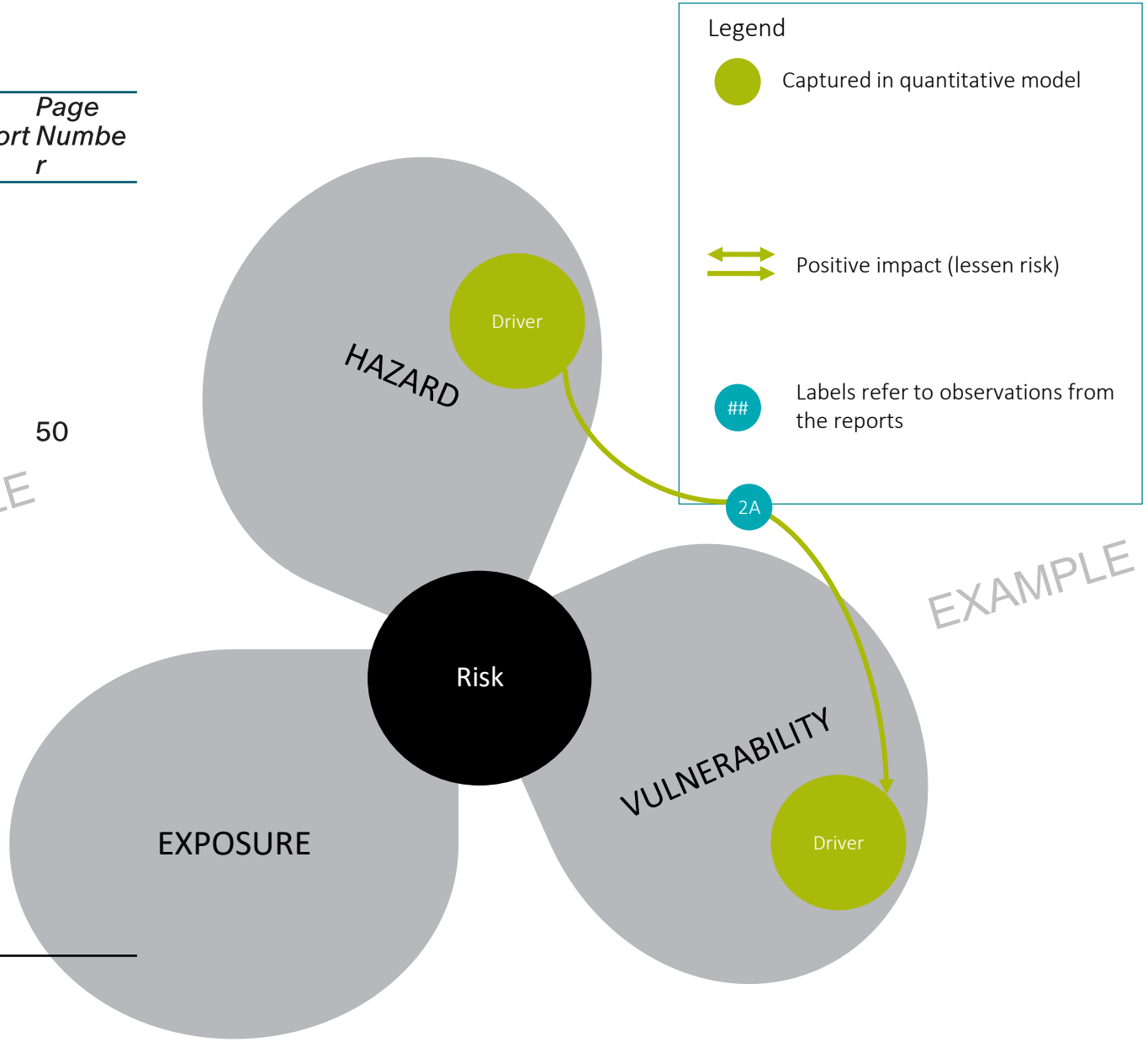
Label	*Interaction noted from report*	*Confidence*	*Report*	*Page Number*
1A	There is a two-way interaction between two drivers in the hazard determinant, where only one of these drivers are typically captured in a quantitative model. This interaction worsens risk so their relationship is represented by a red line. There were multiple observations from several reports to support this, hence the high confidence.	High	A	200



Example output

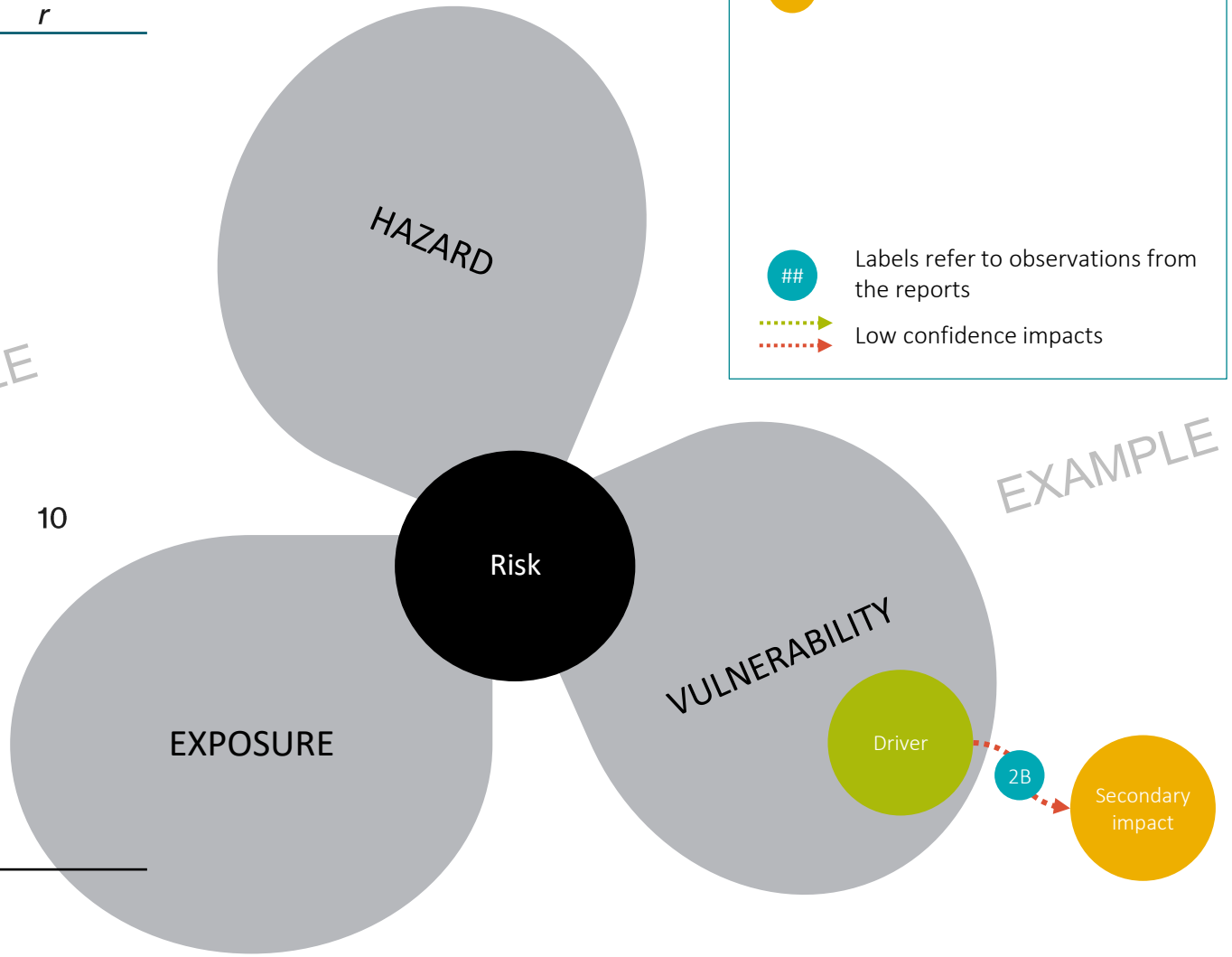
Label	*Interaction noted from report*	*Confidence*	*Report*	*Page Number*
2A	A driver within the hazard determinant and a driver within the vulnerability determinant. This interaction lessens risk so their relationship is represented by a green line. There were multiple observations from several reports to support this, hence the high confidence.	High	A	50

EXAMPLE



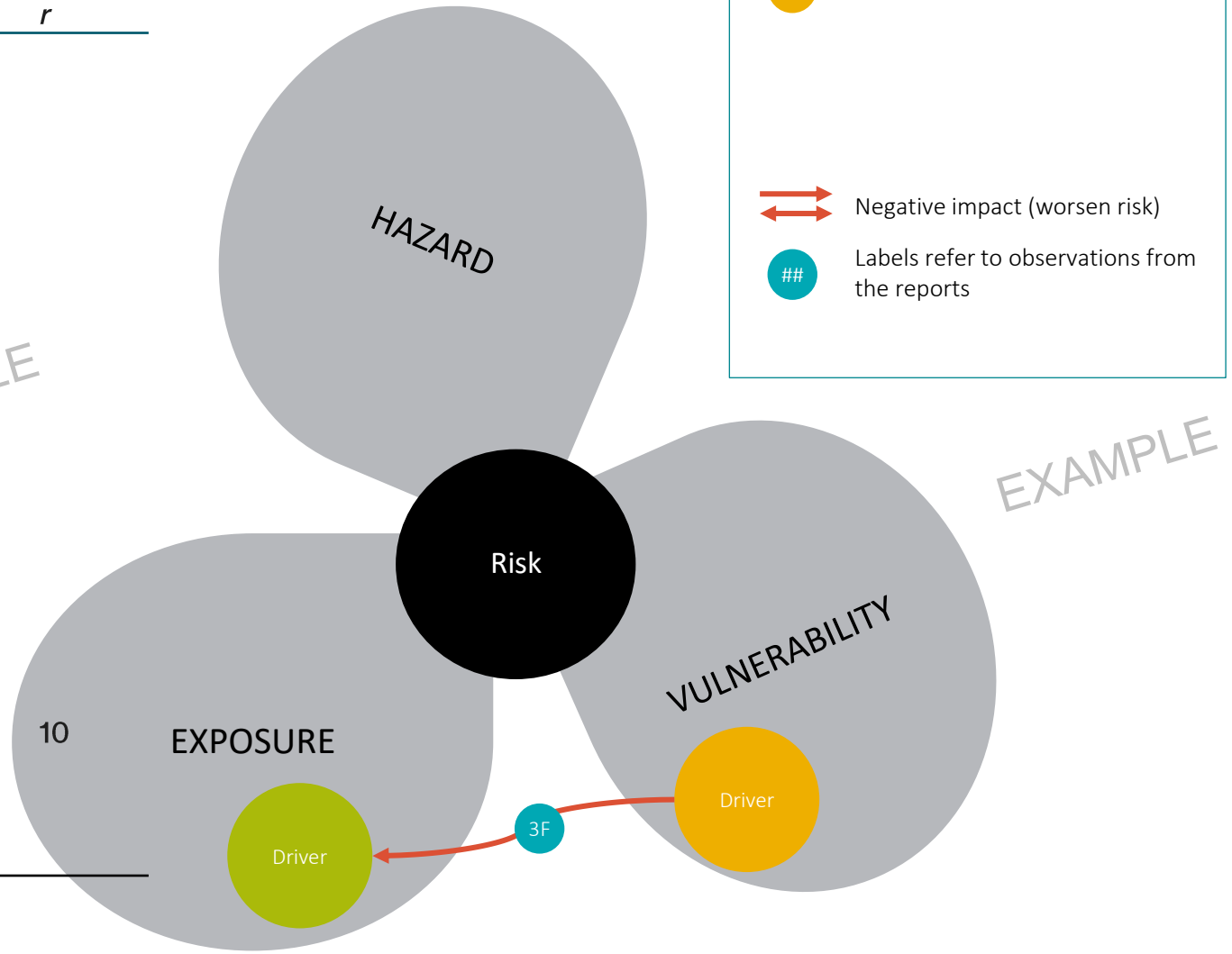
Example output

Label	*Interaction noted from report*	*Confidence*	*Report*	*Page Number*
2B	A driver within the vulnerability determinant has a secondary impact on another driver that is not typically captured within the hazard, vulnerability, or exposure of a quantitative model. This interaction was only observed once, so it is represented by dotted lines i.e. low confidence.	Low	B	10



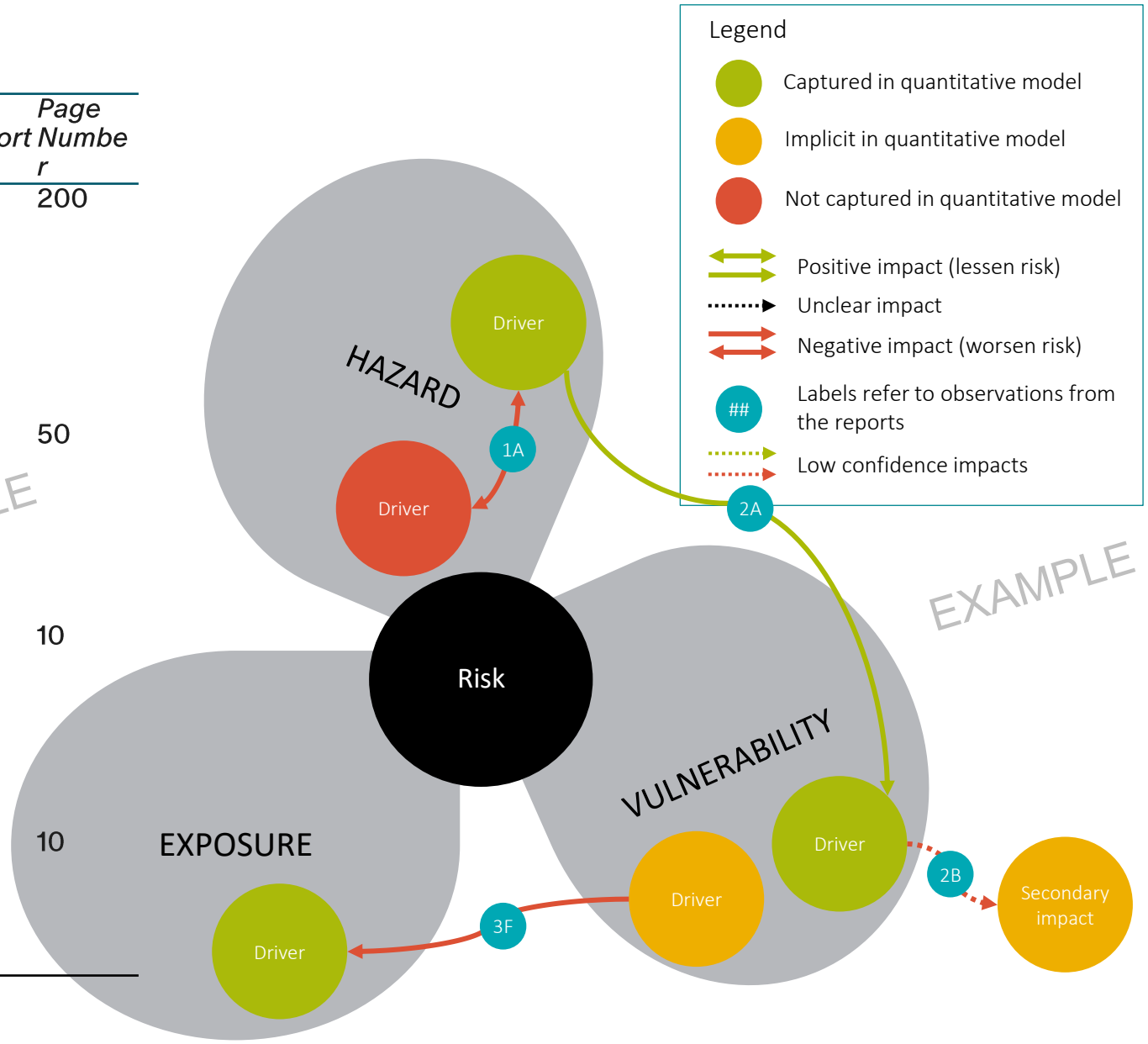
Example output

Label	*Interaction noted from report*	*Confidence*	*Report*	*Page Number*
3F	A driver in the vulnerability determinant has an impact on a driver in the exposure determinant. There were multiple observations from several reports to support this, hence the high confidence.	High	F	10



Example output

Label	*Interaction noted from report*	*Confidence*	*Report*	*Page Number*
1A	There is a two-way interaction between two drivers in the hazard determinant, where only one of these drivers are typically captured in a quantitative model. This interaction worsens risk so their relationship is represented by a red line. There were multiple observations from several reports to support this, hence the high confidence.	High	A	200
2A	A driver within the hazard determinant and a driver within the vulnerability determinant. This interaction lessens risk so their relationship is represented by a green line. There were multiple observations from several reports to support this, hence the high confidence.	High	A	50
2B	A driver within the vulnerability determinant has a secondary impact on another driver that is not typically captured within the hazard, vulnerability, or exposure of a quantitative model. This interaction was only observed once, so it is represented by dotted lines i.e. low confidence.	Low	B	10
3F	A driver in the vulnerability determinant has an impact on a driver in the exposure determinant. There were multiple observations from several reports to support this, hence the high confidence.	High	F	10



Results

02

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The next few slides...

We will not be showing the tables of interactions sitting behind the diagrams. Those are the "workings" that gives us the foundation to creating these diagrams. You can refer to our paper if you want to read the specific interactions noted by the labels in the diagram.

The purpose of talking through these results is to summarise the key learnings from going through the process of qualitative risk assessment.

We grouped the results and learnings into these:

1. Interactions within the hazard risk determinant (applies to all domains)

2. Interactions between determinants of *built* risk

3. Interactions between determinants of *social* risk

4. Interactions between determinants of *economic* risk

5. Interactions between determinants of *natural* risk

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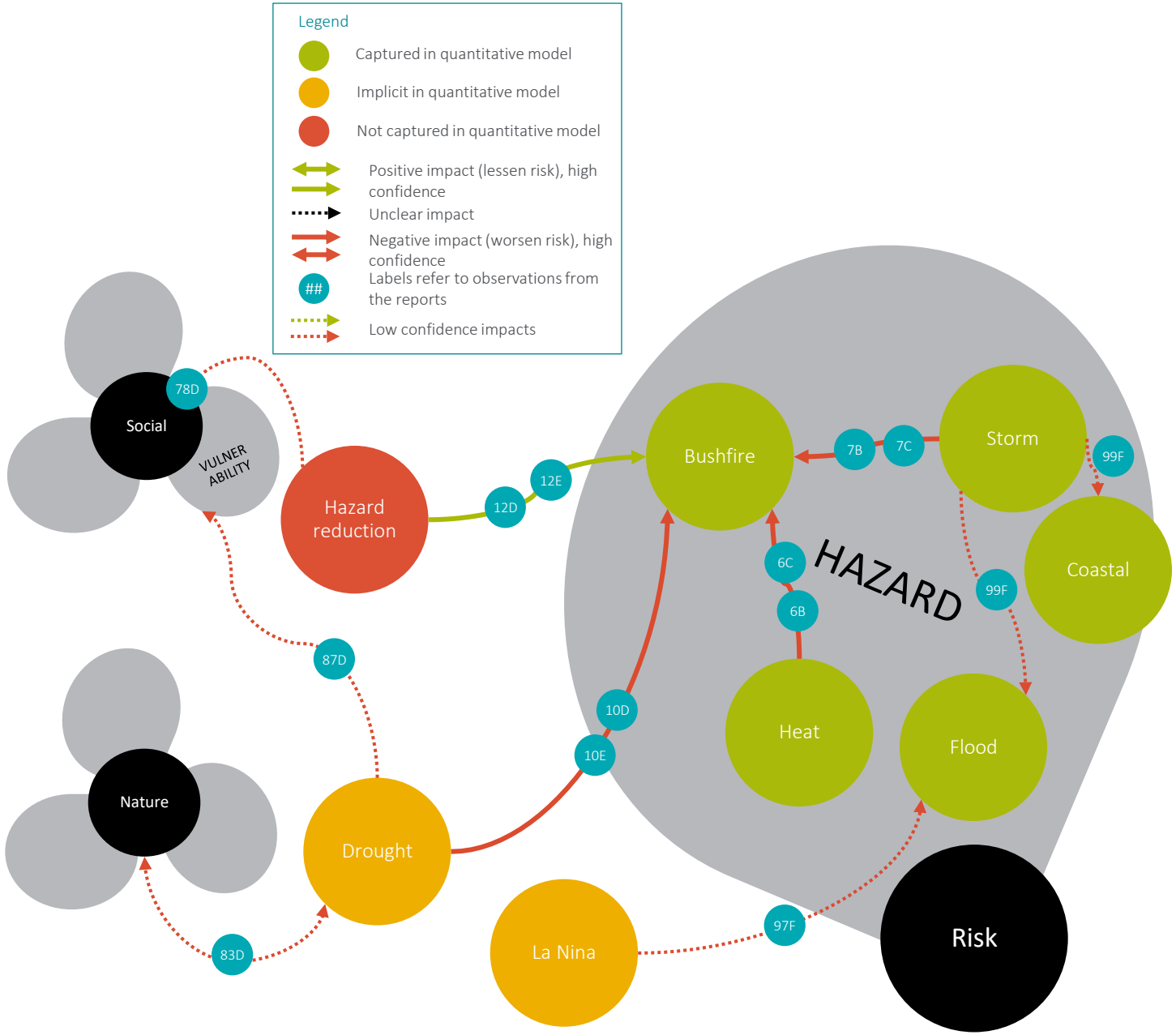
Results – Hazard risk determinant

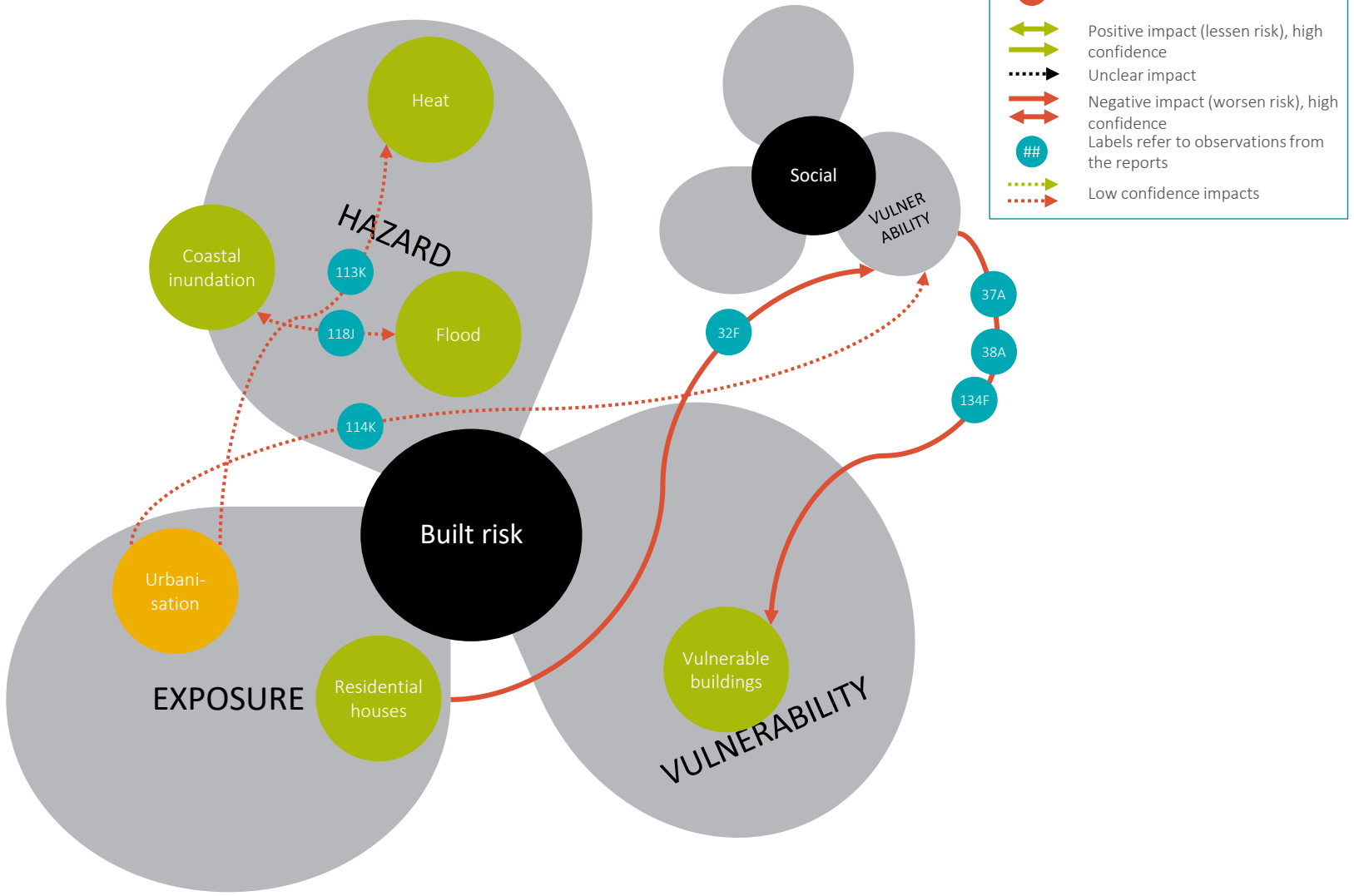
(captures all domains)

- *Hazards interact with each other* – e.g. storms can influence the occurrence of coastal inundation and erosion, floods and bushfires (through lightning); heat stress is associated with bushfires. Quantitative assessment models typically do not explicitly allow for such interactions.
- *Antecedent conditions and climate cycles can have significant impacts on hazards* – e.g. La Niña cycles are associated with increased floods in Australia. Quantitative assessment models, which are based on considering long-term timeframes, do not allow for such cycles.
- *Hazard reduction may affect antecedent conditions* – e.g. the deliberate introduction of fire to reduce fuel loads for future fires is another factor that is not explicitly allowed for within the typical quantitative models. These factors need to be considered within short term risk assessment and response planning, whereas this assessment is long-term.
- *Hazard reduction may lead to detrimental effects on social vulnerability* – e.g. smoke from hazard reduction fires can further exacerbate air quality issues.



Results – interactions between built risk and with other domains

- Low economic capital results in vulnerable populations residing in vulnerable housing, with limited opportunity for investment in resilience.
- Disasters can result in strain on economic capital for households, leading to greater social vulnerability.
- Increased urbanisation may also lead to reduced access to the natural environment, thereby reducing health benefits to populations. This can be exacerbated by heat island effects, caused by man-made hard structures that absorb or retain heat, that can increase heat hazards.



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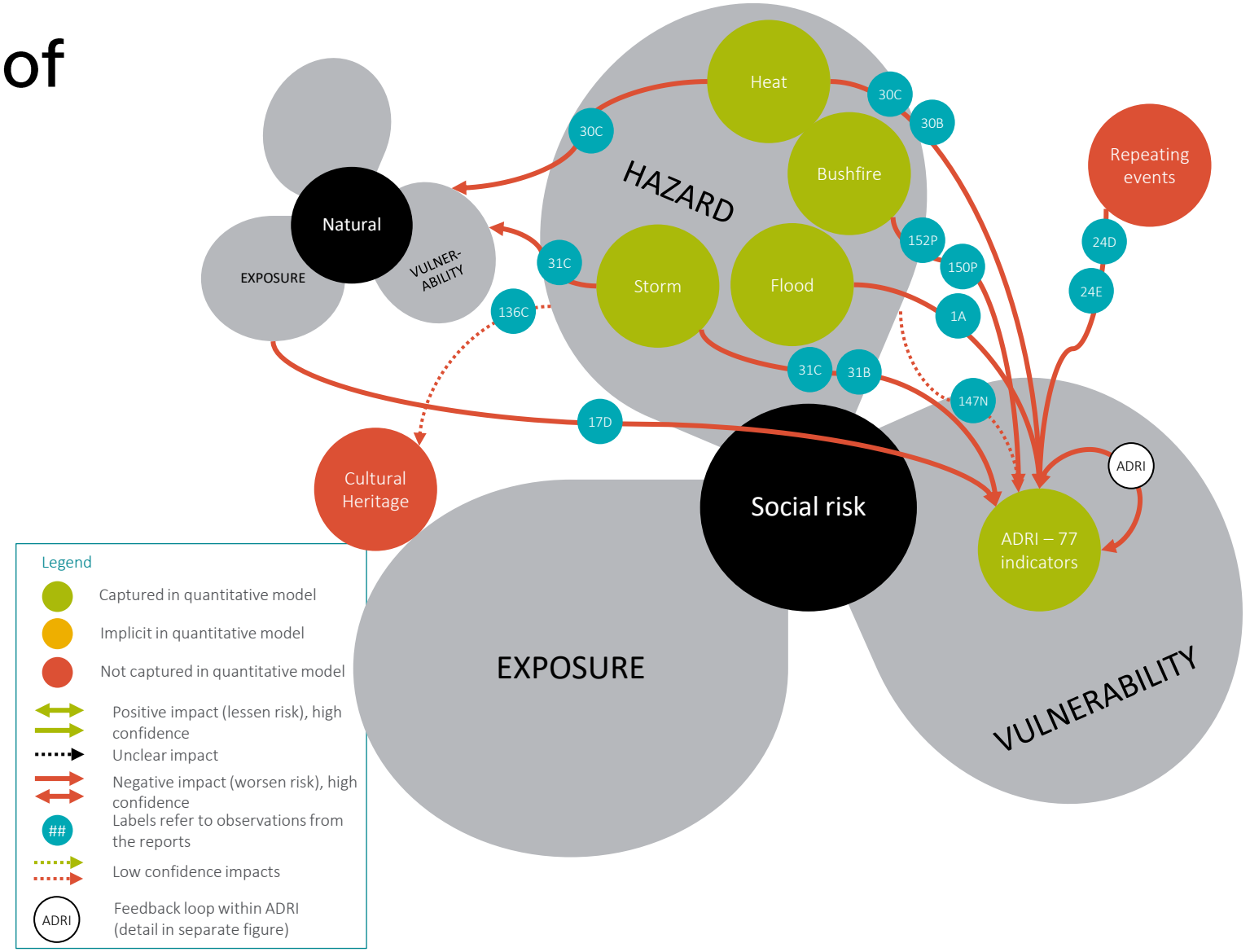
Results – interactions between determinants of social risk and with the natural domain

- Hazards can increase social vulnerability and create a feedback loop that can increase the risk over time.
- Repeating events or hazards, which are not explicitly accounted for in the typical linear quantitative model, have an impact on social vulnerability, as communities that are still recovering from one disaster are more vulnerable to another disaster. Such communities can also be more vulnerable to crime.
- Hazards also impact cultural heritage, which is an important part of the social domain.
- Social vulnerability can be measured quantitatively using the Australia Disaster Resilience Index (ADRI)[1], quantitative models do not necessarily account for the interactions between these indicators. This feedback loop within the vulnerability determinant for the social domain is labelled as 'ADRI' in the white circle

[1] For more information on the ADRI, see https://adri.bnhcrc.com.au/



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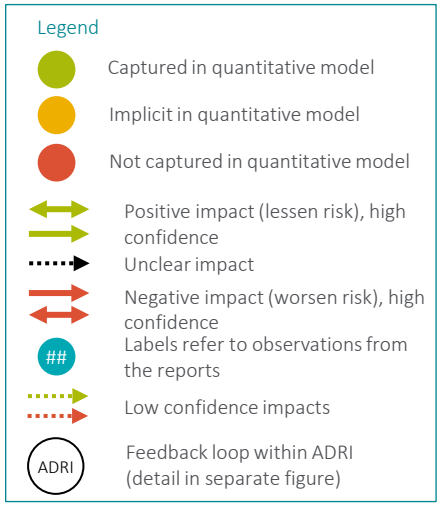
Results – interactions within the vulnerability determinant for social domain

- Social vulnerability can be measured quantitatively using the Australia Disaster Resilience Index (ADRI)[1], quantitative models do not necessarily account for the interactions between these indicators. This feedback loop within the vulnerability determinant for the social domain is labelled as 'ADRI' in the white circle

[1] For more information on the ADRI, see https://adri.bnhcrc.com.au/



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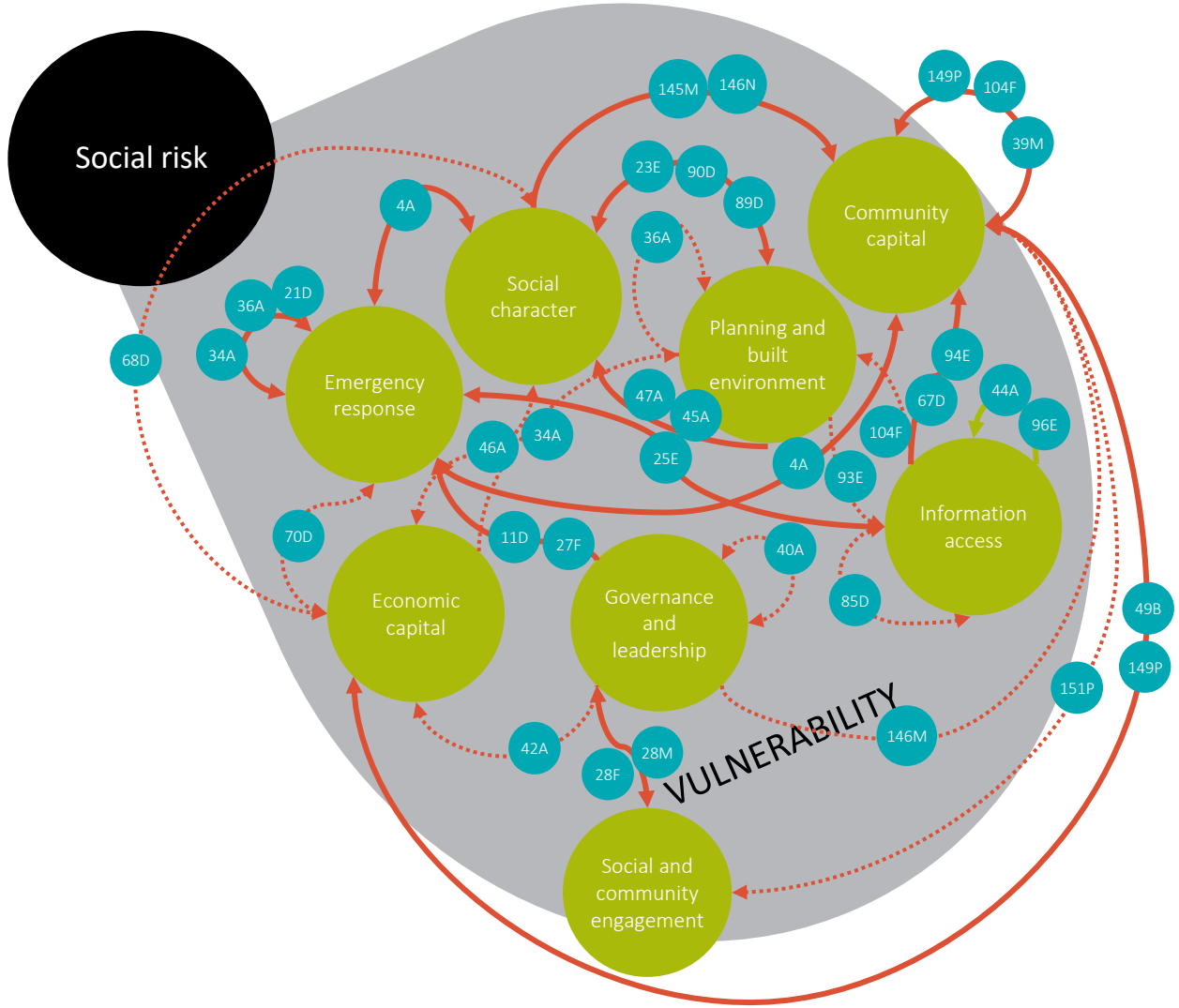
Results – interactions within the vulnerability determinant for social domain



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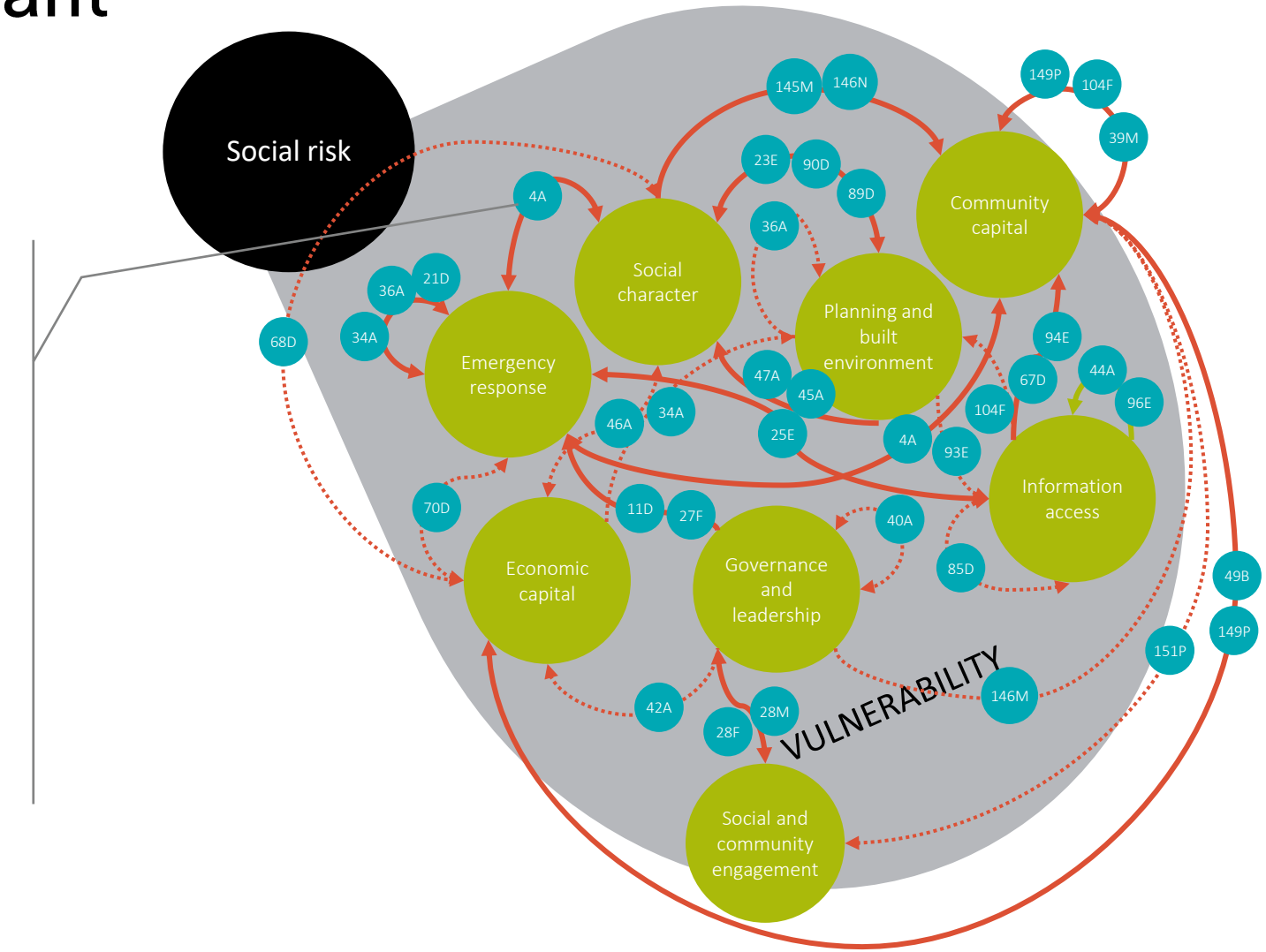
Results – interactions within the vulnerability determinant for social domain

Observations from reports that show interaction between **social character** and **emergency response**

- Burden of recovery and volunteering shifts to a small group of people as time passes by
- Removal services or clean-up processes post-disaster cause residents to feel overwhelmed with decisions
- Re-telling and re-living disaster leads to negative mental health
- Temporary housing in inappropriate locations causes extra burden



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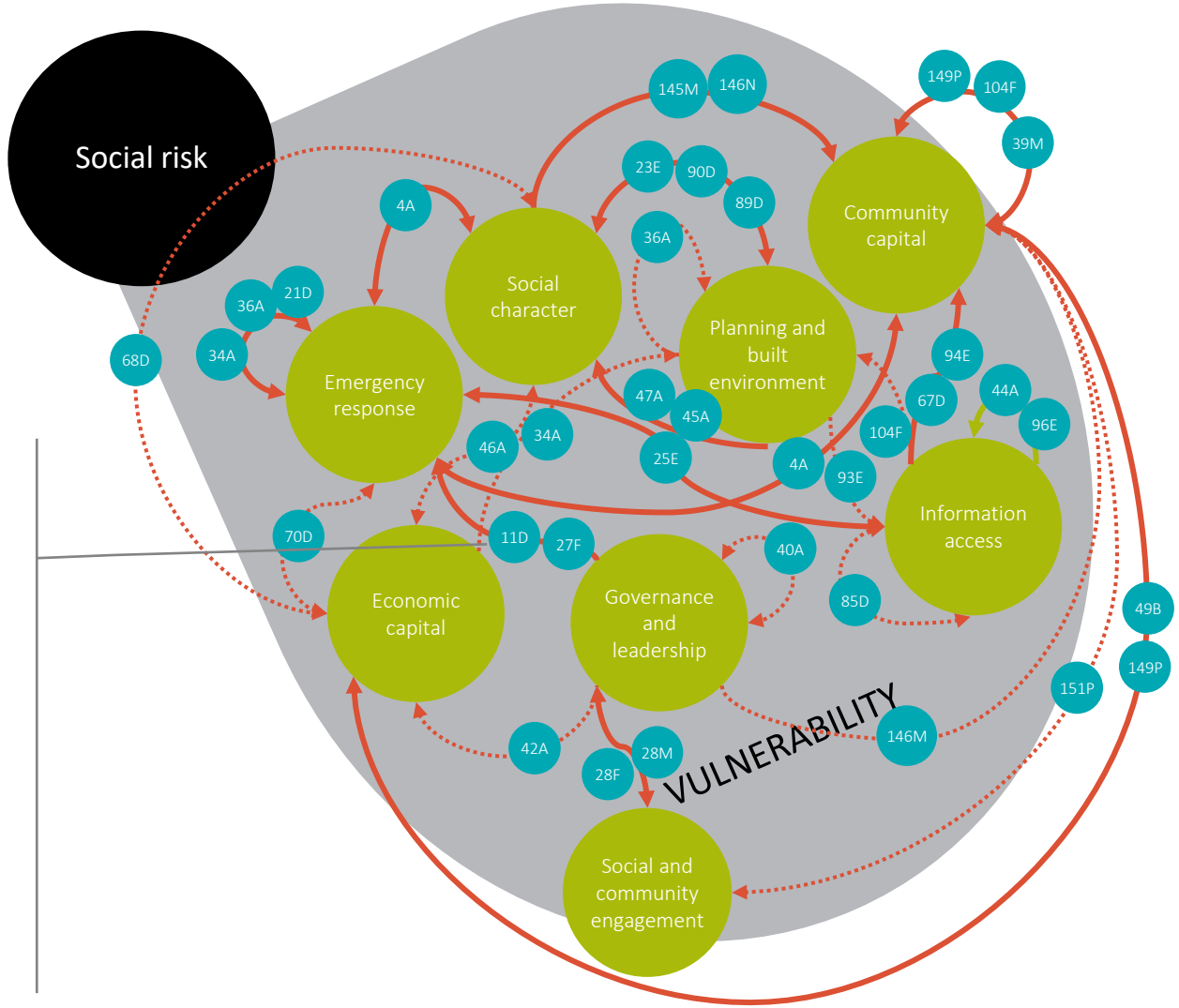
Results – interactions within the vulnerability determinant for social domain

Observations from reports that show interactions between **emergency response** and **governance and leadership**

- Community perceives hazard reduction burning difficult to obtain approval for and so do not pursue it, putting people at risk
- Early media reports on damaged properties caused distress
- People had to tell their story many times and relive the trauma
- People had to repeatedly provide personal information to different agencies post recovery



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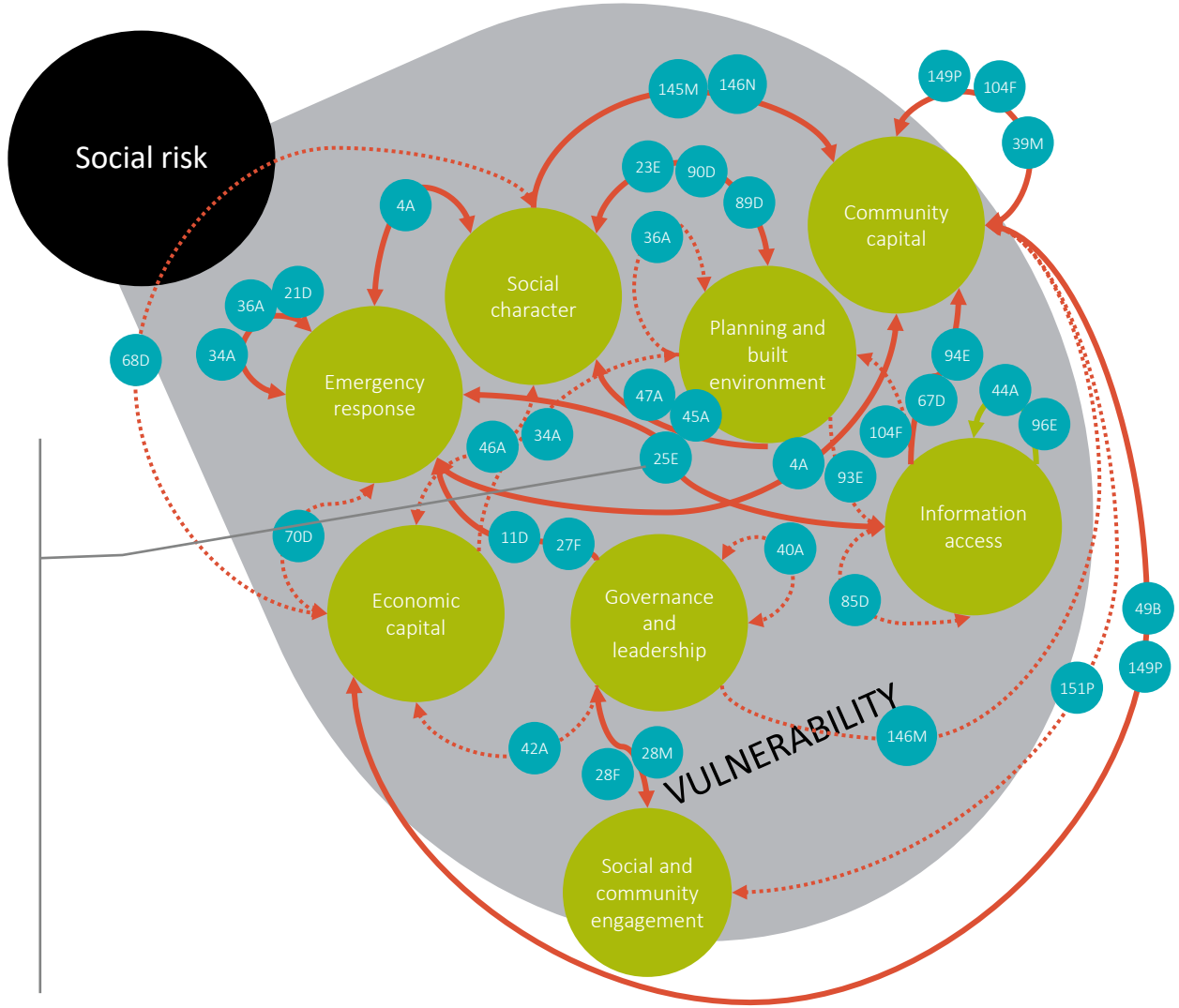
Results – interactions within the vulnerability determinant for social domain

Observations from reports that show interactions between **emergency response** and **information access**

- People were unfamiliar with official 'Neighbourhood Safer Places'
- People who seek shelter were not fully prepared Misconception among tourists that fires would not burn near the coastline
- More localised and detailed information about disaster risk can be a moral hazard for people has this information encourages people to delay evacuation information can be moral hazard for people as they delay evacuation



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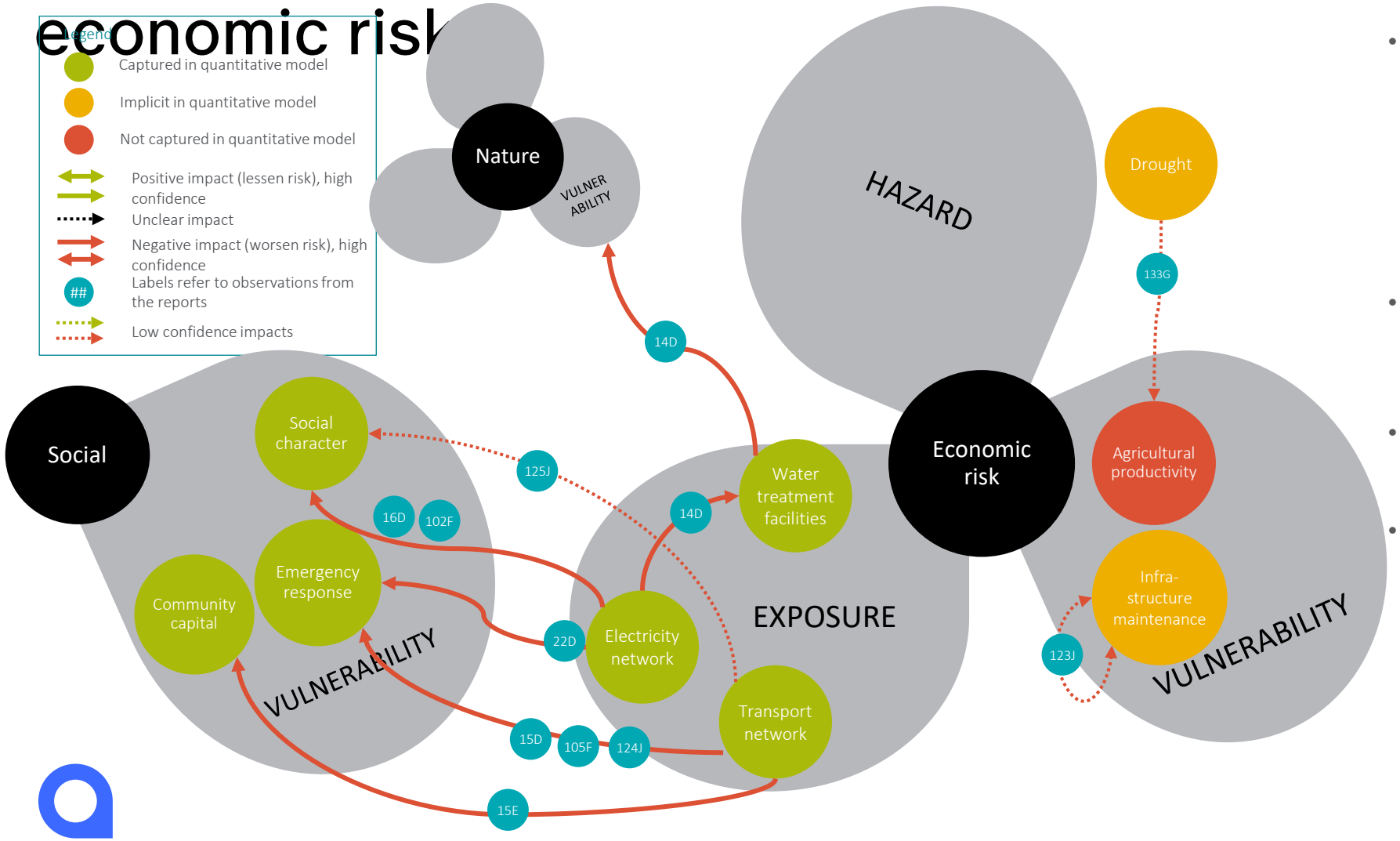
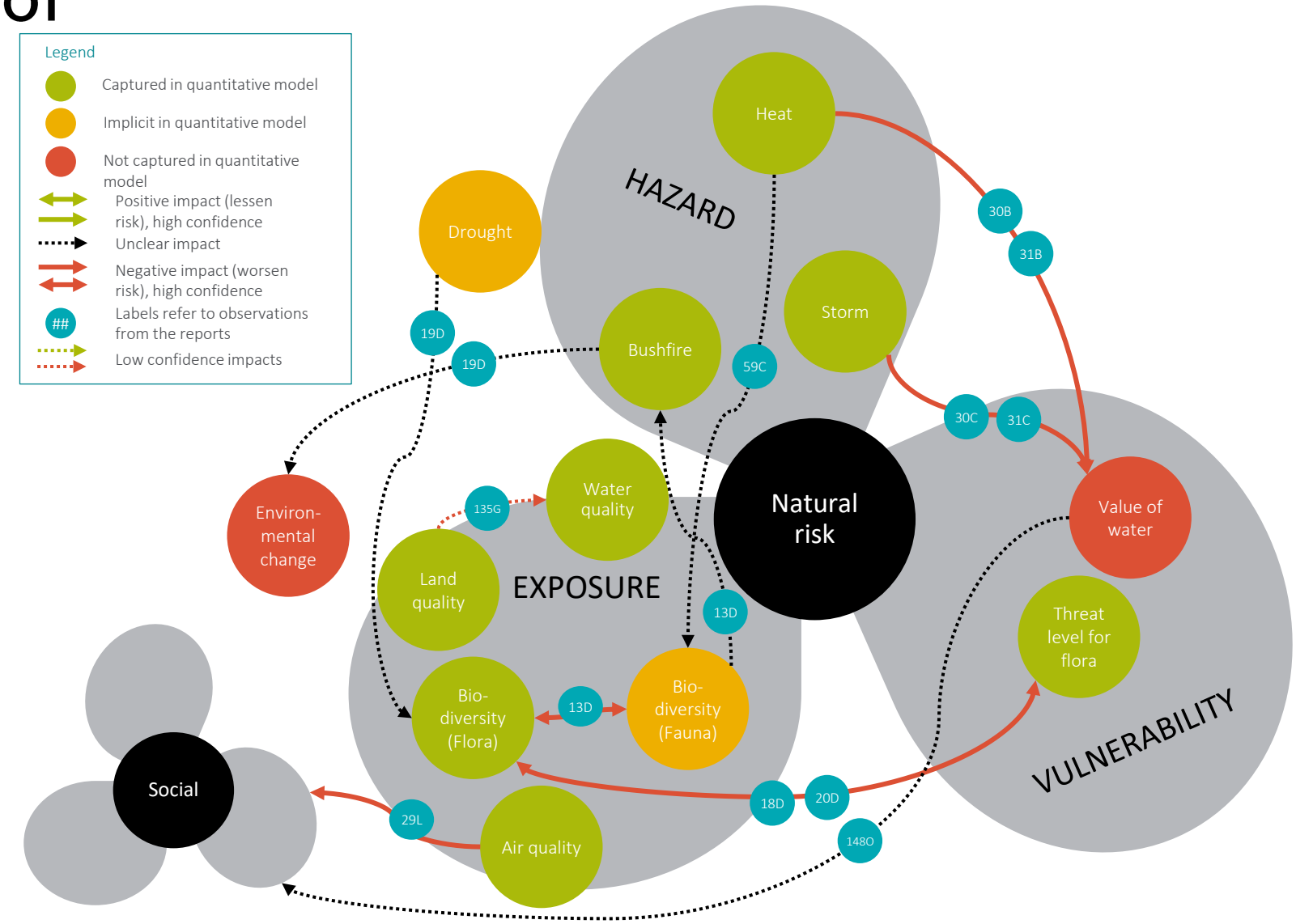
Results – interactions between determinants of economic risk



- Critical infrastructure plays a large role in disaster response and management. Many reports flagged the vulnerability and additional trauma caused by the loss of essential services and communications when critical infrastructure fails during a disaster.
- Emergency response also fails or is hindered when such critical infrastructure fails, which increases the harm to communities.
- Transportation and access to routes are also critical to emergency response.
- Where communities have low communication infrastructure, there is a compounding effect on access to emergency information, post-event societal connection, emergency response and early intervention. This has a direct impact on how people perceive the support they receive and their ability to cope with the loss resulting from disasters.

Results – interactions between determinants of natural risk

- The most important interaction is that impacts on land, water and air quality within the natural domain have consequent health impacts, affecting social vulnerability.
- Ecological environment of flora and fauna are interlinked – for example, damage to flora can impact on any fauna that depend on that flora for food or habitat. Grazing can also impact on ecological environment and soil erosion.
- Change in levels of vegetation (exposure) and bushfire threat level (vulnerability) are interlinked as increased vegetation can increase fuel loads.
- The value of water is not captured within the typical linear quantitative model but has a secondary impact from the storm hazard.
- We noted that hazards interact with each other – e.g. heat stress is associated with bushfires, which is associated with droughts. Hence any interaction with heat, for example heatwaves changing breeding behaviours for fauna, will also be interlinked with bushfires and drought.

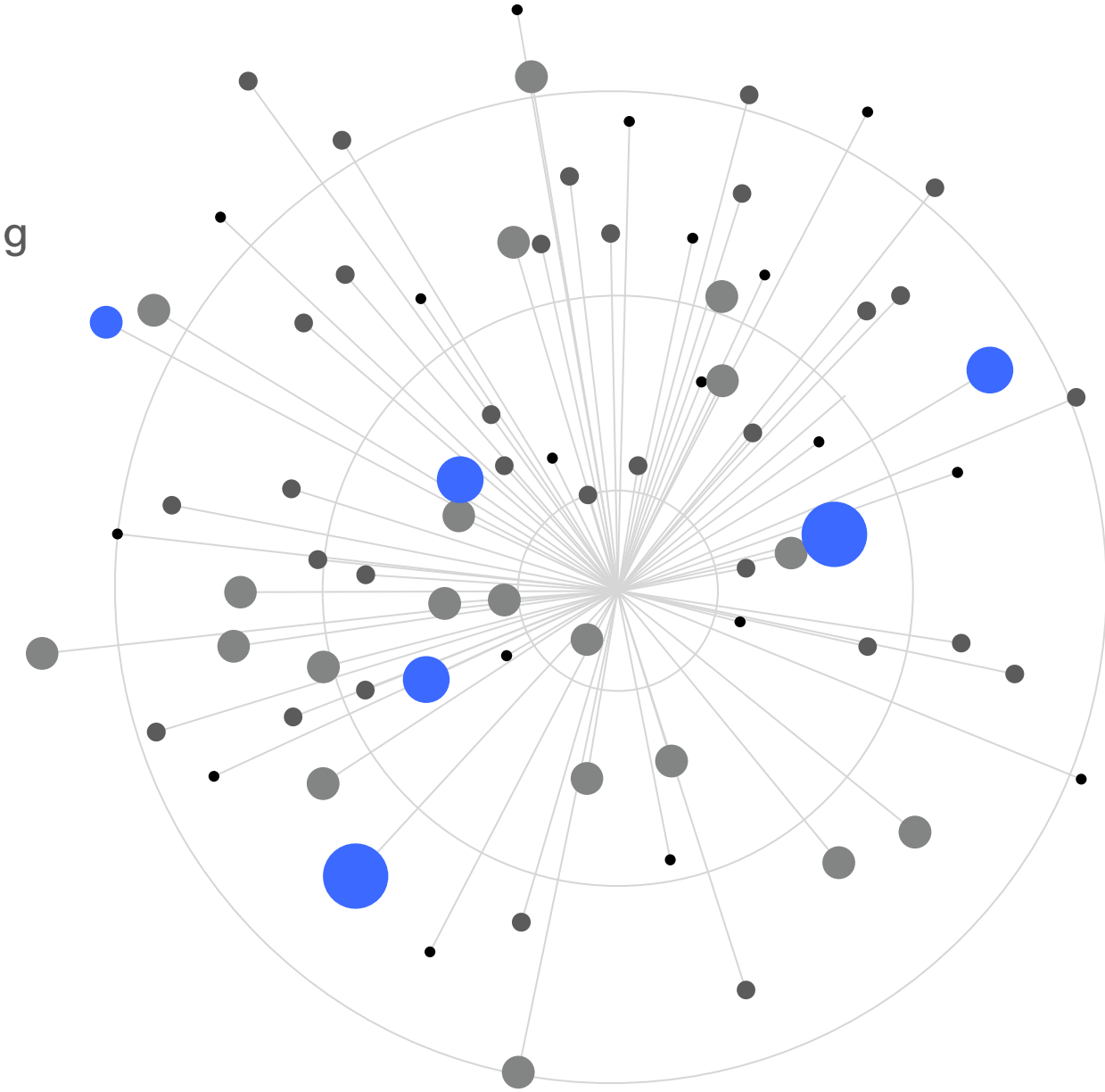


Key Learnings

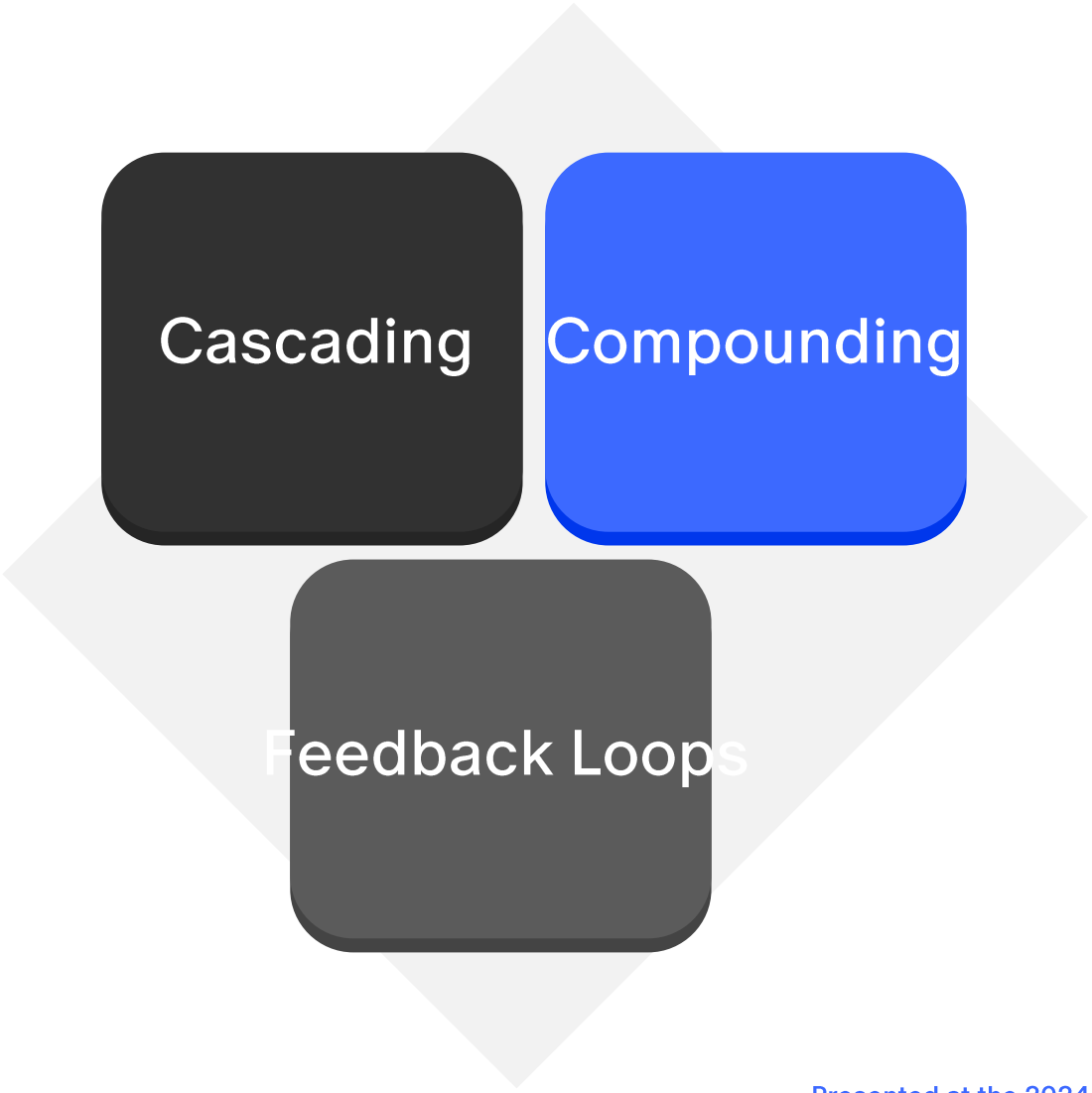
03

Overall findings

- Climate risk is complex, and linear thinking can lose nuances of complexity
- Different time horizons give different treatments
- Climate risk exacerbates existing risks in the social domain
- Large interactions between types of perils
- Climate risk treatments require coordination solutions



Key risks



Cascading

- Hazards e.g., storms to coastal erosion
- Social domain
- Exposure and vulnerability e.g., vegetation and fuel loads
- Built risks
- Hazard determinants e.g., La Niña increased flood risk

Compounding

- Economic exposure and social vulnerability
- Hazards e.g., Repeating events and bushfires
- Social vulnerabilities
- Hazard determinants and antecedent conditions

Feedback Loops

- Between drivers of social vulnerability
- Between hazards and social vulnerability
- Ecological environment of flora and fauna

Improvements

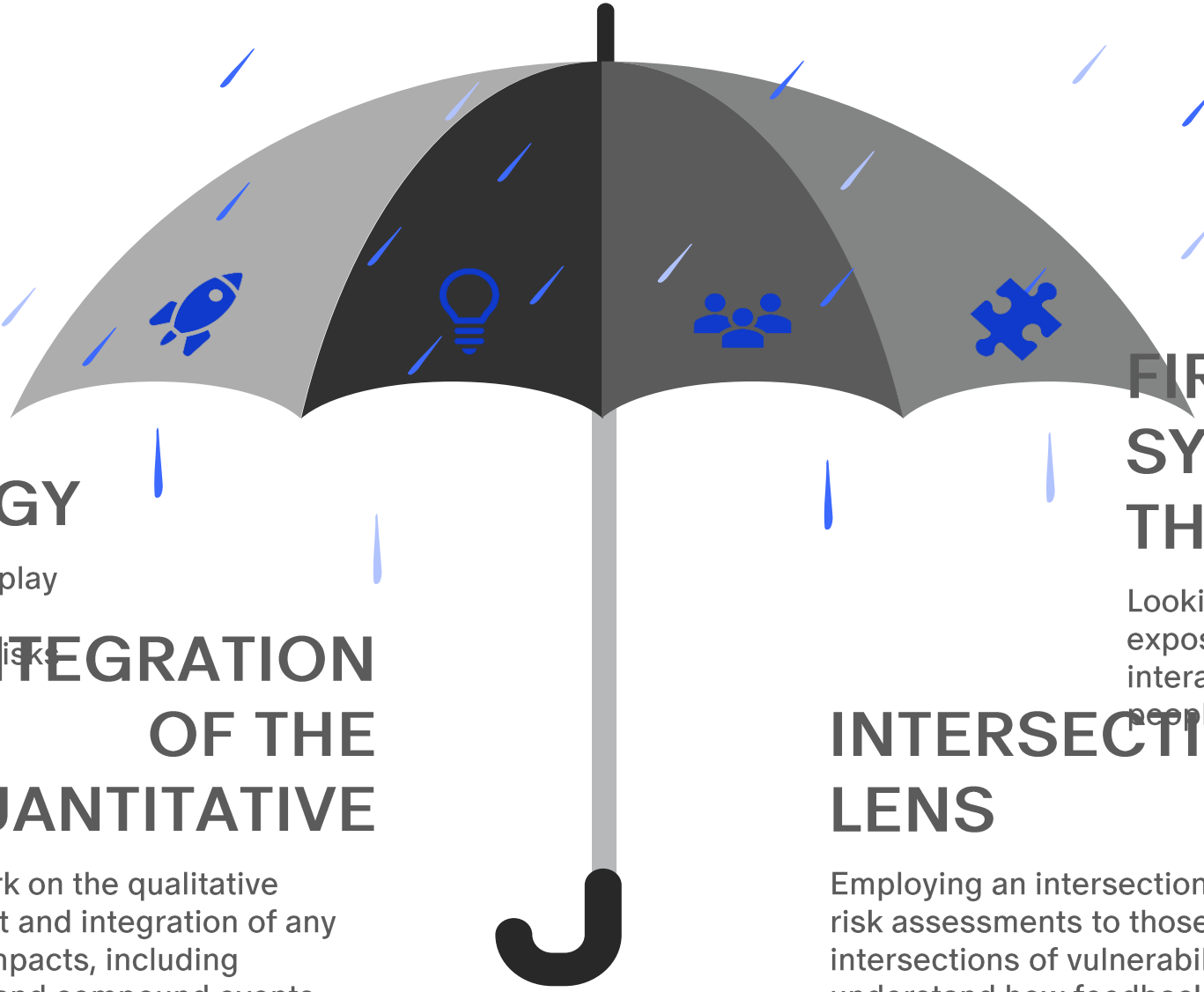
More sources Australia wide

Inclusion of hazard reduction through structural intervention

Intersections of further identities

Inclusion of cyclone

Potential solutions



TECHNOLOGY

Technology and innovation can play a role in mitigation and limiting cascading risks, compounding risks and feedback loops.

INTEGRATION OF THE QUANTITATIVE

Further work on the qualitative assessment and integration of any systemic impacts, including cascading and compound events, within the typical linear quantitative assessment.

FIRST NATIONS SYSTEMS THINKING

Looking at how vulnerabilities, exposure and hazards overlap and interact, and having First Nations people drive this knowledge.

INTERSECTIONAL LENS

Employing an intersectional lens in risk assessments to those at the intersections of vulnerabilities to understand how feedback loops come into force and how they can be broken.

Questions

04

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About the Actuaries Institute

The Actuaries Institute is the peak professional body for Actuaries in Australia. The Institute provides expert comment on public policy issues where there is uncertainty of future financial outcomes.

Actuaries have a reputation for a high level of technical financial expertise and integrity. They apply their analytical and risk management expertise to allocate resources efficiently, identify and mitigate emerging risks and to help maintain system integrity across multiple segments of the financial and other sectors. This unrivalled expertise enables the profession to comment on a wide range of issues including life, general and health insurance, climate change, superannuation and retirement income policy, enterprise risk management and prudential regulation, the digital economy, finance and investment and wider health issues.

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Thank you

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