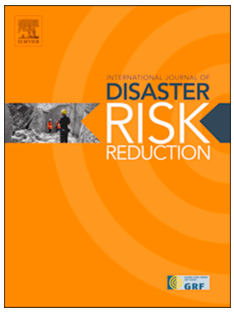

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PII: S2212-4209(26)00101-9

DOI: https://doi.org/10.1016/j.ijdrr.2026.106089

Reference: IJDRR 106089

To appear in: *International Journal of Disaster Risk Reduction*

Received Date: 23 September 2025

Revised Date: 27 February 2026

Accepted Date: 3 March 2026

Please cite this article as: S. Vallis, I. Piri, A. Burgess, P. Besen, A. Morrison, Connecting perceived flood risk and resilience in Auckland, New Zealand, *International Journal of Disaster Risk Reduction*, https://doi.org/10.1016/j.ijdrr.2026.106089.

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Abstract

New Zealand cities are shaped by a history of natural hazards. Climate change has amplified these risks, increasing frequency, intensity, and destructiveness, demonstrated by the nationwide impacts of Cyclone Gabrielle and the 2023 Auckland Anniversary Weekend floods. Utilising anonymous cross-sectional survey and network analysis, this study responds to an existing knowledge gap to investigate the interrelationships between the perceived flood risk and perceived urban flood resilience using selected residential suburbs in Auckland, New Zealand, to support better alignment between urban residents' needs and expectations for policymaking and implementation. Our study provides novel insights through identification of a Flood Resilience Perception cluster characterised by statistical associations between perceived flood risk and perceived urban neighbourhood flood resilience, namely, perception of safety from flooding, trust in local authorities, rainfall worry, distance from flooding source, perceived sufficiency in emergency response, and provision or receipt of assistance during flooding. These interrelationships indicate cognitive, behavioural and informational, sociocultural, and geographic and physical mediators collectively shape the perception of flood risk and resilience at the neighbourhood scale, supported by integrated quantitative and qualitative analyses. Our findings highlight opportunities for greater dialogue between residents and decision-makers through participatory flood risk governance, noting the gap between residents' low awareness of existing digital flood risk communication tools and efforts to seek flood-related information, that can be addressed through improved engagement with

existing public-facing flood risk provisions. The analysis pipeline is freely available and designed for use in territorial jurisdictions in Aotearoa New Zealand and internationally to gauge community flood resilience.

Keywords: Climate Change; Flood Risk Perception; Resilience Investment; Neighbourhoods; Aotearoa New Zealand; Urban: SDG6; SDG11; SDG13; Sustainable Cities and Communities

1. Introduction

Urban neighbourhoods worldwide continue to face significant flood risk exacerbated by environmental changes, consistent with findings from the Intergovernmental Panel on Climate Change (IPCC) including the IPCC Sixth Assessment Report (IPCC AR6), the United Nations World Water Development Report 2024, and the National Aeronautics and Space Administration (NASA) collectively observing changes in atmospheric extremes such as tropical cyclones and heavy precipitation, where variations to the global hydrological cycle are attributed to human-induced climate change. [1–4] More specifically, the United Nations Global Assessment Report (GAR) on Disaster Risk Reduction (2025) emphasises the rising number of flood-related disasters since the year 2000, compared with the preceding two decades, while global annual average losses associated with flooding are estimated to total US$388 billion. [5] These changes and impacts are disproportionately felt by vulnerable groups, where the increased risk to urban populations is ascribed to greater urbanisation that decreases land surface permeability and settlement in floodplains, and worsens current water-related vulnerabilities. [6–10] The IPCC outlines risk as “the potential for adverse consequences for human or ecological systems…[and] results from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system”. [11] In comparison, resilience is defined as “the capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance,

responding or reorganizing in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation". [11] Enhancing urban neighbourhood flood resilience is inherent to multiple United Nations Sustainable Development Goals (SDGs), most notably (SDG) 11 promoting the enhancement of inclusion, safety, resilience, and sustainability for cities and human settlements intersects closely with the tenets of SDG 13 advocating for urgent action to combat climate change and its impact, and SDG 6 supporting availability of sustainable management of water and sanitation for all. [12–14] International policy frameworks including the Sendai Framework for Disaster Risk Reduction (2015), the Hyogo Framework for Action, and 2030 Agenda for Sustainable Development are unanimous in their call for the reduction of risk of disasters that underpins sustainable development, where core recommendations also centre on the importance of investing in resilience to mitigate the effects of disasters, debt, and un-insurability. [15–17]

Historical records demonstrate that earthquakes, flood, and fire have shaped the national story of New Zealand since the colonial era. [18,19] Although the damage incurred by earthquakes garnered national and global attention in recent years, the risk posed by flooding has resulted in major impacts for urban communities across the country. More centralised emergency planning and localised implementation is needed, focusing on flood and superstorm events to enhance community safety. [20] The Auckland Anniversary Weekend floods and Cyclone Gabrielle that occurred in February 2023 wreaked destruction across the country's North Island including the city of Auckland. Heavy rainfall, wind, and flooding following the preceding Auckland Anniversary Weekend flood led to the declaration of a national state of emergency. [21] Reports by the New Zealand Infrastructure Commission identify the January 2023 Auckland Anniversary weekend storm as an extreme rainfall event and highlight critical linkages between stormwater management and land-use planning, noting interdependencies

between water, telecommunications, waste, and transport infrastructure networks that contribute to resilience. [22] The city received 160 mm of rain in six hours and approximately 245mm of rainfall in 24 hours, exceeding the previous 24-hour rainfall record of 161 mm set in 1985. Four deaths occurred as a result of the storm and flooding, while thousands of homes were damaged from flooding and landslides. The Auckland Flood Response Review (2023) outlines the immediate aftermath of the flood that saw major transport and infrastructure disruption, mass evacuation, and loss of life and property. [20] The report highlights broad challenges in managing extreme weather patterns, particularly that advance warnings of prospective flash flooding may only be provided a few hours or minutes before the event, while variation in local geology combined with the scale of urban development accordingly result in a greater presence of soils with limited natural storage capacity and impervious surfaces. Moreover, vulnerable communities are commonly unable to cover the costs of their own flood protection measures, while experiencing a more frequent combination of climate change weather patterns. National-level reports from recent years have adopted an increasing focus on building resilience to climate, with greater attention to flooding hazards, including the National Adaptation Framework (2025) that will feature a new National Flood Map, the Long-Term Insights Briefing (2025), and the development of two new standards relating to natural hazard risk analysis and flood hazard modelling by Standards New Zealand. [23,24]

Informed by these myriad drivers, the objectives of this study are to: (i) examine the associations between perceived flood risk and perceived flood resilience, employing a range of indicators (cognitive, behavioural and informational, sociocultural, geographic and physical, and demographic factors) drawn from established international theoretical frameworks and discourse; and (ii) employ integrated quantitative and qualitative analyses to elucidate the needs, expectations, and priorities of urban residents following the Auckland Anniversary

Weekend Floods and Cyclone Gabrielle, and who are also confronting ongoing the risk posed by evolving extreme weather conditions and climate change.

1.1 Relevant Theoretical Principles and Frameworks

1.1.1 The Risk Perception Paradox and Paradigms

Flood risk perception (FRP) is commonly defined as "assessment of the probability of hazard and the probability of the results (most often – the negative consequences" as perceived by communities, constituting a vital element of flood risk management (FRM).[25,26] Global reports from the United Nations and the World Economic Forum draw attention to the role of risk perception in shaping how actions are prioritised, acknowledging that perceptions indicate individual and collective values that are important for addressing projected long-term ecological, economic, and societal implications from various hazards. [27,28] However, Wachinger et al (2012) present the risk perception paradox that exists in assuming that high risk perception leads to individual preparedness and risk mitigation behaviours, instead revealing that individuals with high risk perception may opt not to undertake these measures due to a number of complex, contextual factors such as level of trust in local authorities and ability to recall damage from previous events or disasters. [29] Nevertheless, Burns and Slovic (2012) focus on understanding public responses to crises to inform more aligned risk management and communication strategies, especially the development of public messaging based on cultural and demographic context as well as acknowledging emotional responses, to reduce avoidance behaviours by individuals and communities when confronted by various crises or disasters. [30] Underpinning these ideas, Kasperson et al (1988) propose a conceptual framework featuring the Social Amplification of Risk to systematically link technical risk assessment with psychological, sociological, and cultural processes that inform risk perception and risk-related behaviour. [31] These views are elaborated on through subsequent studies

further confirming the role of cognitive and affective mechanisms including emotions, trust, and perceived risk in influencing private citizens' behaviours across different global regions. [32–36] Such approaches contribute to the development of more integrated disaster risk management particularly for extreme weather and climate change, propagated by numerous initiatives including the United Nations Framework Convention on Climate Change (UNFCCC). [37]

Within the field of flood risk perception, two central theoretical paradigms for investigating flood risk perception are identified as rationalist and constructivist. Rationalist methods are based on modelling and prediction, while constructivist approaches adopt the view that threats are social constructs, where scholars have come to argue that social factors have not received sufficient scholarly attention. Tierney (1999), Birkholz et al (2014), and Lechowska (2018, 2022) amongst others, promote a constructivist approach to address the social-cultural factors such as vulnerability, capacity, and resilience in flood risk management. [32,38,39] A proliferation of contextual FRP studies have taken place in recent years, connecting property level flood protection (PLFP) with the role of flood risk perception in climate risk management in Canada and England. [40–45] Other studies also offer insights from non-Western cultural contexts, noting the investigation by Adelekan and Asiyanbi (2015) promoting measures to address the social aspects of FRP for vulnerable communities in Lagos, Nigeria, beyond purely structural responses, while Rana et. al. (2020) emphasises the role of previous experiences and hazard proximity in flood risk perception for urban communities in Pakistan. [46,47] Across these studies, a common recommendation is for future research to investigate the interrelationships between the factors that shape FRP, specifically calling for greater cooperation between the social and natural science disciplines. [26,48]

1.1.2 Key Shifts from Structural Resilience to integrating Non-Structural Resilience Strategies

The United Nations Office for Disaster Risk Reduction (UNDRR) defines structural measures as "any physical construction to reduce or avoid possible impacts of hazards, or in the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems" whereas non-structural measures are "measures not involving physical construction which use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education". [49] Studies from previous decades focus on social-ecological resilience frameworks, premised on community capacity for adaptation, including seminal research by Holling (1973) and Folke (2006) that traces the development of socio-ecological resilience, with a particular attention on the agency and interaction of human actors with wider ecological systems, encompassing adaptive capacity and governance that is central to FRM decision-making currently and in the years to come. [50–53] Further research including bibliometric review of FRM discourse reveals a concerted shift towards adopting flood resilience management strategies characterised by embedded sustainability goals and adaptive FRM practices that are responsive to dynamic environmental conditions and lessons from previous experiences. [54,55] Over the years, researchers have sought to examine the impacts of the Safe Development Paradox (SDP) and the 'levee effect' whereby disaster risk reduction initiatives including structural and non-structural protection measures can instead result in heightened long-term risk due to a false sense of security among vulnerable communities or increased development in floodplains for example. [56–59] While environmental phenomena influence flood events, human perception is strongly shaped by flooding frequency, distance to flood source, availability of flood risk information, and financial provisions. [38,60–62] Thaler and Hartmann also point out that these considerations bear implications for more just and equitable FRM practices, with reference to different approaches undertaken in Europe. [63] These findings draw attention to the ineffectiveness of solely focusing on structural measures (e.g. flood walls, embankments) that

can result in maladaptation, whereas a more holistic integration with non-structural measures based on public participation is urgently required.

1.1.3 National Perspectives from Aotearoa New Zealand

National implications for contemporary climate governance have constituted a significant topic for researchers examining the multilayered composition of natural hazards including pluvial flooding, in Aotearoa New Zealand, acknowledging the presence of low-frequency high-impact hazards that bear major nationwide consequences. [19] The work of Lawrence, Quade and Becker (2014) focused on the Hutt Valley region of New Zealand and clarified clear linkages between FRP and the effectiveness of adaptation measures in response to climate change, through communication of information and public expectations of flood risk manager response. [64] Findings revealed that previous experience of flooding shapes FRP and tolerance of flooding, while households who with no prior experience of flooding tended to be more optimistic about future flooding event, in addition to evident risk transfer expectations of households to public authorities for reducing the risk of flooding. More recently, Auliagisni et al (2022) promote participatory models of inclusive, community-based flood-risk mapping to enhance risk communication strategies and existing social networks that contribute to greater community resilience, using the case study of Northland, New Zealand. [65] The authors stress that community knowledge and experience of flooding can further inform future FRM policy development. However, Bajestani et al (2024) and Fu et al (2023) also acknowledge that insufficient national FRM has led to inadequate attention on FRP in the development of risk information and communications. [66,67] The latter study specifically examines residual risk, outlined as ‘the risk remaining after implementing risk reduction measures’ where a contributing factor is the levee effect, albeit targeting local government representatives and flood risk management consultants. [67] Taking a wider lens, Jayawardena et al. (2026) examine the socioeconomic dimensions of climate hazard and risk perception in Auckland New

Zealand, with reference to diverse urban neighbourhoods experiencing flooding and landslide risk. [68]

Acknowledging the vast discourse and notable studies that have driven contemporary individual and collective responses to urban flooding, an existing knowledge gap lies in investigating the associations between perceptions of flood risk and flood resilience. Examining what shapes these perceptions aids our understanding of the cognitive, sociocultural, behavioural and informational, geographic and physical, and demographic mediators that inform resident needs and expectations for achieving greater urban-scale flood resilience and further contributes towards wider urban DRR initiatives and sustainability goals. There is a heightened need to examine the interplay of these factors using localised case studies to reveal the priorities for urban residential neighbourhoods following major flooding disruption and who are facing increasing risks due to climate change. This study employed an anonymous survey questionnaire to investigate: (i) interconnections between flood risk perception (FRP) and perceived neighbourhood flood resilience for residential neighbourhoods in Auckland New Zealand following the 2023 Auckland Anniversary Weekend floods, and (ii) needs and expectations of residential communities for enhancing neighbourhood flood resilience. With reference to key principles from existing discourse, the survey questionnaire was devised using the themes of past experience, future flood risk, recommended improvements, and demographic data. Investigating the associations between perceived flood risk and flood resilience can reveal the role of multiple, varied factors to ultimately inform targeted and context-specific decision-making. Preceding research investigating the factors underpinning community flood risk perception acknowledge that FRP does not necessarily reflect true flood risk, hence the findings from this study are intended to support greater dialogue between urban residents and decision-makers, to eventually help address common public flood risk misperception, and to offer a basis for greater exploration of resilience

perception to reveal public risk tolerance and willingness to pay for risk reduction. [25,38] [69,70]

2. Methods

2.1 Study Area

The study area encompasses two distinct residential suburbs in Auckland, New Zealand, namely Mount Eden and New Lynn. The city of Auckland is the country's most populous centre, with approximately 1,571,718 people (2018), and is situated on an isthmus between the Waitemata Harbour and the Manukau Harbour, in the North Island of New Zealand (**Figure 1**). [71] Criteria for the selection of the study area is as follows: (i) Documented impact: both suburbs are situated within areas in Auckland identified as the most severely affected during the 2023 floods, indicated by high numbers of 'stickered' buildings across the territorial authority wards (Mount Eden located within the Albert-Eden-Puketāpapa Ward and New Lynn located within the Waitākere ward) (ii) Current exposure: both suburbs are identified to be at risk of flooding, containing flood-plains, flood-prone areas, and overland flow paths indicated by territorial authority flood maps; and (iii) Established residential neighbourhoods: featuring a mixture of dwelling types and that have featured increasing urban intensification as part of regional planning reforms in recent years [72][73–77]

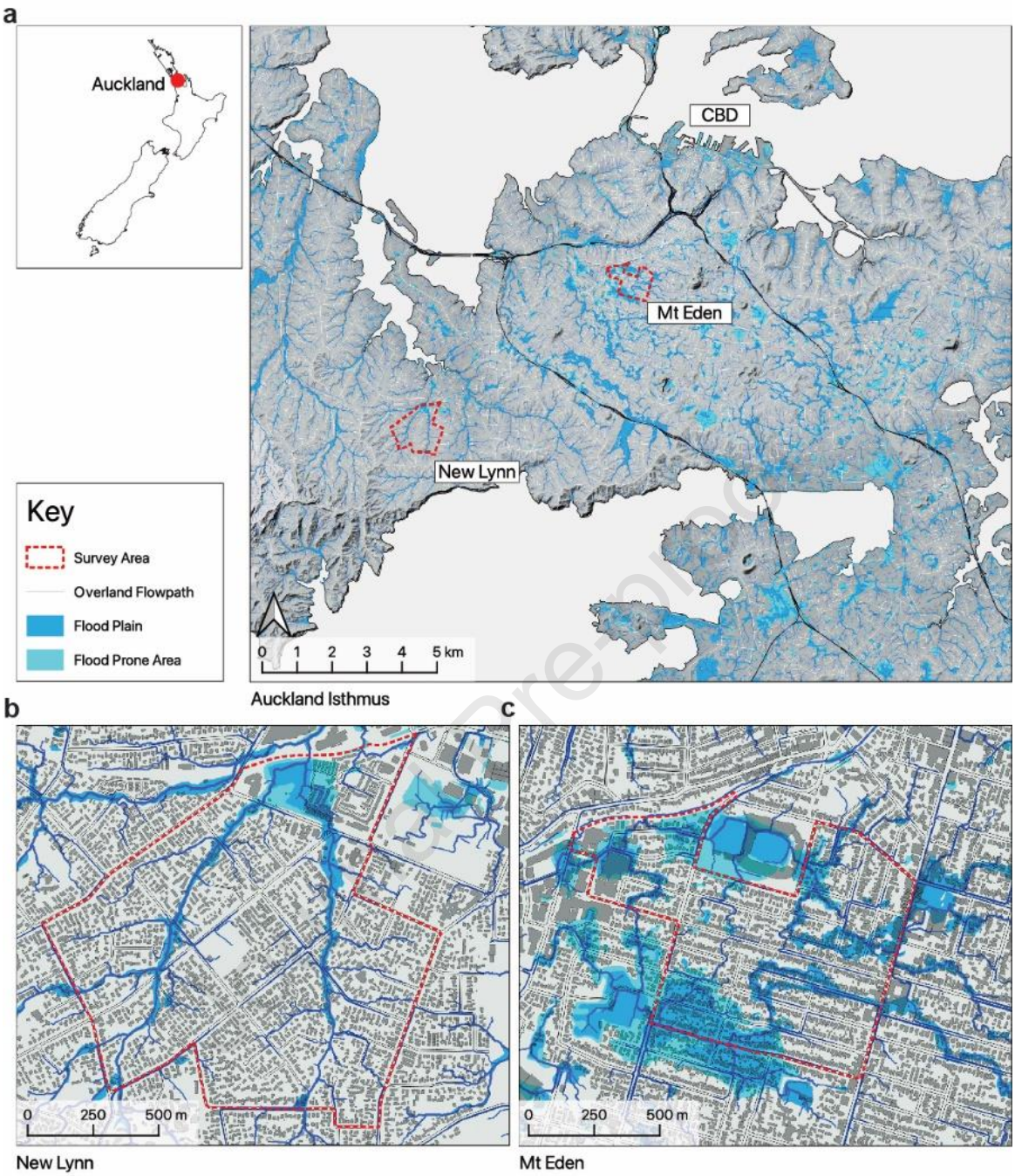

Figure 1: Contextual mapping of flood prone survey area in Auckland, New Zealand. Mapping regions are (a) Auckland Isthmus, and the two survey neighbourhoods, (b) New Lynn, and (c) Mount Eden. Flood prone regions are annotated with blue shading with Flood plain and Flood prone areas coloured dark blue and light blue respectively. Dotted red outlined areas represent survey boundaries. Flooding data from the Auckland Council Open Data, last updated 2025, Base map data from Land Information New Zealand Auckland 1m Lidar 2024, Land Information New Zealand Building Outlines, Land Information New Zealand Road Centrelines.

2.2 Survey Design

Survey invitations were distributed by mailbox drop to the residents and contained a QR-code link to the online questionnaire. Community organisations were also contacted and assisted in the circulation of survey invitations via social media pages. Exclusion criteria for participants was age (i.e. participants were required to be 18 years of age and over to participate in the online survey). Our research objectives focused on neighbourhood perceptions of flood risk and resilience, and the corresponding policy implications, which are closely influenced by residents with agency for household decision-making and responsibility for actioning practical household flood mitigation measures (e.g., homeowners, renters, and taxpayers). Using the Qualtrics platform, 'skip-logic' questions were also introduced to reduce respondent survey fatigue. For example, Question 6 included this feature to ensure that only those respondents who experienced flooding in 2023 were requested to provide further details relating to specific damage incurred.

The indicators used in this study were informed by existing discourse, documenting their role in FRP and urban disaster resilience. The indicators for this study included reference to rationalist (modelling, characterising, predicting) and constructivist (socially constructed) paradigms informing FRP **(Table 1)**: (i) Cognitive factors such as 'rainfall worry' and 'perceived safety' to measure the psychological impacts arising from the 2023 floods; (ii) Behavioural and Informational factors such as 'past experience' including impact on neighbouring properties and community facilities, planning to implement household-level changes following the 2023 floods to explore the role of previous flooding events in shaping resident responses, awareness and access of digital tools used to monitor or respond to neighbourhood flood risk; (iii) Sociocultural factors such as 'trust in local authorities', 'perceived sufficiency of emergency flooding response', 'perceived urgency of government response' were developed to investigate social resilience that is required for successful flood

264 risk management (iv) Geographic and Physical indicators such as 'distance from flooding
265 source' and 'dwelling type' were employed to examine the perceived risk in relation to the
266 physical context of residing in the selected flood-prone suburbs and (v) Demographic factors
267 such as age, gender, ethnicity, residential status (e.g. homeowner, renter, family home), length
268 of time lived at the current residence, size of household.

269 **Table 1:** Development of indicators and survey questions

Survey Indicator Categories and Empirical Evidence	Survey Questions
Cognitive: Worry about rainfall and any potential future neighbourhood flooding; Perception of safety from neighbourhood flood risk; Perception of neighbourhood flood resilience [30,32,34,78–81]	How worried do you feel about rainfall and any potential future flooding in your neighbourhood?
	On a scale of 1-10, how safe do you feel from the risk of flooding in your neighbourhood (with 1 being least safe and 10 being very safe)?
	How would you rank your neighbourhood flood resilience (1 being Low Resilience and 10 being High Resilience)
Behavioural and Informational: Causes of the Auckland Anniversary Weekend flooding in 2023; Planning to make any residential changes after the Auckland Anniversary Weekend floods in 2023; Impact to property, neighbouring properties or nearby community facilities; Awareness and use of digital tools used to monitor, record, or respond to neighbourhood flood risk; Trust in local authorities and emergency management organisations; Access to information regarding neighbourhood flood risk [78,79][30,32,34,80]	What were the causes of the Auckland Anniversary Weekend flooding in 2023? - Selected Choice
	Did you make, or are you planning to make any changes to your home after the Auckland Anniversary Weekend floods in 2023? Please indicate if applicable: - Selected Choice
	Was your property, neighbouring properties or nearby community facilities (e.g. shops, community centre) affected by the Auckland Anniversary Weekend floods in 2023?
	Are you aware of any digital tools or technologies that are used to monitor, record or respond to flood risk in your neighbourhood?
	On a scale of 1-10, how much do you trust local authorities and emergency management organisations to mitigate flood risk (1 being low trust and 10 being high trust)
	Have you previously tried to access to information on flood risk in your neighbourhood?
Sociocultural: Assisting friends or neighbours in recent flooding; Perceived sufficiency of neighbourhood emergency flooding response; Perceived urgency of government perception of neighbourhood flood risk [78,79,82]	Did you assist friends or neighbours in recent flooding, or were you assisted by friends of neighbours?
	In your opinion, was there a sufficient emergency flooding response in your neighbourhood?

	How urgent do you think government organisations perceive flood risk in your neighbourhood?
Geographic and Physical: Perceived distance between residence and source of flooding; Site [78,79][80][81]	What is the approximate distance between your residence and the source of the flooding (with 1 being close and 5 being far?)
Demographic: Age; Gender category; Ethnicity; Dwelling type; Residing on ground floor; Residential status (e.g. homeowner, renter); Length of time lived at current residence; Household size (number of occupants) [78–81]	What is your age range?
	Which of the following gender categories best describes how you self-identify?
	What is your ethnicity? - Selected Choice
	What kind of home do you live in?
	Do you live on the ground floor or higher?
	What is your residential status? - Selected Choice
	How long have you lived at your current residence?
	How many people live in your household (including you)?

Surveys were administered online through the Qualtrics platform (Qualtrics: 03, 2024, 2025). Survey questions were designed to evaluate the interrelationships between cognitive, socioeconomic and demographic, geographic, informational, and contextual factors, using themes of: themes of: past experiences (e.g. occurrence of flooding, emergency response and support), future flood risk (e.g. perception of safety from flood risk, awareness of publicly available information for flood preparedness), recommended improvements for enhancing flood risk response and resilience, in addition to demographic data (e.g. gender, age, ethnicity, residency status, dwelling type and number of inhabitants). Survey questions offered multiple-choice responses including Likert scale ranking and open-ended response fields to enable qualitative responses. Participants had the opportunity to enter a random prize draw upon completion of the survey.

2.3 Survey Data Collection and Bias Mitigation

283 The survey was distributed to participants during June 2024 and September 2024. Participants
284 were informed of the study purpose using a survey invitation and participation information
285 sheet before commencing the survey. The approximate time required to complete the survey
286 was 15 minutes. The survey was pilot tested with a single neighbourhood block in New Lynn
287 where 190 survey invitations were distributed in June 2024 to assess response rate.
288 Acknowledging that survey questions such as indicating the level of trust in local governments
289 can be sensitive, survey responses were gathered anonymously, and participants were informed
290 that all data would be anonymised to support honest responses.

291 **2.4 Ethics, Consent, Data Protection**

292 Ethics approval was received for facilitating simultaneous distribution of invitations for
293 anonymous, online neighbourhood survey questionnaires within two selected neighbourhood
294 suburbs in Auckland, New Zealand. The study was approved by the Auckland University of
295 Technology Ethics Committee (AUTEC) with approval number 24/141.Before commencing
296 the survey, all participants were required to read the participation information sheet where they
297 were informed that survey responses indicated their consent. The participation information
298 sheet included the study aims, methods of data collection, and the right to withdraw at any time
299 without incurring any penalties. The participation information sheet also informed participants
300 that survey responses would remain confidential and anonymous. Survey responses were
301 anonymised before data analysis to protect participant identities.

302 **2.5 Statistics and Reproducibility**

303 Data analysis and plots were undertaken using Python (version 3.9.19; Python Software
304 Foundation 2025). Summary and descriptive statistics were calculated to evaluate survey
305 responses. To assess the associations between all pairwise combinations of responses, a series
306 of statistical tests were employed, including the Kruskal-Wallis H test was used nominal-

numeric comparisons, Cramér's V was used for nominal-nominal comparisons (with significance determined using the Chi-squared test), and Spearman's rank correlation coefficient (rho) was used for numeric-numeric comparisons. For all tests, significance was defined as a q-value of less than 0.05, with multiple comparisons applied using the Benhamini-Hochberg technique. [83,84]

2.6 Network Analysis

These significant associations between features described above were explored using a network analysis approach whereby survey questions were represented as nodes with significant associations between them as edges. Networks were saved as graphml format and visualised using Cytoscape 3.10.3 software. [85]

2.7 Qualitative Data Analysis of Open-Ended Questions

NVivo 15 software was used to analyse responses to analyse five open-ended survey questions (Q6, Q16, Q21, Q27, Q28, in Supplementary Data 1). [86,87] Individual responses to the open-ended survey questions were classified using keyword codes using a grounded theory approach. These codes were subsequently sorted into thematic categories in order to extract commonalities and differences across the survey responses.

2.8 Data Availability

Data is available upon reasonable request to the corresponding author.

2.9 Code Availability

All analysis code is freely available on GitHub at https://github.com/stacyvallis/flood_survey

3. Results

3.1 Significant Associations between Perceived Flood Risk and Perceived Flood Resilience

To identify the factors that underpinned perceived flood risk and perceived flood resilience, we performed a neighbourhood survey in 2024 in two urban neighbourhoods New Lynn and Mount Eden that were impacted by flooding in 2023. A total of 2,500 survey invitations were distributed across both neighbourhoods, with 1,500 survey invitations in New Lynn and 1,000 survey invitations in Mount Eden. The survey contained questions that relate to their personal flood risk perception, neighbourhood resilience, and common confounding variables **(Table S1)**. Mailbox distribution of survey invitations was supported by advertisement on the Community Waitakere Facebook page and posters in local businesses. The survey yielded a response rate of 4.0% in New Lynn and 7.3% in Mount Eden, with an overall response rate of 5.3%. A total of 40 out of 133 responses (30.1%) were excluded from the survey where no age range or zone was selected in the survey responses as per the exclusion criteria. The majority (54.84%) of respondents out of 93 were in the 35-54 age range, and the survey respondents were not biased by the respondents' identified gender (proportion test, effect size, p-value), with respondents identifying as male (n=36), female (n=47), and another gender (n=2) **(Table 2)**. Of the respondents, there were New Zealand European (69.89%), Asian (4.30%), Māori (2.15%), Pacific (1.08%), and Other (15.05%). Most respondents reported owning their home (63.4%) and living in a detached dwelling (75.3%). The average household size was 3.03 individuals (± 1.16 SD). Across both neighbourhoods, 72.0% of respondents (67/93) reported experiencing or observing flood-related damage to their own property, neighbouring homes, or nearby community infrastructure (e.g. shops, community centres).

Our results demonstrate that perceived resilience is not an isolated factor but is highly connected with cognitive factors (e.g. rainfall worry, perception of safety), behavioural and informational factors (e.g. trust in local authorities), sociocultural (e.g perceived sufficiency in

353 flooding response, provision or receipt of assistance during flooding), and geographic and
354 physical factors (e.g. distance from flooding source). Demographic factors such as age and
355 gender did not significantly correlate with perceived resilience. When asked about the
356 participants' FRP, on a scale of 1-10, perception of safety on average was 6.37 ± 2.97, while
357 the average reported neighbourhood flood resilience was 4.92, ± 2.64. A total of 27/93 (29.0%)
358 of respondents reported feeling 'partly worried' about rainfall and potential future
359 neighbourhood flooding, while 14/93 (15.1%) reported feeling 'very worried', and 25/92
360 (26.9%) reported feeling 'not worried'. Significant associations between FRP and perceived
361 neighbourhood resilience arose through perceived safety from flooding, rainfall worry,
362 reported levels of trust in local government authorities to manage flooding, distance from
363 flooding source, perceived sufficiency of emergency flooding response, and residents reporting
364 providing or receiving assistance during flooding.

365 **Table 2:** Summary statistics of survey responses (*n*=93)

Question	Response	Count/Percentage of Total Sample
What were the causes of the Auckland Anniversary Weekend flooding in 2023? - Selected Choice	Unanswered	8/93 (8.6%)
	Heavy rainfall	83/93 (89.2%)
	Other (please specify)	62/93 (66.7%)
	Building on floodplains	63/93 (67.7%)
	Overflowing waterways	67/93 (72.0%)
Did you make, or are you planning to make any changes to your home after the Auckland Anniversary Weekend floods in 2023? Please indicate if applicable: - Selected Choice	Unanswered	34/93 (36.6%)
	Clearing rain gutters	31/93 (33.3%)
	Reducing paved areas/impermeable surfaces	7/93 (7.5%)
	Other (please specify):	34/93 (36.6%)
	Adding stormwater tanks	6/93 (6.5%)
What is your age range?	18-34	15/93 (16.13)
	35-54	51/93 (54.84)
	55-74	24/93 (25.81)
	75-84	3/93 (3.23)
Was your property, neighbouring properties or nearby community facilities (e.g. shops, community centre) affected by the Auckland Anniversary Weekend floods in 2023?	Yes	67/93 (72.04)
	No	18/93 (19.35)

	Unsure	7/93 (7.53)
	Unanswered	1/93 (1.08)
Did you assist friends or neighbours in recent flooding, or were you assisted by friends of neighbours?	Yes	41/93 (44.09)
	No	46/93 (49.46)
	Unsure	1/93 (1.08)
	Unanswered	5/93 (5.38)
In your opinion, was there a sufficient emergency flooding response in your neighbourhood?	Yes	28/93 (30.11)
	No	36/93 (38.71)
	Unsure	25/93 (26.88)
	Unanswered	4/93 (4.30)
How worried do you feel about rainfall and any potential future flooding in your neighbourhood?	Not Worried	25/93 (26.88)
	Partly Worried	27/93 (29.03)
	Worried	21/93 (22.58)
	Very Worried	14/93 (15.05)
	Unanswered	6/93 (6.45)
How urgent do you think government organisations perceive flood risk in your neighbourhood?	Not Urgent	41/93 (44.09)
	Somewhat urgent	31/93 (33.33)
	Moderately Urgent	12/93 (12.90)
	Very urgent	3/93 (3.23)
	Unanswered	6/93 (6.45)
Are you aware of any digital tools or technologies that are used to monitor, record or respond to flood risk in your neighbourhood?	Yes	22/93 (23.66)
	No	63/93 (67.74)
	Unsure	2/93 (2.15)
	Unanswered	6/93 (6.45)
Have you previously tried to access to information on flood risk in your neighbourhood?	Yes	48/93 (51.61)
	No	39/93 (41.94)
	Unanswered	6/93 (6.45)
Which of the following gender categories best describes how you self-identify?	Male/Tāne	36/93 (38.71)
	Female/Wahine	47/93 (50.54)
	Another Gender/ He ira kē anō	2/93 (2.15)
	Unanswered	8/93 (8.60)
What is your ethnicity? - Selected Choice	New Zealand European	65/93 (69.89)
	Māori	2/93 (2.15)
	Pacific	1/93 (1.08)
	Asian	4/93 (4.30)
	Other (Please state)	14/93 (15.05)
	Unanswered	7/93 (7.53)
What kind of home do you live in?	A (e.g. Apartment)	3/93 (3.23)
	B (e.g. Row/Terrace home)	13/93 (13.98)
	C (e.g. Detached house)	70/93 (75.27)
	Unanswered	7/93 (7.53)
Do you live on the ground floor or higher?	Unsure	2/93 (2.15)
	Ground Floor	71/93 (76.34)
	Higher than Ground Floor	12/93 (12.90)

	Unanswered	8/93 (8.60)
What is your residential status? - Selected Choice	Homeowner	59/93 (63.44)
	Renter	18/93 (19.35)
	Family Home	8/93 (8.60)
	Unanswered	8/93 (8.60)
How long have you lived at your current residence?	Less than 1 year	2/93 (2.15)
	1-5 years	29/93 (31.18)
	6-10 years	14/93 (15.05)
	11-15 years	10/93 (10.75)
	16-20 years	9/93 (9.68)
	20 years+	22/93 (23.66)
	Unanswered	7/93 (7.53)
Site	New Lynn	38/93 (40.86)
	Mount Eden	55/93 (59.14)
On a scale of 1-10, how safe do you feel from the risk of flooding in your neighbourhood (with 1 being least safe and 10 being very safe)?	Mean (SD)	6.37 (2.97)
What is the approximate distance between your residence and the source of the flooding (with 1 being close and 5 being far?)	Mean (SD)	2.20 (1.14)
On a scale of 1-10, how much do you trust local authorities and emergency management organisations to mitigate flood risk (1 being low trust and 10 being high trust).	Mean (SD)	3.93 (2.22)
How would you rank your neighbourhood flood resilience (1 being Low Resilience and 10 being High Resilience)	Mean (SD)	4.92 (2.64)
How many people live in your household (including you)?	Mean (SD)	3.03 (1.16)

To identify the relationships between responses within the survey, we employed a network analysis approach where each node represents one of the 18 quantitative survey questions and each edge represents a significant relationship between the survey question responses (Chi-squared, Spearman, and Kruskall-Wallis tests for categorical-categorical, numeric-numeric, and numeric-categorical associations respectively) **(Figure 2, Table S2)**. Of the 210 pairwise comparisons between the twenty-one survey quantitative questions that had categorical or numeric format answers and one site variable (New Lynn or Mount Eden), there were thirty-four significant relationships (**Figure 3, Table S2)**.

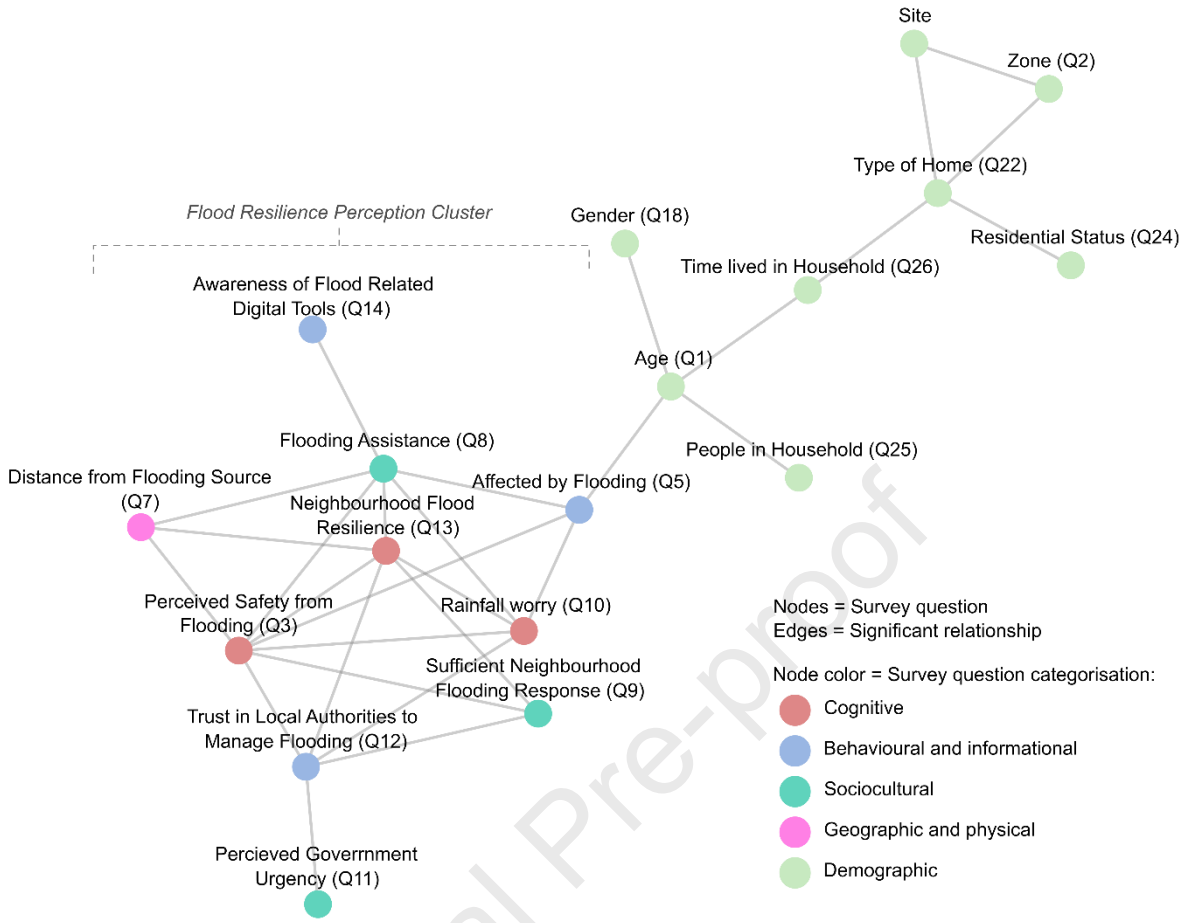

Figure 2: Significant relationships between survey question responses. Network nodes are survey questions and edges are monotonic significant associations between them pairwise (Kruskal-Wallis, chi-squared, or Spearman, $q<0.05$). Shorthand questions are presented, and full question are available in supplementary data.

Two response groups emerged from the network. A cluster containing factors such as Age (Q1), Gender (Q13), Number of People in Household (Q25) or Type of Home (Q22) was named the 'Demographic cluster'. The second cluster was highly interconnected and contained factors that were flooding resilience, named the 'Resilience cluster'. Amongst nodes in the Resilience Cluster are Neighbourhood Flood Resilience (Q13) with Flooding Assistance (Q8), Rainfall Worry (Q10), Flood Risk (Q3), Perceived Sufficient Neighbourhood Flood Response (Q9), Distance from Flooding Source (Q7), followed by Trust in Local Authorities to Manage Flooding (Q12). Experiencing impacts of past flooding is associated with Flooding Assistance

384 (Q8), Rainfall Worry (Q10), and Flood Risk (Q3). Awareness of Digital Technologies for
385 Reporting, Responding to Flood Risk (Q14) is associated with Flooding Assistance Q8)
386 (Cramer's V= 0.52, Chi squared p < 1.47E-9). Interestingly, there was no significance found
387 between perceived neighbourhood resilience and type of dwelling (Q22), time lived at
388 residence (Q26), residential status (Q24), age (Q1) or gender (Q18).

389 We next sought to investigate the relationships within the Resilience cluster between FRP
390 factors and perceived Neighbourhood flood resilience **(Figure 3)**. Perceived neighbourhood
391 flood resilience had the second highest number of connections, or degree (n = 6), of any
392 question revealing its collinearity with many individual survey question responses.

393 In order of significance, these relationships with perceived neighbourhood flood resilience
394 included perceived safety from flooding (Spearman rho=0.75, 1.32E-16), trust in local
395 authorities to manage flooding (Spearman rho=0.64, 2.40E-11), rainfall worry (Kruskall-Walls,
396 p=2.85E-09), distance from flooding source (Spearman rho=0.49, 7.50E-5), perceived
397 sufficiency in flooding response (Kruskall-Wallis, p=4.32E-4), provided or received assistance
398 during flooding (Kruskall-Wallis, p=4.6E-3).

399

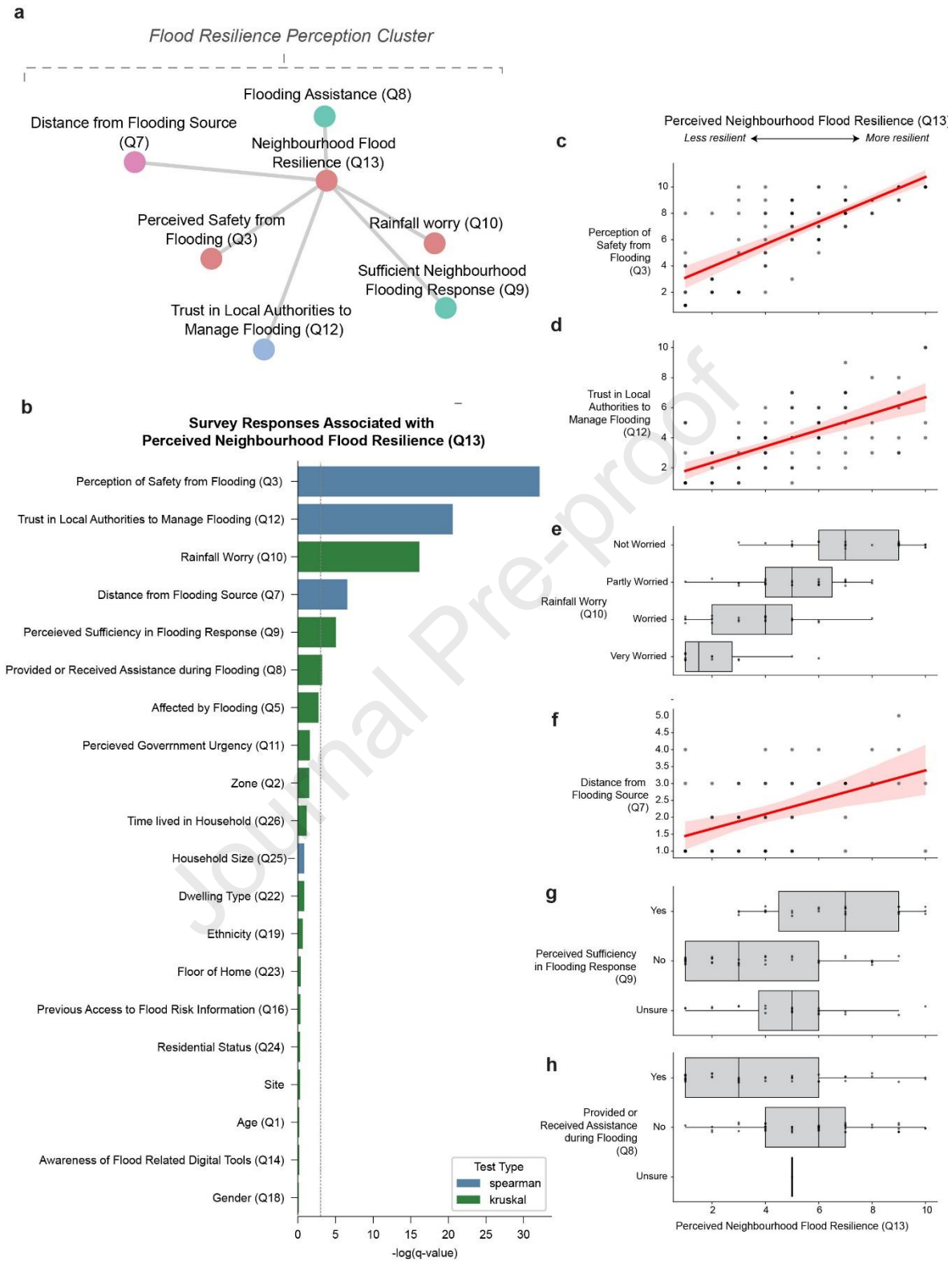

Figure 3: Perception of neighbourhood flood resilience is strongly associated with FRP factors. (a) Summary diagram of significant associations between perceived flood resilience and flood risk perception factors, derived from Figure 2 (b) Bar plot of significance of survey

questions with neighbourhood flood resilience (Q13) adjusted for false discovery rate (FDR). Numeric-numeric comparisons were measured using Spearman correlation and bars coloured blue. Numeric-categorical comparison were measured using Kruskal-Wallis and bars coloured green. Vertical grey line represents significance ($q<0.05$). The plots on the right illustrate the significant relationships from (b). Scatter plot with fitted linear regression line between flood resilience (Q13) and Q3, Q12, and Q7 shown in c, d, and f respectively. Points represent individual observations. The solid line denotes the ordinary least squares (OLS) regression fit, and the shaded area indicates the 95% confidence interval. Horizontal boxplots showing the distribution of flood resilience (Q13) across Q10, Q9, and Q8 shown in e, g, and h respectively. Each box represents the interquartile range (IQR) with the line inside indicating the median. Whiskers extend to 1.5 times the IQR and points represent individual observations.

3.2 Community Needs and Expectations for Urban Neighbourhood Flood Resilience

The survey results highlight urban resident needs and expectations, noting that residents have expressed interest in a range of infrastructural measures including nature-based solutions, in addition to more information relating to local flood risk, that can collectively enhance urban neighbourhood flood resilience **(Table 3)**. Survey participant observations indicate flood impacts and damage occurring on residential properties and affecting whole neighbourhoods including disruption to arterial streets, roads, and to local businesses. Direct quotes encapsulating these impacts included: “Houses down the road from us were completely flooded out and needed full renovations”, and “Neighbours, school and nearby shops were flooded with water soaking belongings and requiring repairs.” Participants report no planned or pending actions following flooding, due to existing compliance with local government flood risk management strategies, in addition to cost, renter status, and no flood damage. Recommendations for neighbourhood flood risk preparedness ranged from specific or individual property interventions to neighbourhood scale actions **(Table 3)**. Neighbourhood improvement and maintenance measures were identified, while penalties for non-compliant residential development were suggested to improve neighbourhood flood preparedness. The uneven impacts of flooding were highlighted, including emotional trauma as a result of significant impact on some residents and resident concerns regarding the affordability of

418 emergency supplies. Current residents across both neighbourhoods acknowledged surrounding
419 landscape and geology as consideration for flood mitigation, together with potential impacts
420 from prospective high-density housing developments and the consequential loss of green
421 spaces.

422 Of 93 survey responses, 48/93 (51.61%) recorded 'Yes' to having previously accessed
423 information on neighbourhood flood risk, while 39/93 (41.94%) recorded 'No', and 6/93
424 (6.45%) did not provide a response **(Table 2)**. Of those respondents who reported previous
425 attempts at accessing this information, a variety of information sources are included **(Table 3)**.
426 Government organisations (local and national) constituted a common source of information,
427 where commonly consulted resources were existing residential property records and the
428 Auckland Council Flood Viewer tool. Historical records, word of mouth, and media (including
429 web searchers, news and social media channels) were also cited as sources of information for
430 neighbourhood flood risk. Advice was also sought from building industry professionals and
431 international companies.

432 **Table 3: Thematic coding for open-ended responses**

Question number	Question	Response code	Frequency
Q17:	In the context of "Question 16: Have you previously tried to access to information on flood risk in your neighbourhood?", "If you responded yes to the previous question, please indicate where you may access information on flood risk in Auckland?"	Property File Documents E.g. Land Information Memorandum	7/93
		Local Government Website including GIS and Flood Risk Viewer	26/93
		General Web Sources	3/93
		Word of Mouth	1/93
		Local Government	4/93
		General Flood Maps	3/93
		National Sources E.g. Civil Defence or Natural Hazards Commission	5/93
		International Companies	1/93
		Historical Record	1/93
		Media including News and Social Media Channels	2/93
		Professional Advice	1/93

		Community Welfare and Support Organisations	1/93
Q7:	In the context of "Question 6: Was your property, neighbouring properties or nearby community facilities (e.g. shops, community centre) affected by the Auckland Anniversary Weekend floods in 2023" , "if you responded yes to the previous question, could you specify the type of damage that has occurred and has this been resolved since the flooding?"	General damage to neighbouring properties	25/93
		General damage to roads and streets	6/93
		Residential damage to backyard or front yard	9/93
		Residential damage to garages	9/93
		Residential damage to basements	6/93
		Residential damage to home	10/93
		Damage to personal belongings	5/93
		Damage to community facilities e.g. public places or shops or businesses	12/93
		Drains overflowing	6/93
		Fallen tree	2/93
		Damage Resolved	15/93
		Damage Unresolved	1/93
		Resolution Statues Unclear	6/93
Q22:	In the context of Question 21: "Did you make, or are you planning to make any changes to your home after the Auckland Anniversary Weekend floods in 2023?" , "Please indicate if applicable: - Other (please specify): - Text"	Acquire Pumps	2/93
		Add Stormwater Tanks	3/93
		Adding or Amending Planting	2/93
		Alter Boundary Fence	1/93
		Clear Drain	4/93
		Clearing Garden	1/93
		Clearing Gutters	29/93
		Community Collaboration	1/93
		Contacted Local Authority for Assistance	1/93
		Dig Water Hole	2/93
		Ensure Sufficient Overland Flow Paths	1/93
		Install Boundary Fencing	1/93
		Install Raingarden	1/93
		Installing New Drainage System	3/93
		Moving Storage of Household Items	4/93
		Reconsider Planned Renovation	1/93
		Reduce Impermeable Surfaces	6/93
		No Changes Planned	5/93
		Replace Household Components or Fixing Damage	4/93
		Unable to Make Changes	2/93
		Stocking Emergency Kit	2/93
		Tree Maintenance	1/93
Q27	"Are there any improvements that you like to see for improving flood risk preparedness in your neighbourhood? If yes, please give examples	Better management of local waterways	4/93
		More considered urban intensification eg do not build at ground level	8/93
		Community drain clearing and maintenance	3/93
		Flood mitigation or adaptation measures for vulnerable homes	2/93
		Footpath slops	1/93
		Improved drainage infrastructure eg better rubbish and waste management	31/93
		More detention and retention tanks	1/93
		More information eg current risk assessment or emergency meeting points	8/93
		More local neighbourhood interaction and planning	1/93
		More native planting on berms	1/93

		More rain gardens or wetland areas	3/93
		More soakage pits in streets	1/93
		More trees and improved tree maintenance	4/93
		Penalties for non-compliant development	1/93
		Scorer holes	1/93
		Less Concrete	1/93
		Street maintenance eg sweeping litter and leaves	2/93
Q28:	"Is there any additional information you would like to share?"	Improved Stormwater Drainage	4/93
		More Neighbourhood Planting	3/93
		More Research and Dissemination	2/93
		Lacking Communication to Residents	3/93
		Insufficient Planning and Maintenance	1/93
		Emotional Trauma	2/93
		Affordability of Emergency Supplies	1/93
		More Community Collaboration	2/93
		Trust based on Local Community Effort	1/93
		Local Geology and Landscape Advantages and Impacts	3/93
		Lacking Public Awareness	1/93
		Lacking General Actions	6/93
		Uneven Impacts of Flooding	2/93
		Individual Residential Preparedness	1/93
		Flood Risk Interventions Working Well	1/93
		Flood Impacts from High Density Housing and Loss of Green Spaces	1/93
		Considerations for Potential Residential Property Buyers	1/93
		Responsible Recycling and Litter Management	1/93

4. Discussion

Underestimating flood risk is a growing challenge for flood risk management.[26,88] Previous studies identify a need for greater scholarly attention to address associations between perceptions of flood risk and resilience leading to enhanced flood-risk management. [25,26,89–91] While flood risk perception can indicate willingness to take precautionary actions against external threats based on worry, awareness, and preparedness, resilience encompasses the capacity for recovery and adaptation and comprises a global priority for DRR initiatives. [15,92–96] Investigating perceived risk and perceived resilience can highlight discrepancies between perception and reality and consequently informs the development and uptake of context-specific risk management policies and communication strategies. Our study provides insights by linking urban residents' perceived flood risk (or FRP) and perceived resilience,

445 considering cognitive, behavioural, sociocultural or contextual, and geographic mediators
446 using quantitative and qualitative analyses.

447 *4.1 Limitations*

448 This study presents a sample of responses using cross-sectional survey; hence it is important
449 not to make hasty generalisations about other neighbourhoods and potential changes in
450 perceived flood risk and perceived flood resilience over time. Previous research has shown that
451 ambiguities concerning the significance of demographic and geographic factors with FRP can
452 arise, especially concerning gender, age, home ownership, and distance from flooding source,
453 hence cultural contextualisation is important to further understand these relationships. [26] In
454 the reported study, gender, age, and home ownership did not display significant associations
455 with the perception of resilience (**Figure 3a**). The sample is majority homeowners (Mount
456 Eden 68.5%, 64.7% New Lynn), albeit consistent with 2023 census data, residing in detached
457 dwellings and reporting New Zealand European ethnicity. [97,98]. **While pilot testing the**
458 **survey was conducted, this process did not include triangulation for cross-verification of**
459 **participant responses. Key limitations of not applying triangulation methods for the data**
460 **collection instrument in this study are in addressing potential researcher bias, validation**
461 **and enhancing contextual interpretation of participant responses, and to increase**
462 **generalisability of the findings. [99]**

463 **4.1 Perceived Flood Risk and Resilience through the lens of Worry, Awareness,**
464 **Preparedness**

465 There is a need to investigate contextual or sociocultural influences in conjunction with
466 cognitive, behavioural, socioeconomic and demographic, informational, and geographic
467 factors that shape FRP. [26,38,100–102] To achieve this, we applied network analysis to
468 understand the relationships between all quantitative survey responses associating perceived

469 flood risk with perceived resilience (**Figure 2**). The resulting network revealed two distinct
470 clusters, one capturing perceived resilience-related factors (Flood Resilience Perception
471 cluster), and the other comprising demographic characteristics. From the Flood Resilience
472 Perception cluster classified, we employed a qualitative analysis of the text-based responses to
473 the survey questions 7,17, 22, 27, 28.

474 Our analysis reveals that perceived neighbourhood flood resilience was highly central to the
475 Flood Resilience Perception cluster (degree=6). These nodes are ranked based on their
476 significant relationships with the central node, in the following order by significance:
477 perception of safety from flooding (Q3), trust in local authorities to manage flooding (Q12),
478 rainfall worry (Q10), distance from flooding source (Q7), perceived sufficiency in flooding
479 response (Q9), provided or received assistance during flooding (Q8) (**Figure *3***). Both selected
480 study areas experienced flooding during the Auckland Anniversary Weekend floods in 2023,
481 and a majority of survey respondents (67/93, 72.04%) reported impacts to their properties,
482 neighbouring properties or community facilities **(Table 2)**. This finding aligns with existing
483 literature where perceptions of safety from flooding and rainfall worry informing FRP are also
484 highly likely to shape perceptions of neighbourhood flood resilience, and where past
485 experiences of flooding strongly contribute. [25,103,104]

486 Sociocultural factors, including social ties with people, communications networks, level of
487 trust in local authorities, and public protection mechanisms also moderate FRP. [25,26] This
488 effect is evident through previous studies where trust in local authorities is shown to be
489 significant where there are low individual knowledge levels of the flood threat. [103] In this
490 study, sociocultural influences such as trust in local authorities and emergency management
491 services (Q12), providing or receiving assistance during flooding (Q8), and residents'
492 perceived sufficiency of emergency flooding response (Q9) that traditionally define FRP, also
493 here connect FRP with perceived neighbourhood flood resilience. However, noting that a

494 number of respondents reported relatively low levels of trust in local authorities and emergency
495 management organisations to mitigate flood risk (average 3.9 ± 2.2), together with feeling a
496 degree of worry about rainfall and future neighbourhood flooding ("partly worried" (29.03%),
497 "worried" (22.58%), and "very worried" (15.05%)), in addition to respondents reporting
498 feeling "moderately safe" with high variance (average 6.4 ± 3.0) and reporting moderate
499 resilience ranking with high variance (average 5.0, ± 3.0), the findings from this study suggest
500 there is scope for greater engagement between neighbourhood residents and local authorities
501 to address any potential misperceptions relating to increasing flood risk, enhance
502 neighbourhood flood risk mitigation strategies, and neighbourhood flood resilience.
503 Respondents' perception of sufficiency of emergency flooding response (30.11 % indicating
504 'Yes' and 38.71 % indicating 'No') also suggests an opportunity for clearer communication of
505 emergency management provisions and authorities' capacity to respond to future
506 neighbourhood flooding, to help clarify the nature of public expectations, residents' roles for
507 property-level flood responses, and if any realignment of resources is necessary, for example.

508 These goals can also be achieved by enhancing the exchange of information between
509 neighbourhood residents and authorities, demonstrated by the relationships between worry
510 levels with informational factors such as awareness of flooding causes, previous access to flood
511 risk information, and awareness of digital tools for managing flood risk (e.g. considering digital
512 tools for monitoring, recording or responding to flooding). While a more indirect relationship
513 is observed between awareness of digital tools for recording and responding to flood risk and
514 perceived flood resilience, only half of the respondents reported previously attempted to access
515 information on neighbourhood flood risk (48/93, 51.61%) and the majority were unaware of
516 digital tools or technologies used to monitor, record, or respond to neighbourhood flood risk
517 (63/93, 67.74%) **(Table 2)**. However, respondents reported use of the local government
518 geospatial maps and flood risk viewer tool to understand local flood risk, indicated in the open-

519 ended Question 17, implying that employing more targeted strategies aimed at public
520 participation encouraging the uptake of existing resources could be valuable **(Table 3)**.

521 We have shown that perceived resilience was associated with six FRP factors ordered by
522 significance: perceived safety, trust in local authorities, rainfall worry, distance from flooding,
523 perceived sufficiency in emergency flooding response (**Figure *3***). As expected, predictability
524 in behavioural response can be viewed through the positive associations between these factors.
525 For example, perceived neighbourhood flood resilience (Q13) was positively associated with
526 perceived safety from flooding (Q3). Positive associations are also evident between the former
527 factor and reported levels of trust in local authorities to manage flooding (Q12), and with
528 perceived sufficiency in flooding response (Q9). Reported distance from flooding source (Q7)
529 also generated a positive association with perceived neighbourhood flood resilience (Q13). In
530 comparison, there are negative associations between perceived neighbourhood resilience (Q13)
531 and reported rainfall worry (Q10), as well as between responses reporting providing or
532 receiving assistance from neighbours during flooding (Q8) and perceived neighbourhood
533 resilience (Q13).

534 Investigating the associations between perceived flood risk and perceived flood resilience at
535 the urban neighbourhood scale, our study seeks to operationalise the DRR targets and priorities
536 outlined by the Sendai Framework. [105] In particular, examining the factors informing
537 community flood risk perception demonstrates the varied cognitive as well as sociocultural
538 dimensions that can help inform greater people-centred DRR efforts as captured in Priority 1
539 of the Framework. Additionally, understanding prevailing perceptions of flood risk and flood
540 resilience, can highlight existing gaps or misconceptions and accordingly aid the development
541 of more coherent, effective DRR frameworks and governance strategies, contributing towards
542 achieving the aims of Priority 2. More broadly, these outcomes can also contribute towards
543 future preparedness measures, including public and private investment priorities to enable

544 structural and non-structural resilience strategies, encapsulated by Priorities 3 and 4 of the
545 Framework. Drawing on these priorities and the findings from our study, we have proposed a
546 series of policy-relevant recommendations in the following section.

547 **4.2 Policy Implications of Perceived FRP and Perceived Neighbourhood Flood Resilience**

548 Acknowledging the multifaceted nature of resilience encompassing adaptation, transformation,
549 and recovery, in conjunction with the five pillars of urban resilience (natural, economic, social,
550 physical, and institutional resilience) a deeper understanding of perceived flood risk and
551 perceived flood resilience can inform more aligned, context-specific, and equitable policy
552 development and implementation. [106] [11,106–108] Our findings support a need for greater
553 dialogue between residents and local authorities, for example relating to emergency meeting
554 points and access to clear up-to-date guidance for flood risk management. For neighbourhood
555 residents, greater dialogue can further moderate current levels of perceived safety from
556 flooding, rainfall anxiety, and perceived sufficiency of emergency flooding response, in
557 keeping with the realities of the current flood risk. More closely aligning levels of true flood
558 risk with perceived flood risk and resilience enriches awareness of environmental realities,
559 encourage preparedness, followed by participation in longer-term adaptation efforts. Managing
560 public expectation and reliance on local authorities during future flooding can contribute
561 towards improved and more sustainable emergency resource allocation. [12]

562 Arising from the quantitative and qualitative analyses discussed in the preceding sections of
563 this paper, we propose the following policy-relevant recommendations to inform future
564 initiatives and eventual policy development: (i) coordinated development and implementation
565 of combined structural and non-structural flood resilience measures, including defining clearer
566 priorities and exploration of unintended consequences resulting from possible national urban
567 intensification initiatives currently in discussion [109,110][111] and (ii) adoption of

568 participatory co-design strategies will be valuable to engender greater levels of trust and
569 facilitate more effective information-sharing of critical data resources between urban residents
570 and decision-makers (e.g. territorial authorities) and addressing potential misperceptions of
571 local flood risk; and (iii) targeted investigation and policy support to identify and minimise
572 barriers that might prevent residential or property-level alterations to improve flood resilience.

573 **Conclusion**

574 Acknowledging that risk perception does not necessarily reflect true risk and perception does
575 not necessarily lead to action, this study investigated the interconnections between perceived
576 flood risk and resilience for urban neighbourhoods in Auckland New Zealand following the
577 2023 Auckland Anniversary Weekend floods, where specific emphasis was placed on
578 understanding the nuanced needs and expectations of residential communities for enhancing
579 neighbourhood flood resilience. Quantitative and qualitative data analysis were employed to
580 investigate the socio-spatial implications emerging from the intersection of perceived flood risk
581 and resilience within two selected residential suburbs in the city of Auckland. Significant
582 findings emerging from the study demonstrate that many associations were monotonically
583 connected between perceived flood risk and perceived neighbourhood flood resilience,
584 specifically perception of safety from flooding, trust in local authorities, rainfall worry, distance
585 from flooding source, perceived sufficiency in emergency flooding response, and provision of
586 assistance during flooding, that we characterised as a 'Flood Resilience Perception Cluster'.

587 The Flood Resilience Perception Cluster features a combination of cognitive, behavioural,
588 socioeconomic, demographic, and geographic factors. The majority of survey respondents
589 reported experiencing or observing impacts on personal properties, neighbouring properties or
590 nearby community facilities such as shops or community centres from the Auckland
591 Anniversary Weekend floods in 2023, and the survey results demonstrate that resident

perceptions may appear predictable (e.g. high perceived resilience and high perceived safety from flooding) while the combined cognitive, behavioural, sociocultural, and geographic factors are central in targeting improved urban resilience measures. Specifically, these mediators stress the importance of including non-structural measures based on public participation in enhancing urban resilience to flooding, in keeping with the recommendations from the existing discourse.

Understanding these factors can shape the development of timely and relevant public policy initiatives to address existing misconceptions regarding flood resilience and resilience of vulnerable residential suburbs. The associations between perceived flood resilience and trust in authorities and providing or receiving assistance during the 2023 flooding highlights the importance of trust-building amongst residents and decision-makers, as well as scope for empowering households to respond proactively during future flooding. At a practical level, greater participatory efforts, such as co-designing policies and implementation strategies would be beneficial in enhancing public trust in authorities, deepening collaboration between neighbourhood residents, and convey shared resident and stakeholder priorities for addressing the growing risk of flooding, supporting broader urban DRR efforts.

The Flood Resilience Cluster characterised in this study also offers a reproducible pipeline to further test across multiple, diverse urban neighbourhoods and governance contexts nationally and internationally. In particular, future studies could target: (i) the administration of longitudinal surveys prior and following flooding events in neighbourhoods across different regions and (ii) designing and administering a survey of decision-makers and neighbourhood stakeholders such as local authorities, emergency response teams, and community organisations would provide a valuable comparison of needs and expectations between multiple parties and inform a more inclusive urban flood resilience building strategies.

Acknowledgements

We thank the School of Future Environments at Auckland University of Technology and survey participants for supporting this project. This research was funded by the School of Future Environments Contestable Funding Round 2024. We would like to acknowledge Carrig Conservation Limited for their guidance.

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974 **Competing Interests**

975 The authors declare no competing interests.

976 **Author Contributions:**

977 All authors conceived and designed the study. S.V., I.P., P.B., and A.M. performed the field
978 research activities. S.V. analysed the data. S.V. and A.B. contributed materials/analysis tools.
979 S.V. wrote the paper, and I.P., P.B., and A.M. reviewed the paper.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: