



Identifying and classifying broader scale of disaster impacts to better inform disaster management policies and practice

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Abstract

Disasters are often assessed by factors such as their magnitude, severity and impact on affected communities. Typically, disaster management policies are largely informed by learnings from large-scale disasters. Many studies, however, have shown that cumulative smaller scale disaster impacts have similar outcomes comparable to larger scale disasters. This indirectly contributes to a lack of consistency in and paucity of data related to both smaller-scale disasters and their associated cumulative impacts. This paper argues that greater attention needs to be paid to collecting disaster impact data on a range of disaster-scale events along with their cumulative impacts to better inform disaster management policies and practice. The paper aims to test the hypothesis that a better understanding of a wide range of disaster scale types and their impacts on communities, including small-scale disasters, enables the development of more just, consistent and equitable disaster management policies and practice. Analysing economic costs, evacuation and rainfall data from past flood events that affected Aotearoa-New Zealand over the last three decades, the paper found discrepancies and lack of coherence in disaster data collection and reporting, along with a predominant reliance on rainfall intensity data for disaster risk reduction and planning. The findings also confirmed the importance of identifying economic damages for a range of disaster scales, including those from small-scale disasters. This highlights the need for developing a spectrum to better classify and identify disaster impacts based on various spatial and temporal contexts. The paper concludes by affirming that such database would provide much needed evidence for developing a methodology that enables the identification of the level of disaster impacts; thereby guiding the implementation of more just, consistent and equitable disaster management policies and practice.

Keywords Disaster risk reduction · Disaster database · Emergency management · Disaster response · Disaster recovery · Flooding

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1 Introduction

Evaluating and learning from past disasters,¹ including the intensity and spatial dispersion of their impacts, is critical to mitigate future disruptions more effectively (Aryal 2012; Johansson 2015). In disaster literature, many classifications are used to categorise disasters based on their impact and scale, including small, moderate, large or extreme (Johansson 2015). The development of such classifications provides opportunities for institutional capacity development and policy changes so as to best deal with various disaster types and scales (Baker and Refsgaard 2007). Nevertheless, disaster management is primarily informed by learnings from large-scale disasters (also called focusing events) that cause severe impacts (Birkland 2006; Voss and Wagner 2010). Consequently, research pertaining to small-scale disasters and their cumulative impacts are under-represented, although these disasters are potentially increasing as a result of global climate change (Fraser et al. 2020)

Undoubtedly, large-scale disasters result in more visible consequences in their immediate aftermath due to the number of casualties and financial damage they often cause. However, international studies (e.g., Brennan and Danielak 2021; Cadag et al. 2017; Wisner and Gaillard 2009) show that small-scale disasters often have a greater cumulative impact than large-scale disasters. In particular, Cadag et al. (2017) explain that media tend to pay less attention to small-scale disasters that do not reach the level of an ‘emergency’ or a ‘crisis’, making them less known to the general public. This leads to a scarcity of loss and damage data on small-scale disasters, including in international disaster databases (Browne 2013). The absence of such data hinders the understanding of risk patterns pertaining to small-scale disasters and their inclusion in risk assessments supporting disaster risk reduction (Serje et al. 2012), leading to ad hoc, place-based or localised responses (Brennan and Danielak 2021). Additionally, historical impact data (such as economic impact data) are becoming increasingly important to guide climate change policies (Ignjacevic et al. 2021), especially to ensure more robust information about a range of disaster impacts (from both large and small scale disasters) are available to enable better preparation and response to a wide range of climate related disasters in the future.

In this context, the principal hypothesis guiding this paper is that a better understanding of a wide range of disaster scale types and their impacts on communities, including small-scale disasters, enables the development of more just, consistent and equitable disaster management policies and practice. The rationale behind this is that more detailed information about a wider range of disaster scale types and impacts can facilitate the identification of chronic disaster conditions that may otherwise be neglected by disaster mitigation and recovery efforts, or exacerbated by climate change. To test this hypothesis, the paper focuses on Aotearoa-New Zealand’s disaster management system and analyses flood disaster data spanning three decades as a proxy to understand how small-scale disasters and their impacts might be reported on and recorded. The paper starts with a review of how disaster impacts are reported in the literature and current classification systems. It then outlines the data collection and analysis methods, followed by key findings. The paper concludes by discussing the application of a disaster scale and impact spectrum for disaster management policy and practice by using the example of high-frequency-low-impact disasters.

¹ Disasters are ‘A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.’ UNISDR. (2009). *UNISDR terminology on disaster risk reduction*. UNISDR. page 9.

2 Current trends used to identify and classify disasters and their impacts

Currently, there are several systems used to describe disaster scales and their impacts (Blong 2003). For example, Ravago et al. (2020) propose the classification of disaster indices into three types, namely: (1) disaster event indicators that describe the hazard magnitude and intensity; (2) consolidated indices that generate information from multiple variables to determine disaster impacts at the local scale or disaster resilience; and, (3) national level indicators covering disaster damage, vulnerability and risk.

In parallel, disaster magnitude scales are widely used to facilitate communication about disasters and the corresponding decision-making processes (Ripley et al. 2020). Scales can help in determining when a situation needs to escalate to a higher level of the emergency management hierarchy prior to disasters requiring assistance or intervention (Rohn and Blackmore 2015). They also enable the comparison between similar or different events, which can be used as an important tool to rationally allocate limited resources to concurrent disasters (Rohn and Blackmore 2015). However, there is no universally accepted scale for assessing the magnitude of a disaster and their associated impacts together. Disasters, such as earthquakes, are commonly indicated by the strength/degree of the hazard, yet this is not the only factor that drives impacts (Wang and Sebastian 2021).

Despite the fact that a disaster may have a high value on a hazard strength scale, it can also have a lower impact value if the exposed value and/or vulnerability levels are low (Wang and Sebastian 2021). The use of hazard scales that solely link physical hazard parameters with expected damage does not always account for the wide range of impacts experienced by different communities in response to disasters of similar hazard intensities (Chang and Tanner 2022). Disaster impacts are either positive or negative, including economic, social and/or environmental effects. In disaster literature and practice, examples of metrics to quantify social and economic impacts include the following: number of human casualties and injuries, number of permanently or temporarily displaced people, impacts on properties measured in terms of numbers of buildings damaged or destroyed, impacts on infrastructure and lifelines, impacts on crops and agricultural systems, and financial or economic loss (including insurance loss) (Below et al. 2009; Lavell et al. 2012). These are also assessed based on the disaster magnitude, duration, rate and the irreversibility of impacts.

While there are a number of well-established and widely used disaster scales in the preparation, response, and recovery of disasters (Chang and Tanner 2022), there isn't a single tool available to evaluate the severity of disasters (Yew et al. 2019). Nevertheless, social scientists such as Fischer attempted to propose a system to classify catastrophes similar to the Richter scale. His classification, however, is confined only to the severity of a disaster and its impact on a locality or region, and does not take complex features such as social resilience or economic strength into consideration (Rohn and Blackmore 2015). Further, various attempts have been made to identify the scale of disasters based on their impacts or strength. These include the Bradford disaster scale (Keller et al. 1997), classification of disaster severity Gad-el-Hak (2009), disaster impact index (Gardoni and Murphy 2010), unified localisable crisis scale (Rohn and Blackmore 2015), and emergency events database (EMDAT) (see Table 1 in the Supplementary Material for details).

Notably, the classification systems use different variables to classify disaster scales and their impacts. They also appear to overlook the features of speed and secondary and cumulative impacts, instead placing an emphasis on one-time disasters and their direct impacts (Staupe-Delgado and Rubin 2022; Twigg 2004). Further, the terminology used implies

that small scale disasters have no consequences or are only marginally disruptive, such as ‘insignificant’ and ‘minor’, and therefore are not worth considering. However, despite their non-destructive nature, small-scale disasters can cause serious detrimental socioeconomic consequences, including compromising transportation and sewage systems, and public health (Pando and Lavell 2012). Furthermore, the vulnerability² factor is also absent from the current disaster classification systems. The damage and loss resulting from a disaster are ultimately determined by the level of vulnerability of the community, its infrastructure and its production that varies between different spatial and social units (Lavell 2002). Repeated disasters increase communities’ vulnerability by increasing their constant exposure³ to disasters and eroding their ability to cope with future catastrophes (Boubacar et al. 2017). Thus, the impact of a disaster depends on where it occurs (Caldera and Wirasinghe 2021). Unlike larger scale disasters, small-scale disasters do not cause mortalities or destruction of economic assets, but they do expose certain vulnerable groups more than others (Browne 2013).

In summary, the way the current disaster indices and classification systems are developed can mainly capture the larger scale disaster impacts that are visible immediately after a disaster. Consequently, this is likely to exclude the impacts of smaller to moderate scale disasters that are frequent and chronic (Shrestha and Gaillard 2013). Failure to capture these impacts, and to respond to them, can make the affected communities more vulnerable to new disasters trapping them into a ratchet effect (Shrestha and Gaillard 2013); hence the focus of this paper on the importance of capturing data on a broader spectrum of disasters scales and impacts so as to enable the development of more just, consistent and equitable disaster management policies and practice.

3 Methods

This paper aims to test the hypothesis that a better understanding of a wide range of disaster scale types and their impacts on communities, including small-scale disasters, enables the development of more just, consistent and equitable disaster management policies and practice. To this end, we apply a case study approach (Yin and Campbell 2018) focused on Aotearoa-New Zealand’s disaster management system. Aotearoa-New Zealand is an island country located in the Pacific Ocean subjected to a variety of disasters, including earthquakes, volcanoes, erosion and landslides (UNDRR, 2020). We chose to focus on flood data as a proxy to understand how small-scale disasters and their impacts might be reported on and recorded because flooding is the country’s most common and costly natural hazard (Mason et al. 2021). Additionally, flood impacts are expected to be amplified as a result of land subsidence, climate change, and socioeconomic developments creating a suitable case for our study (IPCC 2022).

Aotearoa-New Zealand has a three-tiered governance structure comprised of the central government, regional councils and the territorial authorities (Lawrence et al. 2015). The institutional-statutory framework for emergency management is led by the National

² Vulnerability is understood as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. UNISDR. (2009). *UNISDR terminology on disaster risk reduction*. UNISDR. page 30.

³ Exposure refers to people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. *UNISDR terminology on disaster risk reduction*. UNISDR. page 15.

Emergency Management Agency (NEMA, former Ministry of Civil Defence and Emergency Management) and the Civil Defence Emergency (CDEM) Act 2002. The CDEM Act (2002) emphasises a coordinated and integrated approach to policy, planning and decision-making at the national and local levels in order to manage hazards, risks, and emergency responses and recovery (CDEM Act 2002) by empowering regional and territorial authorities. The level of emergency response in Aotearoa-New Zealand is based on the CIMS (Coordinated Incident Management System) through national, CDEM Group or regional, local and incident site level (MCDEM 2015). Small to medium scale disasters are managed by the territorial authorities or the Civil Defence Management groups at the regional levels. Following the international trend, the system used to classify disaster scales and impacts varies across government agencies (see Table 2 in the Supplementary Material for further details). For example, while the Ministry for the Environment and the National Emergency Management Agency (NEMA) have similar level of detailed classification of impacts, the Ministry for Primary Industries has relatively fewer levels of impact categories. In spite of this, all three disaster classifications deem to acknowledge small to medium-scale disasters, but neither use specific variables to capture the cumulative impacts of disasters such as the past disaster occurrences in the recent years. In fact, Harrison et al. (2022) explain that disaster impact data collected by emergency management organizations are not being stored nor collected systematically. Additionally, at present, Aotearoa New Zealand only has a centralised disaster database for earthquakes and there has been slow progress in expanding this to collate loss and impact data for other hazards (Harrison et al. 2021). Nevertheless, a more comprehensive database covering multiple hazard types and inherent impacts is indispensable for research, policy development, and decision-making (Cuthbertson et al. 2021).

3.1 Data collection and analysis

We collated flood disaster data from the last 32 years (1991–2021) irrespective of their scale, intensity or impacts to identify what and how impacts were reported. The 3-decade period was selected because it is a known timeframe used in climate research that enables the observation of climatic trends (WMO 2017). This is helpful to illustrate what disaster scales comprise the most common ones affecting the country, and any potential changes in flood trends overtime.

The available disaster data did not cover all the required categories for the examination of the impacts, nor provided detailed information because they are often captured from incident reporting. Therefore, to address this issue we collected flood disaster data from a range of publicly available online data sources, including websites collating information on historical flood events, media articles and technical reports (see Table 1). Additionally, data from international databases were not available because small-scale disasters do not meet the criteria to be included in the EM-DAT database and DesInventar lacks data on Aotearoa New Zealand. Nevertheless, the collated locally available data helped to understand the disaster scale media attention is often focused on, and potentially the type of disasters authorities may deem as important for information to be communicated with the wider public.

To overcome issues related to data paucity and quality, we used several different sources to fill information gaps and, therefore, triangulate information for verification. Data triangulation was an important step because it helped to enhance reliability of the data collected and analysed (Noble and Heale 2019). However, we were unable to capture specific

Table 1 List of sources used for the data collection

Type of source	Details
Websites	New Zealand Historic Weather Events Catalogue Insurance Council of New Zealand New Zealand Official Year books Meteorological Society of New Zealand National Emergency Management Agency Flood List funded by the European Centre for Medium Range Weather Forecasts New Zealand Flood Pics WeatherWatch New Zealand Insurance Business New Zealand Water New Zealand Science Media Centre GNS Science Hut Bagger New Zealand Regional Council websites District Council websites City council websites
News outlets	New Zealand News Herald Radio New Zealand Otago Daily Times Stuff New Zealand Newshub New Zealand
Reports	Order paper for the meeting-District Plan review subcommittee 15/12/2020 West Coast Hydrometric and Climatological State of Environment Report Responding to a 100-year storm-An actual example in Auckland Wharekawa Coast 2120–Wider River Flood Assessment Vulnerability and Interdependency Assessment Reports South Island storm and floods December 2010 Natural hazards background report–Greater Wellington Regional Council 2005 Climate change effects on the Land Transport Network Volume two

information on the cause and progression of events, operational tactical decision-making, response measures, and intervention results. This information would be helpful to understand the emergency response against different impact levels of disasters. Care was also taken to extract information from media sources by contrasting them with other data sources so as to avoid inaccurate reports resulting from first-hand accounts gathered under time constraint.

We searched for flood events that occurred each year from 1990 to 2021 and compiled them in Microsoft Excel. The events were recorded chronologically. The details of each of the events were categorised into the following, and data triangulation was used to complement missing information:

- year
- month and date
- name of the event
- scale of the event
- amount of rainfall and duration
- affected areas
- spatial area
- population per location
- evacuation details
- type of flooding
- type of damages
- recorded economic damage
- other available details

During our initial search, we selected 350 out of 370 flood events dating up to August 2021 that contained information on their impacts. Given the abovementioned lack of consistency in data reporting, collection and storage (Harrison et al. 2021), we followed an inductive data analysis approach (Azungah 2018) to identify potential categories suitable for analysis. Following an initial screening of the data collected, we identified four categories for which there was sufficient information related to event reporting and response. These included economic damages, number of evacuees in each event, rainfall data and other direct impact information. Our analysis, therefore, focuses only on these elements.

4 Results

Figure 1 provides an overview of the distribution of the 350 flood events between 1990 and 2021. The highest number of events recorded in any given year occurred in 2008 (21 events), while the lowest number of events occurred in 1993 (2 events). The average number of events recorded per year is 10.94. Excluding the last two years (2021 and 2020), the highest number of events occurred during the 2000–2009 period. Figure 1 also shows that there is no clear trend regarding the frequency and intensity of events over the past 32 years.

Table 2 depicts the types of flooding reported. Out of the 350 records approximately 50 percent of the events have recorded the type of the flood event. Even among those recorded events where more than one location is affected, only a few of them cover the type of

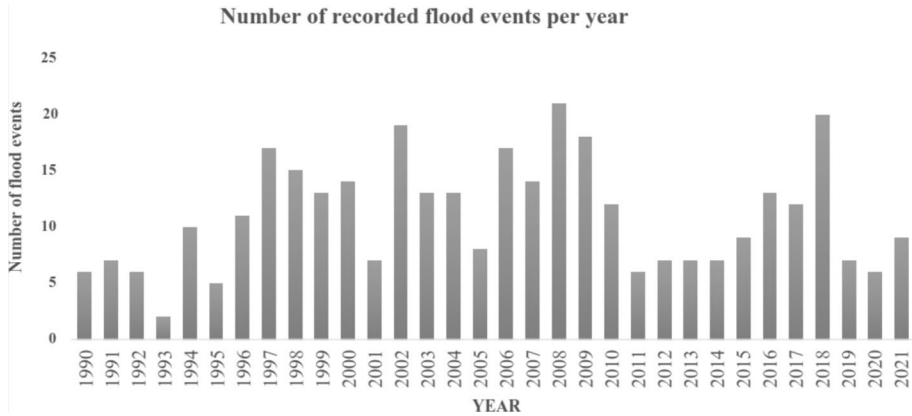


Fig. 1 Summary of the recorded flood events for the 1990–2021 period by year

Table 2 Types of flooding reported

Type of flooding	Number of events (n = 178)
Flash floods	34
Surface floods	81
Coastal floods/Sea floods	9
River floods/Fluvial floods	5
Localised floods	3
Inland floods	1
Combination of types	11
Localised surface flooding	33
Other	1

Table 3 Distribution of economic damages and losses across times

Period	Reported economic damages Amount (NZD Million)	Percentage of the total economic damages (%)*	Number of events per period (n = 144)
1990–1999	181	9	34
2000–2009	460	22	49
2010–2019	969	47	50
2020–2021	462	22	11

* Based on the total economic damages of the 144 events taken into the analysis

flooding that may not be representative for the entire event. Localised surface flooding is the most mentioned type of flood, while flash floods are the second most noted.

4.1 Economic damages

Of the 350 flood events analysed, 144 had recorded information on economic damages or losses. We distributed the 144 flood events across time-periods of 10 years and the last two years to identify any decadal pattern (see Table 3). The data show a steady increase in economic damages over time. Notably, the eleven rainfall events that occurred over the last two years (January 2020–August 2021) represent 22 percent of all economic damages registered for the whole 1990–2021 period. It is important to note, however, that this could also be a result of a gradual increase in the insurance payouts to cover for damages due to inflation and not solely based on exacerbated flood events.

We further aggregated the economic data into 11 categories based on the value of the insurance claims (see Table 4). This showed that the large majority of events (94 out of 144) resulted in up to less than NZD10 million worth of damages. These events are mostly comprised of surface flooding, flash flooding and localised and minor floods (see Table 4).

4.2 Evacuation information

Out of the 350 flood events analysed, 146 event records mentioned evacuations. However, only 117 events had information on evacuation. Many records reported the number of individuals evacuated, while others reported the number of households or families evacuated. To enable comparison, we converted the household numbers to persons, by multiplying the number of households by 2.7, which is the average number of people living in a household according to Aotearoa-New Zealand government statistics (Stats NZ, 2019). Table 5 shows the breakdown of the number of evacuees in groups of 50 people. Just over a third of the events resulted in up to 50 evacuees. The next most frequent number of evacuees per event

Table 4 Value and number of insurance claims

Value of insurance claims (NZD million)	Aggregated sum of economic damages (NZD million)	Percentage from the total events considered (%)	Number of events (n = 144)
≤ 10	260.42	65.3	94
10–20	247.87	11.8	17
20–30	228.94	6.3	9
30–40	170.50	3.5	5
40–50	316.03	4.9	7
50–60	201.48	2.8	4
60–70	183.99	2.1	3
70–80	74.50	0.7	1
80–90	87.72	0.7	1
90–100	188.66	1.4	2
> 100	112	0.7	1

Table 5 Percentage of flood events based on the number of evacuees per event

Number of evacuees	Percentage of the total number of events considered (%)	Number of events (n = 117)
0–50	35.9	42
50–100	20.5	24
100–150	11.1	13
150–200	9.4	11
200–250	6.0	7
250–300	2.6	3
300–350	0	0
350–400	1.7	2
400–450	0.9	1
450–500	1.7	2
> 500	10.3	12

was between 50 and 100 persons (20.5 percent). Notably, only 10.3 percent of the events resulted in the evacuation of more than 500 people.

4.3 Cross-comparison between economic damage and number of evacuees

Only 73 out of the 350 events had both evacuation and economic damages information. There is weak positive correlation of the economic damages and the evacuation data (0.3967) (see Fig. 2). Although the statistics suggest the positive correlation between the two categories, high economic damages may not always be associated with high evacuation numbers. Some events that resulted in low economic damages had comparatively higher

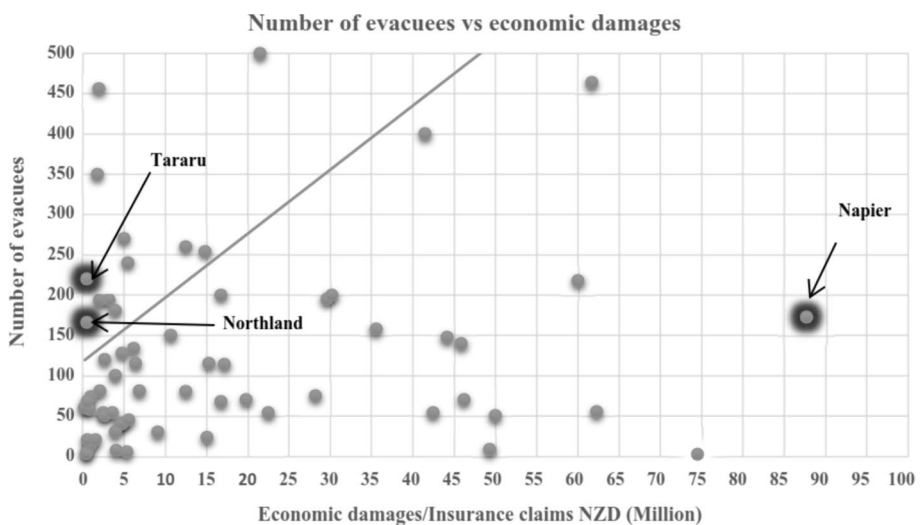


Fig. 2 Number of evacuees versus insurance claims

evacuation numbers. For example, the Northland and Hawke’s Bay flooding in June 1997 resulted in the evacuation of 166 people but only NZD 0.5 million in insurance claims have been reported (ICNZ 2022; NEMA 2022, January 24). Similarly, approximately 100 people were evacuated from flooding at Tararu in January 2002 but insurance payouts were only NZD 0.25 million (January 2002 South Island and Waikato flooding, the total event recorded more than 220 evacuees and more than NZD 0.5 million damages). By contrast, the November 2020 Napier flooding event led to the evacuation of more than 173 people and estimated damages valued over NZD 87.72 million.

4.4 Rainfall data

Rainfall data were available for 75 percent of the events that were recorded (n=262). However, rainfall data were reported in many different temporal and spatial scales making it difficult to construct comparisons between events. Additionally, rainfall data were not often reported along with the disaster impact information such as evacuation and economic damages and vice versa. For example, when flooding occurred at a wider spatial scale, reporting on the rainfall data did not cover the entire spatial scale extent and mostly informed the highest rainfall amounts. Therefore, only the above mentioned 262 events had reported rainfall data on both rainfall depth and duration. Only 43 out of the 262 events however, had consistent data for a 24-h rainfall period, economic damages and evacuation information. We cross examined the data to identify any correlation between rainfall intensity, economic damages and rate of evacuation (see Fig. 3). The analysis shows a

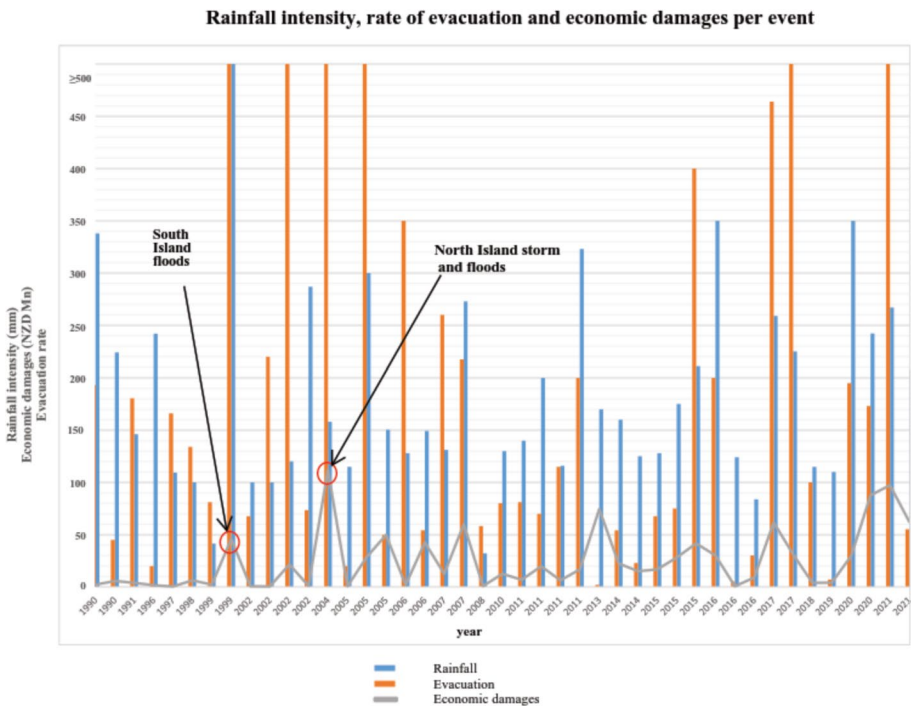


Fig. 3 Rainfall intensity, rate of evacuation and economic damages per event

weak positive relationship among the three. For example, the South Island flooding event in November 1999 reported the highest amount of rainfall (i.e., 600 mm/24 h) resulting in more than 1000 evacuations and total insurance payouts valued at NZD 46.1 million. The 2004 February North Island storm and flooding event had a lower amount of rainfall (i.e., 158 mm/24 h) but led to more than 2,300 evacuations and over a NZD112 million in insurance payouts.

4.5 Other event attributes

Detailed information for at least one of the three major categories (rainfall intensity, evacuation rates, and economic damages) was available for 289 events out of the 350 recorded events, demonstrating the importance of these triggers for event reporting. While the remaining 61 events did not provide any information related to those categories, we reviewed them to identify other factors that led to those events being covered by the media or technical reports. We found that most of the 61 events had reported impacts on infrastructure damages, especially transport infrastructure. These included road closures, damages to bridges, impassable roads, isolation of communities, disruption to lifeline utilities and infrastructure. Others covered impacts on affected communities such as damages to livelihoods, casualties/fatalities, damage to property, rescue operations, economic damages to livelihoods such as crop and livestock losses. This suggests that qualitative descriptions of impacts may comprise another attribute that prompts coverage by the media or technical reports.

Out of the 61 events, there were some flood events that were captured only in technical reports and not reported in the main media. These events were considered as 'minor flood events'. The information on these events were the most limited of all events (see Table 6).

5 Discussion

Findings from our study point to several gaps that prevent a broader range of disaster scales and their impacts from being captured in Aotearoa-New Zealand's current disaster classifications, event reporting and data recording. This includes, but is not limited to: (1) the lack of coherence in data collection and reporting about disasters; (2) the limitations of

Table 6 Details recorded on minor flood events

Description	Details recorded
Spatial scale	Mostly limited to 1 or 2 localities
Types of flooding	Localized surface floods, flash floods
Type of impacts	<i>Infrastructure</i> Road closure, inundation of property and damage to infrastructure <i>Communities</i> Rescues, accidents
Type of assistance provided to the affected	Business as usual
Duration of the event	1–2 days
Fatalities or casualties	No information
Frequency	Repeated occurrences

primarily relying on rainfall intensity data for disaster risk reduction and planning; and, (3) the importance of identifying the economic damages of a range of disaster scales, including small-scale disasters. These gaps make it difficult to develop more just, consistent and equitable disaster management policies and practice that address the wider range of disaster scales and impacts and how they affect communities.

5.1 Discrepancies and lack of coherence in disaster data collection and reporting

As the emphasis in the first priority action of the Sendai Framework for Disaster Risk Reduction (SFDRR) suggests, it is important to have systematic and comparable disaster data so as to ensure more resilient and sustainable societies (SFDRR, 2015–2030). Moreover, the availability of disaggregated data may enhance analysis power and add value to the data (United Nations Office for Disaster Risk Reduction 2019) as well as disaster risk analysis and forecasting (Mizutori 2020). The absence of such information, including the duration and intensity of smaller floods can hinder the identification of the spatial and temporal distribution of disasters and their impacts on communities. Our findings show that flooding events tend to not be recorded individually, but rather as aggregates or as a combination of several events. In light of the accumulation of a few events, these combined data can be interpreted as intensive risks. As such, they exceed the threshold for extensive risks⁴ (United Nations Office for Disaster Risk Reduction 2019) preventing the identification of dangers, challenges and characteristics related to them.

Brennan and Danielak (2021) state that it is essential for decision-makers to understand the full scope of climate-related weather phenomena—from small to large scale events and their associated losses to provide supportive services to populations at risk. However, they also show that there are not enough quantitative and granular data for such analysis—a problem that we have also encountered in our own study. The absence of both local and international historic disaster databases entailing a range of disaster scales, along with the scarcity of information related to their duration and intensity, may hinder the identification of the real impacts of flood hazards. This compromises the development of more just, consistent and equitable disaster management policies and practice because systematic and standardised data on the disaster occurrences and their impacts are crucial for adequate disaster response and recovery activities (Mazhin et al. 2021).

To address this issue, it is fundamental to bridge such a data gap by establishing a national disaster repository that includes data and their impacts on all climate related disasters. Such disaster loss data could record all disasters and their impacts regardless of their spatial or temporal scale. This will help avoid the 'threshold bias' fallacies of the existing threshold criteria, which filter the inclusion of small-scale disasters, resulting in the under-representation of small and repeated events (Gall et al. 2009). Importantly, disaster-related information is relatively short-lived and difficult to compare across time and regions, making it less helpful for disaster-related projections (Pascal et al. 2006; UN ESCAP 2021). In these circumstances, it is critical for disaster loss data to be collated in a disaggregated manner—as recommended by the SFDRR Priority 1, paragraph 24 (e). The Sendai framework also suggests a methodology through the 'Data Collection Protocol' to standardise

⁴ 'Extensive risk' refers to the risks associated with dispersed populations being exposed to repeated or persistent hazards of low or moderate intensity, often locally specific, which can cause debilitating cumulative effects from disasters UNISDR. (2009). *UNISDR terminology on disaster risk reduction*. UNISDR.

the collection of disaster data. This protocol lays a comprehensive system that consists of six phases starting with damage and loss data recording and ends with cost–benefit analysis. The protocol also defines actors who should record and analyse the data that correspond to each phase of disaster loss and damage data collection (Rajasekharan et al. 2021) and formalise the process. Such systematic and methodical collation of data would produce comparable data, enable researchers and practitioners to examine the fuller scope of disasters, and support the development of more just, consistent and equitable disaster management policies and practice.

5.2 Limits to using rainfall intensity as a primary trigger for disaster risk reduction planning for flood events

Our study showed that high rainfall was the most common factor for triggering disaster reporting on flood events. This is probably due to how particularly challenging it is to respond effectively during rapid onset events such as flash floods, which are usually triggered by intense rainfall (Khajehei et al. 2020). Although the amount of rainfall contributes towards the scale or the severity of a flood event, our analysis showed that extreme rainfall does not always result in severe impacts. Therefore, rainfall data alone cannot be considered as the main variable for flooding reporting as it has different impacts based on the location's physical and social attributes. Similarly, studies (Pascal et al. 2006; Potter et al. 2021) have shown how the antecedent conditions (e.g., cumulative rainfall) may aggravate to disastrous conditions along with other characteristics such as the vulnerability of the population and the characteristics of the previous season. The damages caused by rainfall are a result of both the precipitation itself and the socio-economic aspects of the population (Moreira et al. 2017). Therefore, as noted by Khajehei et al. (2020), it is important to examine not only the characteristics of the hazard such as frequency, duration, severity and magnitude, but also the socio-economic vulnerability of the affected community. Data on vulnerability, however, are difficult to collect due to its change over time and space, and it is more challenging to assess social vulnerability or human vulnerability due to their complexity (Harrison et al. 2021). The majority of studies on social vulnerability have focused on physical impacts like loss of life and physical injuries, rather than nuanced social impacts. These vulnerability factors are easier to quantify but may not capture the diversity of the community. For example, other impacts such as poor biophysical, social, and/or financial capital of communities are rather less quantifiable. However, for a better understanding of the dynamics of social vulnerability it is important to identify factors that result from human behaviour such as risk governance aspects, land use decisions, and individuals' status, all of which change over time (Harrison et al. 2021). Our findings showed that relatively small-scale flooding events have generally affected one to three communities at any given event, whereas the temporal scale was mostly limited to a shorter duration of two days. The available information however, does not allow for the identification of the extent of their impacts on these locations. For this to be determined, further examination of potential risk factors such as population density and characteristics of the (built) environment is required. Therefore, our study suggests that the disaster records that are heavily dependent on the spatial and temporal distribution of rainfall may not appropriately inform decisions as their impacts are not adequately considered.

All these aspects suggest that common rainfall thresholds alone are inefficient for determining the scale of a disaster or its corresponding disaster response. In an attempt to bridge this gap, the World Meteorological Organization (WMO) has proposed using impact-based

warnings. Impact-based forecasts and warnings aim to anticipate impacts to minimize adverse effects through pre-emptive and preparatory mitigation measures (Jenkins et al. 2022). It is a structured method of combining hazard information with exposure data and vulnerability information to identify risks and guide decision-making (UN ESCAP & World Meteorological Organization, 2021). Therefore, extensive improvements are needed in collecting and storing impact information about events to better facilitate forecasting and decision-making in the future (Kaltenberger et al. 2020). In particular, better frequency and the impact data could help identify communities that are mostly affected by multiple disasters and whether appropriate mechanisms are in place to address their needs.

5.3 Economic damages and intangible impacts

Our findings showed that less severe flood events such as frequent, localised flooding were under-reported, including their economic and non-economic impacts. The majority of the events with recorded detailed information were those that were considered larger disasters such as the ones affecting comparatively larger spatial scales, communities and other severe economic impacts. Smaller scale floods were mainly reflected in institutional reports primarily intended for technical analysis, which are not targeted at a general audience. In some cases, small-scale disasters occur concurrently with large-scale disasters which draw all attention (Cadag et al. 2017). Potter et al. (2021) report that in Aotearoa-New Zealand there is no national agency that coordinates smaller scale hydrological events. Also, Aotearoa-New Zealand has a somewhat unique insurance system where the government-owned Earthquake Commission (EQC) provides natural hazard insurance together with the private insurers for affected residential properties (Saunders et al. 2015). As this mechanism is well established to provide funds for recovery, it may suggest that the country may not have had the need to showcase the importance of addressing the small-scale disaster impact separately. Despite its potential as a strategy to reduce disaster risk in theory, insurance serves as a short-term adaptive measure providing financial support for disaster recovery (Saunders and Becker 2015). In fact, insurance has demonstrated little effectiveness in disaster risk reduction practice, and has been criticised for failing to address the actual vulnerabilities of places as well as encouraging maladaptive tendencies (O'Hare et al. 2016; Saunders and Becker 2015).

From a community perspective it is necessary to increase awareness of affected communities about future projections of repeated disasters and their adverse physical impacts such as cumulative impacts and chronic conditions. This requires an in-depth examination of whether or not these disasters may impact the coping capacities of households and local authorities. Although insurance plays a role as a short term recovery methodology, it needs to be underscored that it provides a false sense of security to the insured (O'Hare et al. 2016) and that the risk is always priced. Consequently, it is necessary to thoroughly analyse how effectively insurance mechanisms behave as a short-term resilience⁵ strategy for socio-economically vulnerable communities prone to small-scale recurring disasters (Tenakoon et al. 2023).

⁵ Ability to anticipate and resist disruptive events, minimise adverse impacts, respond effectively, maintain or recover functionality, and adapt in a way that allows for learning and thriving. In essence, it's about developing a wide zone of tolerance – the ability to remain effective across a range of future conditions MCDEM. (2019). National Disaster Resilience Strategy. <https://www.civildefence.govt.nz/cdem-sector/plans-and-strategies/national-disaster-resilience-strategy/>.

Due to the availability of insurance mechanisms as a tool for recovery, countries such as Aotearoa-New Zealand use insurance data to access the losses pertaining to disasters. However, these data largely represent only direct economic losses. More importantly, they reflect insured losses and, as such, only reflect a fraction of the total cost of a disaster (Ladds et al. 2017). Further, our findings also showed that data on economic damages have captured only the larger scale impacts and tangible economic impacts. Generally, the indirect costs of smaller events are considered insignificant (Walton et al. 2004), but communities that confront small-scale disasters concurrently may encounter various different socio-economic impacts which accrue over a longer period and therefore could be considerably larger. Therefore, disaster loss data should be collected and analysed systematically to illustrate the real extent to which disasters impact the economy (Marulanda et al. 2008) despite the argument that economic losses alone do not represent the full cost of disasters.

6 Conclusion

In this paper, we aimed to test the hypothesis that a better understanding of a wide range of disaster scale types and their impacts on communities, including small-scale disasters, enables the development of more just, consistent and equitable disaster management policies and practice. For this, we examined records of 350 flood events that affected Aotearoa-New Zealand during a 32-year time period through publicly available online data. Firstly, our results have shown that the data pertaining to event reporting and recording evolved mainly around conventional categories related to hazard strength and direct impacts. These included economic damages, evacuation information and rainfall data (hazard strength). Our study also identified inherent challenges to using hazard intensity parameters such as rainfall data to determine the scale of a disaster because they can misrepresent hazards and their risk, especially indirect impacts that are not easily quantifiable.

Secondly, our study also confirmed that disaster classifications and practices do not seem to adequately capture the cumulative impacts of recurring disasters. This gap leads to under-reporting and underrepresentation of disasters that may not show severe direct impacts. Importantly, our study showed that most reported disasters did not constitute major catastrophes. Despite this, disaster classification systems are not tailored to capture a wider range of disaster scales resulting in emergency management policies that predominantly focused on fewer in number large scale disasters. This prevents the identification of communities that repeatedly experience small-scale recurring disasters whose disaster resilience may be already at risk and further compounded by not receiving equitable policy consideration.

Thirdly, our results did not identify that emergency response or recovery exercises pertaining to small-scale disasters. It appears that the majority of events (big and small in scale) are predominantly managed under business-as-usual operations and supported by short-term disaster recovery strategies. Hence, more attention needs to be given to examine how different disasters impact communities and whether the current response and recovery strategies are sufficient for achieving improved societal benefits. For this, we need to better understand cumulative and indirect impacts, including by creating mechanisms that are fit for purpose for recording and reporting a range of disasters. This includes small-scale disaster impact data which can shed light upon response and recovery in addition to large-scale disasters.

There were a number of limitations to this study, including the availability of consistent data. While using publicly available data have helped to overcome this gap to a certain extent, it has its own limitations. This study relied on disaster data gathered across a variety of societal sectors, which was not designed nor intended for the purposes of the study. Additionally, data from different sources of information may be inconsistent or conflicting for the same occurrence, with limited verification capabilities and thus being less detailed (Aryal 2012; Serje 2012). Another limitation of our study is its focus only on flood events. To simplify the analysis, we excluded other types of disasters that occurred in the same geographical area during the study period.

Findings from this study have important practical and theoretical implications. From a practice perspective, the availability of a more comprehensive database, including improved disaster recording and reporting could provide the means for a detailed understanding of the spectrum of disasters (and associated impacts) affecting a specific area based on various spatial and temporal scales. This could be used to develop a standardised methodology to identify the level of disaster impacts guiding the disaster preparedness and response phase so that small-scale disasters were not continuously overlooked. To accomplish this, a national disaster repository could be established with the disaggregated data on disaster impacts (as recommended by the SFDRR 2015–2030), alongside with community's vulnerability data. Such a system would avoid the provision of scattered, inconsistent and incomparable data. A comprehensive regional and local impact database would also help determine the different but appropriate levels of disaster response and recovery interventions needed by the different localities against different disaster scales. Hence, helping to reduce the inconsistencies in disaster management policies and practices so as to deliver more just, consistent and equitable outcomes to affected communities.

From a theoretical perspective, the paper identifies several areas for future research. Identifying the disaster trends and hotspots alongside with the changing community vulnerability towards recurring disasters warrants the need to monitor the effectiveness of emergency preparedness and response policies. Additionally, a holistic policy approach, which integrates emergency management policies with socioeconomic policies and development policies, should also be examined simultaneously to inform long term resilient policies.

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Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

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