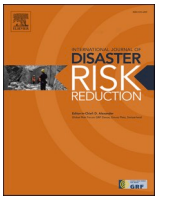
International Journal of Disaster Risk Reduction 127 (2025) 105651

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr



Measuring individual preparedness for flood and bushfire emergencies

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ARTICLE INFO

Keywords:
Measure
Individual preparedness
Preparedness scale
Theory of planned behaviour
Flood
Bushfire

ABSTRACT

Floods and bushfires are escalating in frequency and intensity due to climate change and other contributing factors, leading to significant risks for communities. Individual preparedness plays a vital role in mitigating the impacts of these events; however, improving preparedness requires a thorough understanding of current preparedness levels and identifying areas of weakness. This research addresses a critical knowledge gap by developing standardised self-assessment tools to measure preparedness in response to flood and bushfire emergencies. In addition, this study examines key factors influencing preparedness behaviours using the Theory of Planned Behaviour (TPB). Surveys for flood and bushfire preparedness were designed and validated based on expert feedback, and data were collected from Australian residents. The final 11-item flood preparedness scale and 13-item bushfire preparedness scale, along with their corresponding TPB constructs, provide a solid framework for assessing flood and bushfire preparedness levels. Findings show a positive association between preparedness scales and TPB measures. Individuals who perceived their area as high-risk for floods or bushfires, and those with emergency services experience, scored higher on both preparedness and TPB measures. Males had significantly higher preparedness levels for both hazards, while females scored significantly higher on bushfire TPB measures. Younger individuals scored higher on TPB measures, whereas older individuals had significantly higher bushfire preparedness scores. The study also highlighted the gap between attitude and action, with respondents showing higher attitudes toward preparedness but lower risk perception and intentions to prepare, underscoring the need for targeted risk communication strategies. These validated scales serve as practical tools for individuals, researchers, policymakers, and emergency management practitioners to assess preparedness levels and address community vulnerabilities, contributing to the development of safer and more resilient communities.

1. Introduction

Climate-related emergencies have escalated in frequency and severity in recent years, underscoring the urgency of addressing their impacts. In 2023 alone, 63 of the 66 natural hazards with damages surpassing one billion dollars were extreme weather events [1]. Floods remain the most prevalent of these, driven by heavy rainfall, overflowing rivers, and the cascading effects of cyclones, storm

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https://doi.org/10.1016/j.ijdrr.2025.105651
Received 1 April 2025; Received in revised form 4 June 2025; Accepted 13 June 2025
Available online 14 June 2025

surges, and tsunamis. Similarly, bushfires increasingly threaten densely vegetated regions worldwide. Recent notable events include the 2020 South Asian floods, the 2024 European floods, and catastrophic bushfires such as Australia's 2019–2020 Black Summer, the 2023 Hawaii wildfires, and the 2020 and 2024 California wildfires. Collectively, these events highlight the urgent need for enhanced disaster management strategies. While the impacts of these hazards are well-documented, there is a pressing need for localised adaptation measures to mitigate their societal and environmental toll [2–8].

Individual preparedness plays a pivotal role in minimising the damage caused by natural hazards. It involves proactive measures and strategies undertaken by individuals or households to ensure safety, mitigate disaster impacts, and strengthen their capacity to respond effectively and recover swiftly from emergencies [9–11]. Acting as a crucial layer of protection, individual preparedness complements the efforts of rescue and emergency services by empowering individuals to minimise harm during crises [12,13]. By embedding a culture of preparedness, communities can transform their response to natural hazards from reactive to proactive, significantly lessening societal and economic losses [14,15].

To underscore the vital role of individual preparedness, the United Nations 2015–2030 Sendai Framework for Disaster Risk Reduction highlights community engagement and education as fundamental pillars for mitigating disaster risks. This critical framework calls for proactive measures to empower individuals and communities with the knowledge and tools needed to prepare for and respond to hazards [16]. This approach not only mitigates the immediate impacts of disasters but also fosters long-term resilience by creating informed, self-reliant communities capable of adapting to evolving risks.

Measuring the current level of individual preparedness is essential before implementing any strategies to enhance it. Understanding the existing state of preparedness and identifying areas of weakness are critical steps in developing a comprehensive, tailored plan that meets the specific needs of the community or individuals [11,12,17]. By assessing preparedness levels, we can pinpoint gaps, prioritise areas for improvement, and allocate resources more effectively. This process not only helps evaluate community progress but also ensures that disaster planning and management efforts are optimised. Without a proper measurement tool, it becomes impossible to track improvements or assess the effectiveness of interventions aimed at educating and preparing the public. Consequently, without such data, we cannot evaluate the impact of preparedness initiatives or adjust strategies as needed.

Several previous studies have measured individual preparedness through surveys and interviews [2,11,17–19]. However, only a few have developed and validated self-reported assessment tools to evaluate individual preparedness for natural hazards [20–24]. Moreover, existing tools often overlook all key dimensions of preparedness, including knowledge, psychological readiness, and action planning. Despite the critical importance of standardised measures to assess individual preparedness, there is a notable gap in self-report scales tailored to specific hazards such as floods and bushfires. To address this gap, this study aims to develop a comprehensive and targeted approach to measure preparedness for floods and bushfires.

In addition to measuring existing individual preparedness levels, it is imperative to understand individuals' intentions to prepare and the factors influencing these intentions. Identifying the motivators that drive proactive action and the barriers that impede preparedness efforts provides valuable insights. This study takes a novel approach by applying the Theory of Planned Behaviour [25] to examine individuals' intentions to prepare for floods and bushfires. This approach complements and validates the preparedness scales by identifying the drivers and hindrances to preparedness, ultimately facilitating the development of strategies to promote proactive behaviours.

Individual preparedness is often discussed using generalised frameworks for different natural hazards. However, the nature of each hazard, such as onset time, predictability, and required protective actions, differs substantially. This study addresses the need for hazard-specific insights by exploring whether distinct preparedness dimensions emerge for floods and bushfires, based on individuals' self-reported perceptions and behaviours.

This study aims to measure individual preparedness for flood and bushfire emergencies by developing standardised self-report tools and validating them by examining individuals' intentions to prepare. The purpose of this research is to answer the following questions.

1. What does it mean to be prepared for a flood/bushfire?
2. How can we measure flood/bushfire preparedness by asking a limited number of questions?

By introducing flood and bushfire preparedness scales validated through perceptual and intentional data, this study aims to bridge the existing knowledge gap and provide an action-oriented measurement tool for evaluating individual and community preparedness. It offers a deeper understanding of strengths and deficiencies in preparedness, the determinants that foster proactive behaviours, and the barriers that hinder them. The study also employs an exploratory approach using factor analysis to capture the differences between flood and bushfire preparedness revealed by the data and emphasises to the importance of treating each hazard as distinct when developing assessment tools or public messaging strategies. Ultimately, this research seeks to inform and enhance preparedness initiatives, contributing to the development of effective, evidence-based strategies for improving disaster preparedness at both the individual and community levels.

2. Conceptual framework

Preparedness is a broad and multifaceted concept. According to the United Nations Office for Disaster Risk Reduction, preparedness refers to "the knowledge and capacities developed by governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions" [26]. Similarly, UNESCO [27] highlights the practical and action-oriented aspects of preparedness, defining it as "activities and measures taken in advance to ensure an effective response to the impact of hazards, including the issuance of timely and effective

early warnings and the temporary evacuation of people and property from threatened locations". Additionally, the Sendai Framework for Disaster Risk Reduction 2015–2030 emphasises the importance of "understanding disaster risk" and "enhancing disaster preparedness for better response and to 'Build Back Better' in recovery, rehabilitation, and reconstruction" [16]. While the aforementioned definitions involve various actors, including governments, emergency services, and communities, this study specifically focuses on individual preparedness, emphasising the ability of individuals and households to proactively prepare for potential hazards.

In this study, individual preparedness is defined as 'the capacity of individuals and households to anticipate, plan for, and respond to potential hazards, thereby minimising disruption and damage'. This definition applies consistently across both flood and bushfire contexts, with the core principles of preparedness remaining unchanged, though the specific actions may vary depending on the distinct nature of each hazard. This means that while both floods and bushfires require individuals and households to anticipate risks, develop emergency kits and response plans, and take proactive measures, the specific preparedness actions differ due to the unique characteristics and impacts of each hazard, such as sealing gaps to prevent water entry for floods versus clearing vegetation to reduce fire risk for bushfires.

To address this, it is essential to decompose the concept into measurable components, which will facilitate a detailed examination of each element and guide item development for assessing individual preparedness in response to floods and bushfires. Although the same framework and broadly aligned questions are initially applied in developing preparedness scales, individuals' responses ultimately shape the final tools. Developed through exploratory and confirmatory factor analyses, the scales emphasise different aspects depending on the hazard. Individual preparedness for flood and bushfire hazards can be categorised into several key dimensions.

1. **Knowledge and local risk awareness**: Understanding the risks associated with each hazard and the corresponding protective actions.
2. **Psychological preparedness**: The mental readiness to act decisively during emergencies.
3. **Practical action**: Tangible steps taken to prepare, such as assembling emergency kits or developing evacuation plans.

Individual preparedness can be measured using various approaches, including interviews [17,18], questionnaire surveys [2], and the development of standardised scales [20,21]. While interviews and questionnaires provide valuable qualitative insights, they often lack the consistency and comparability required for broader applications. In contrast, scale development offers a systematic, standardised method for measuring preparedness that ensures validity and reliability. A well-constructed scale allows for the consistent assessment of preparedness levels across different populations, eliminating subjective biases and variability in data collection methods. Furthermore, a standardised scale enables meaningful comparisons of preparedness across diverse cultures and nations, providing a robust foundation for cross-cultural research.

Scale development has been employed in this study to measure individual preparedness for flood and bushfire hazards. This method is widely adopted across various fields to quantify abstract concepts and behavioural intentions [28]. Scales are considered among the most reliable tools due to their replicability and their ability to systematically capture perceptions [29]. For instance, it has been utilised in assessing cyclists' road behaviour [30], people's perceptions regarding climate [31–34], perceptions regarding nature [35,36], and learning and innovation skills self-efficacy [37]. These examples demonstrate the effectiveness of using validated self-report scales to quantify complex behavioural constructs, providing valuable data for intervention strategies.

Another often overlooked aspect of measuring preparedness is the underlying factors that influence whether an individual is well-prepared or poorly prepared. Understanding preparedness levels without identifying the reasons behind them provides an incomplete picture, making it difficult to design effective strategies to improve preparedness. Without uncovering these root causes, it becomes challenging to determine why individuals or communities may fall short in specific components of preparedness.

To address this gap, this study adopts the widely utilised Theory of Planned Behaviour (TPB) as a framework to justify the proposed conceptual model and the interrelationships among its constructs and variables. The TPB [25] posits that an individual's intentions to perform a specific behaviour are determined by three key factors: attitudes (beliefs about the behaviour), subjective norms (social pressures), and perceived behavioural control (confidence in one's ability to perform the behaviour). This theory has been successfully applied in various fields, including health [38], environmental sustainability [39], car driver's behaviour [40–43] and disaster preparedness and response [44–47] to predict and understand behaviours.

In this study, TPB constructs are operationalised through a validated self-reported scale measuring individuals' intention to prepare for flood and bushfire emergencies. To improve the framework relevance in the context of disaster preparedness, two constructs of perceived risk and anticipated regret, are added to the three core components of TPB. Perceived risk has been applied in previous studies to capture cognitive evaluations of likelihood and severity of threats that shape behavioural intentions within the TPB model [41,43,48]. Anticipated regret, which reflects the emotional response associated with the negative consequences of potential loss, has also been employed as an additional predictor in TPB-based research [48,49]. Together, these extensions to the basic TPB model provide a more comprehensive understanding of preparedness behaviour, resulting in five key components examined in this study.

1. **Attitude**: Refers to how individuals evaluate the importance and effectiveness of preparedness and protective measures. People who see preparedness as effective are more likely to engage in it.
2. **Subjective norm**: Reflects how social influences, such as family and community, impact a person's behaviour and intentions to prepare for an emergency.
3. **Perceived behavioural control**: Refers to individuals' confidence in their ability to take necessary actions for preparedness. Higher confidence and available resources lead to greater preparedness behaviours.

4. **Perceived risk**: Involves individuals' beliefs about the likelihood and severity of hazards like floods or bushfires. When people perceive a high risk, they are more motivated to prepare and feel emotionally ready to act in response to an emergency.
5. **Anticipated regret**: Refers to the emotions people expect to feel if they fail to prepare for an emergency event. The fear of regretting inaction often motivates individuals to take preventive steps and prepare proactively.

TPB is particularly well-suited for this study as it provides a comprehensive framework for understanding the psychological and social drivers of preparedness behaviours. While prior research has identified factors like risk perception or prior experience as predictors of preparedness, few studies have systematically examined the interplay of attitudes, social influences, and perceived control in shaping intentions to prepare for specific hazards such as floods and bushfires [50,51]. TPB helps capture the hidden psychological drivers and barriers that influence behaviour, such as attitudes, perceived social norms, and perceived behavioural control.

Developing preparedness scales alongside the TPB models for flood and bushfire preparedness provides a robust framework for assessing individual preparedness levels. Preparedness scales offer a standardised approach to quantify various dimensions of preparedness, ensuring consistency and reliability in measurement across diverse contexts. By integrating TPB, these scales provide a more comprehensive understanding of the psychological drivers underlying preparedness behaviours, including attitudes, subjective norms, and perceived behavioural control. This combination not only facilitates a deeper understanding of the factors influencing preparedness but also enables targeted interventions to address specific barriers. Together, preparedness scales and TPB models form a comprehensive construct, equipping researchers and policymakers with actionable insights to enhance community resilience effectively.

The proposed flood and bushfire preparedness scale and TPB construct offer a unique tool that not only measures the current level of preparedness but also helps predict future behaviour based on individuals' intentions. This framework provides valuable data for identifying gaps in preparedness at the individual, household, or community level.

3. Method

3.1. Survey design

To develop flood and bushfire preparedness surveys, an initial item development process was conducted through a review of the literature and existing guidelines. A pool of approximately 100 flood-related and 100 bushfire-related questions was created using a five-point Likert scale (1 = Strongly disagree, 5 = Strongly agree), with each question addressing either one of three key preparedness dimensions (knowledge and local risk awareness, psychological preparedness, and practical action) or one of the five elements of the TPB: Attitude, Subjective norm, Perceived behavioural control, Perceived risk, and Anticipated regret. Each question was carefully examined to ensure it measured a distinct aspect of preparedness, providing comprehensive coverage of the concept and capturing its multifaceted nature. Questions that overlapped in content were merged (with caution to avoid double-barrelled questions) or removed to enhance clarity and prevent respondent fatigue.

Two sets of approximately 55 questions each, one for flood and one for bushfire preparedness, underwent extensive expert review. During this stage, experts from various flood and bushfire emergency organisations assessed each question based on two factors: clarity and relevance. Flood-related questions were reviewed by flood experts, and bushfire-related questions were reviewed by bushfire experts. Using a scale from 0 to 100, they rated the extent to which each question was relevant for measuring preparedness and whether it was clearly worded. Additionally, a comment box was provided after each question, allowing experts to freely share their opinions and suggestions for improving or adding questions.

In addition to the scale and the TPB questions, a set of image-based questions was designed to assess participants' risk perception, which can be utilised to validate the preparedness scale and TPB questions. Participants were asked to answer the question, "How risky do you think driving on this road would be?" and rate the risk of driving in each image on a scale from 0 to 10. Five images for the flood survey, and five images for the bushfire survey were captured from the actual past flood and bushfire events (Fig. 1).

The final set of questions (after expert feedback) included 16 questions for the flood preparedness scale in the flood survey and 18 questions for the bushfire preparedness scale in the bushfire survey. In addition, each survey included 12 questions for the TPB and five image-based questions on risk perception. The total number of questions was 33 for the flood survey and 35 for the bushfire survey. The flood and bushfire preparedness surveys comprehensively address various aspects, including knowledge, attitude, psychological preparedness, action preparedness, and risk perception. The surveys are structured into three main sections.

1. *Flood and Bushfire Preparedness Scale*: These statements are used to develop preparedness scales that assess overall individual preparedness, including knowledge about flood and bushfire, the presence of an emergency plan and more practical aspects such as awareness of risks associated with driving in floods and bushfires.
2. *Theory of Planned Behaviour Questions*: Incorporating the TPB, this section investigates participants' psychological preparedness by exploring their thoughts, feelings, and beliefs regarding preparations for flood and bushfire events. Questions cover dimensions such as attitude, subjective norm, perceived behavioural control, perceived risk (susceptibility), and anticipated regret.

Fig. 1. Risk perception images: participants rated each image on a scale of 1–10 in response to the question, "How risky do you think driving on this road would be?" (F1) 2016, Houston Flood, United States,[1] (F2) & (F3) 2021 flood, United Kingdom,[2] (F4) 2018 flood, United States,[3] (F5) 2020 flood, United Kingdom,[4] (B1) 2022, Southwest Europe (Portugal) wildfires,[5] (B2) 2017, California wildfires,[6] (B3) 2020, Australia bushfires,[7] (B4) 2015, Fort McMurray, Alberta, Canada wildfire,[8] (B5) 2020, California wildfires.[9].

[1] https://www.youtube.com/watch?v=R0gsydbQMdU.
[2] https://www.youtube.com/watch?v=Gh0tKhb5P5w https://www.youtube.com/watch?v=p2_rOqIqTzA&t=512s.
[3] https://www.youtube.com/watch?v=N0wc8MnQgMw&t=288s.
[4] https://www.youtube.com/watch?v=a8TYLit80Ho&t=1s.
[5] https://www.youtube.com/watch?v=WFKTeNq_zGA.
[6] https://www.youtube.com/watch?v=qi6dAPBvyYU.
[7] https://www.youtube.com/watch?v=sh31knRtO7U.
[8] https://www.youtube.com/watch?v=or7tWjWI0ZA.
[9] https://www.youtube.com/watch?v=v5TZ6zilkk4.

3. *Risk perception of driving through flood/bushfire*: Image-based questions were designed to validate the survey by assessing participants' risk perception regarding their decision to drive through flood or bushfire conditions.

Both the flood and bushfire surveys were designed using the Qualtrics platform, and eligible participants were Australian residents aged 18 and over. Ethics approval was obtained from UNSW Sydney, and data collection was conducted with the assistance of Qualtrics services with separate participants for the flood and bushfire surveys. To enhance the quality of responses, two dummy questions were added for quality control purposes to assess participants' attention while answering the questions. Respondents who provided incorrect answers to any of these questions were considered to have submitted inaccurate responses, and their surveys were removed. Moreover, to minimise any tendency toward social desirability bias [52], a statement was included in the instruction section for each set of questions: "There is no right or wrong answer, please remain as truthful and honest as possible in your assessment of each statement".

The flood and bushfire survey questions designed for participants at this stage are not identical to the final set of questions in the scales, as they need to be tested with communities to ensure their suitability for effectively measuring individual preparedness in response to flood and bushfire. Some questions were omitted in the final scales (Appendix Table A1 and Table A2). To achieve this, we employ a rigorous methodological approach, including exploratory and confirmatory factor analyses with two separate samples of Australian residents for the flood and bushfire surveys, ensuring the reliability and validity of the developed scales.

3.2. Participants

Two separate samples of Australian residents were recruited with the assistance of Qualtrics services for the flood and bushfire preparedness surveys. The sampling aimed to achieve a roughly proportional representation of age, gender, and state population in Australia. The sample included 700 responses for the flood survey and 550 responses for the bushfire survey (Table 1). The flood sample had 39 % male and 60.7 % female participants, and the bushfire sample had 42.7 % male and 57.1 % female participants. Both samples have a diverse age range, with the largest age group being 30–39 years old (20.9 % for the flood sample and 22.6 % for the bushfire sample). The samples were well-represented across Australian states, with the highest representation from New South Wales (29 % for flood and 28 % for bushfire), followed by Victoria (24.6 % for flood and 26.4 % for bushfire). The majority of participants lived in urban areas (68.9 % for the flood sample and 69.6 % for the bushfire sample) and most perceived their areas of residence as not flood-prone (73 %) or bushfire-prone (75.5 %). A large proportion of respondents had lived in Australia for most of their lives, with

Table 1
Demographic characteristics of the flood (n = 700) and bushfire (n = 550) samples.

Demographic characteristics	Category	Flood sample		Bushfire sample	
		Count	%	Count	%
Gender	Male	273	39.0	235	42.7
	Female	425	60.7	314	57.1
	Prefer not to answer	2	0.3	1	0.2
Age	18–24	73	10.4	56	10.2
	25–29	61	8.7	47	8.6
	30–39	146	20.9	124	22.6
	40–49	128	18.3	77	14.0
	50–59	112	16.0	74	13.5
	60–69	108	15.4	105	19.1
	70–79	46	6.6	47	8.6
	+80	26	3.7	20	3.6
State or Territory	Australian Capital Territory	36	5.1	17	3.1
	New South Wales	203	29.0	154	28.0
	Northern Territory	3	0.4	3	0.6
	Queensland	120	17.1	104	18.9
	South Australia	53	7.6	42	7.6
	Tasmania	37	5.3	17	3.1
	Victoria	172	24.6	145	26.4
	Western Australia	76	10.9	68	12.4
Area of residence	Urban	482	68.9	383	69.6
	Regional	200	28.6	154	28.0
	Remote	18	2.6	13	2.4
Live in flood-prone areas	Yes	189	27.0	135	24.5
	No	511	73.0	415	75.5
Years of living in Australia	Less than a year	9	1.3	11	2.0
	1–4	13	1.9	17	3.1
	5–9	24	3.4	18	3.3
	10–19	38	5.4	32	5.8
	20+	92	13.1	79	14.4
	All my life	524	74.9	393	71.5
Primary language at home	English	655	93.6	519	94.4
	Other	45	6.4	31	5.6
Experience in emergency services	Volunteer	62	8.9	35	6.4
	Employee	44	6.3	30	5.5
	Both	6	0.9	7	1.3
	None	588	84.0	478	86.9
Total		700	100	550	100

74.9 % in the flood sample and 71.5 % in the bushfire sample having lived in Australia all their lives. English was the primary language spoken at home for 93.6 % of the flood sample and 94.4 % of the bushfire sample, indicating that most participants could access news and resources and understand warning messages without a language barrier. Most participants (84 % of the flood sample and 86.9 % of the bushfire sample) had no experience volunteering or working with emergency services, suggesting that their knowledge and responses likely reflect those of the general population rather than being influenced by professional expertise.

3.3. Data analysis

Data was analysed using Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA). To develop the flood and bushfire preparedness scales, EFA was conducted using IBM SPSS Statistics version 28, and CFA was performed using the *lavaan* package in RStudio 4.2.0. The total samples of flood (n = 700) and bushfire (n = 550) responses were each randomly divided into two subgroups for cross-validation. EFA was initially performed on 300 responses from the flood survey to identify the latent variables. This was followed by CFA on 400 responses, and then on the full set of 700 responses to confirm the validity of the results. The same process was applied to the bushfire survey, with EFA performed on 300 randomly selected responses, followed by CFA on 250 and the full set of 550 responses.

For the TPB analysis, Covariance-Based SEM (CB-SEM) was employed using the *lavaan* package in RStudio 4.2.0. This approach was chosen to assess how the five dimensions of TPB predict the intention to prepare for floods and bushfires. CB-SEM was selected as it enables the estimation of complex relationships between multiple latent variables within the TPB framework and their effects on intention to prepare.

The responses to image-based questions on risk perception were examined in relation to the preparedness scale and TPB for flood and bushfire surveys. This was done to validate the scales and explore whether risk-taking tendencies are associated with participants'

preparedness. The influence of gender and age on the preparedness scale and TPB scores was also assessed using t-tests for both total scores and each dimension of the scales.

4. Results

4.1. Flood and bushfire preparedness scales

Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were employed to develop the flood and bushfire preparedness scales. The total flood and bushfire responses were randomly divided into two subgroups: 300 responses for EFA and 400 responses for CFA in the flood sample (n = 700), and 300 responses for EFA and 250 responses for CFA in the bushfire sample (n = 550). The Kaiser-Meyer-Olkin (KMO) values were 0.81 for the flood sample and 0.82 for the bushfire sample. Bartlett's test of sphericity was significant (flood: $\chi^2(120) = 1224.82, p < 0.001$; bushfire: $\chi^2(153) = 1149.75, p < 0.001$), indicating that both samples were suitable for factor analysis.

Exploratory factor analysis (EFA) was conducted for both the flood and bushfire samples using Maximum Likelihood Estimation as the factor extraction technique. After extraction, the factors were rotated using Promax rotation. Several items were removed due to poor factor loadings (see Appendix Table A1 for the flood scale and Table A2 for the bushfire scale). A threshold of 0.4 is commonly used in social science research [53], though lower loadings may still be meaningful depending on theoretical relevance and context [54]. Of the 16 items in the flood survey, 11 had significant factor loadings above 0.4 (Appendix Table A3), and of the 18 items in the bushfire survey, 13 had significant factor loadings above 0.4 (Appendix Table A4). These items were retained in the final scales, which consist of 11 items for the flood scale and 13 items for the bushfire scale.

Following EFA, confirmatory factor analysis (CFA) was conducted on both samples. CFA was first performed on a subset of the data (n = 400 for the flood sample and n = 250 for the bushfire sample) and subsequently on the full dataset to ensure the validity of the results (see Appendix Table A3 for the flood scale and Table A4 for the bushfire scale). After the CFA, one flood scale item (VS3, loading = 0.39) and one bushfire scale item (SS1, loading = 0.34) had factor loadings slightly below the commonly used 0.4 threshold [53]; however, they were retained in the final scales due to their theoretical relevance to the flood vehicle safety and bushfire social support factors, respectively [54]. The results indicated an acceptable model fit, with the following fit indices for the full dataset: Comparative Fit Index (CFI) = 0.92, Tucker-Lewis Index (TLI) = 0.89, Root Mean Square Error of Approximation (RMSEA) = 0.08, Standardised Root Mean Square Residual (SRMR) = 0.05 for the flood sample; and CFI = 0.90, TLI = 0.87, RMSEA = 0.07, SRMR = 0.05 for the bushfire sample (Fig. 2).

The final flood preparedness scale comprised 11 items across four factors: Factor 1 - Action plan, Factor 2 - Self-efficacy, Factor 3 - Local risk awareness, and Factor 4 - Vehicle safety (Table 2). The bushfire preparedness scale, on the other hand, comprised 13 items across four factors: Factor 1 - Response efficacy, Factor 2 - Action plan, Factor 3 - Social support, and Factor 4 - Vehicle safety (Table 3). The differences that emerged between the two scales suggest that preparedness is not a uniform concept across different types of hazards. Fig. 2 presents a visual comparison of the flood and bushfire preparedness scales.

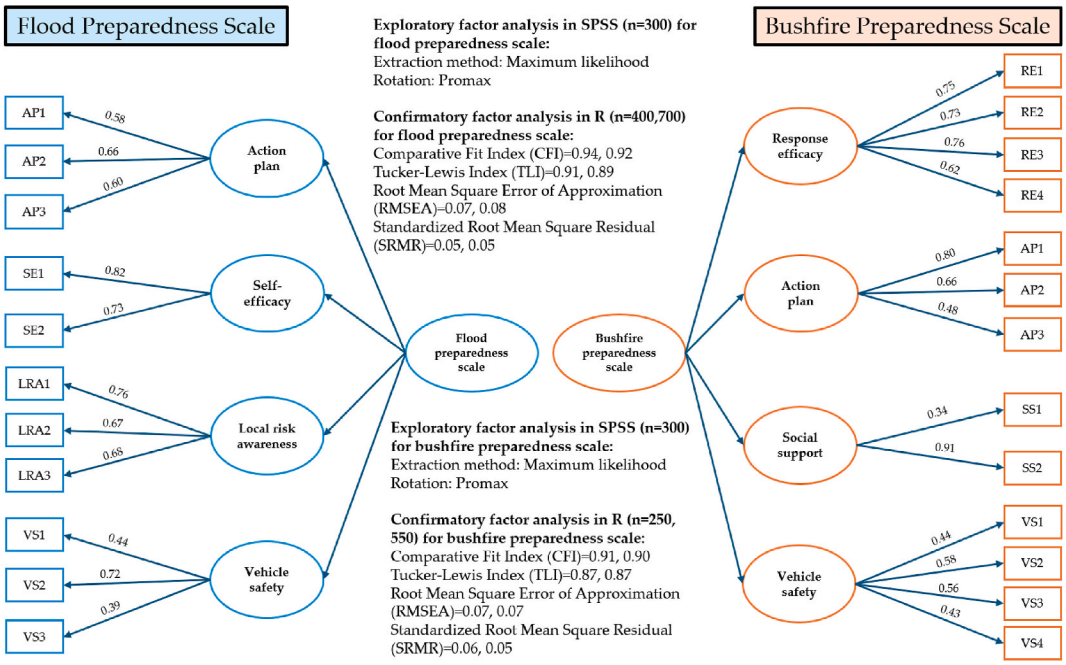

Fig. 2. Flood and bushfire preparedness scales.

Table 2
Flood preparedness scale: mean of each factor, mean and standard deviation of each item in the final scale, and factor loadings results from the CFA on total responses (n = 700). Each item is assigned an initial code (from the original survey) and a new code based on the factor it belongs to after factor analysis.

	Code	Item content	Factor		Mean (factor)	Mean (item)	S.D.	Factor loading	S.E.	z-value	p-value
1	FP7	I believe having an emergency kit with essential supplies for floods is necessary.	Action plan	AP1	3.69	3.89	0.91	0.580	0.069	10.83	<0.001
2	FP14	Before I evacuate, I use sandbags to make a wall (at least the height of expected water) across doorways.		AP2		3.47	1.06	0.664	0.124	10.83	<0.001
3	FP15	Before I evacuate, it would be helpful to block drainage holes (e.g. showers, sinks, toilets) in home to stop back flow of water.		AP3		3.71	0.93	0.596	0.101	10.39	<0.001
4	FP1	In a flood emergency, I am able to make quick decisions to ensure my safety and the safety of others.	Self-efficacy	SE1	3.84	3.88	0.80	0.816	0.065	15.83	<0.001
5	FP2	I am confident that I can stay calm and composed in the challenging situation of a flood emergency.		SE2		3.79	0.86	0.732	0.061	15.83	<0.001
6	FP3	I know about the best routes in our neighbourhood to avoid floods.	Local risk awareness	LRA1	3.41	3.56	1.05	0.762	0.067	15.62	<0.001
7	FP4	I know about the shelters in our neighbourhood to seek safety during floods.		LRA2		2.94	1.15	0.665	0.061	15.62	<0.001
8	FP12	I know the level of risk at the area where I live, and take precautions to safeguard my property against floods.		LAR3		3.73	0.95	0.679	0.051	15.90	<0.001
9	FP9	I would not travel by vehicle through flood waters.	Vehicle safety	VS1	4.22	4.42	0.81	0.437	0.087	7.62	<0.001
10	FP13	If I decide to evacuate during a flood disaster, I make sure to leave early, before any roads are affected by flooding.		VS2		4.20	0.75	0.717	0.198	7.62	<0.001
11	FP16	If I find myself trapped in a car in floodwaters, unable to open the car door due to water pressure, it would be helpful to roll down the window, climb onto the roof (children first), position for stability (prepare to swim), and contact emergency services.		VS3		4.04	0.81	0.385	0.135	6.52	<0.001

4.2. Theory of planned behaviour (TPB) models for flood and bushfire preparedness

Covariance-Based Structural Equation Modelling (CB-SEM) was conducted using the *lavaan* package in RStudio 4.2.0 to analyse the TPB constructs for both the flood and bushfire samples. This approach allowed for the estimation of relationships between multiple latent variables within the proposed constructs and their effects on the intention to prepare. The model specified latent variables and their interrelationships, estimating factor loadings, regression paths, and covariances. Table A5 in the Appendix presents the factor loadings for the flood TPB model, while Table A7 shows those for the bushfire TPB model. The analysis was based on datasets of 700 respondents for the flood sample and 550 respondents for the bushfire sample.

Fig. 3 illustrates the TPB models for flood and bushfire preparedness. The results demonstrated an acceptable model fit, with the following fit indices: CFI = 0.98, TLI = 0.96, RMSEA = 0.06, SRMR = 0.03 for the flood sample, and CFI = 0.96, TLI = 0.93, RMSEA = 0.07, SRMR = 0.04 for the bushfire sample.

By estimating both regression paths and covariances, the model provides a comprehensive understanding of how the factors interact and contribute to the intention to prepare for these emergencies. The regression estimates represent the strength and direction of the relationships between the TPB factors and the intention to prepare for floods and bushfires. As shown in Table A6 and Table A8 in the Appendix, all the TPB factors, including attitude, subjective norm, perceived behavioural control, perceived risk, and anticipated regret, significantly predict the intention to prepare for floods and bushfires. These estimates indicate how changes in one factor influence the outcome variable, with standardised coefficients allowing for comparison of the relative importance of each factor.

Covariances, on the other hand, capture the degree to which the TPB factors are related to one another. Table A6 in the Appendix presents the regression and covariance estimates for the flood TPB model, while Table A8 provides the same for the bushfire TPB model. In both models, attitude and subjective norm, as well as attitude and anticipated regret are significantly related. This suggests that individuals with a strong positive attitude toward preparedness are more likely to have the support of family and friends and be surrounded by others who consciously prepare for floods and bushfires. Additionally, those with a high attitude toward preparedness believe that taking action to prepare can protect their families from severe consequences and minimise their regret over potential loss and damage. Another important covariance in both models is the relationship between subjective norm and perceived

Table 3
Bushfire preparedness scale: mean of each factor, mean and standard deviation of each item in the final scale, and factor loadings results from the CFA on total responses (n = 550). Each item is assigned an initial code (from the original survey) and a new code based on the factor it belongs to after factor analysis.

	code	Item content	Factor		Mean (factor)	Mean (item)	S.D.	Factor loading	S.E.	z-value	p-value
1	BP1	In a bushfire emergency, I am able to make quick decisions to ensure my safety and the safety of others.	Response efficacy	RE1	3.73	3.86	0.79	0.747	0.057	15.66	<0.001
2	BP2	I am confident that I can stay calm and composed in the challenging situation of a bushfire emergency.		RE2		3.70	0.90	0.728	0.071	15.66	<0.001
3	BP3	I know about the best routes in our neighbourhood to avoid bushfires.		RE3		3.60	1.05	0.759	0.083	16.26	<0.001
4	BP10	I know the level of risk at the area where I live, and take precautions to safeguard my property against bushfires.		RE4		3.75	0.92	0.622	0.072	13.46	<0.001
5	BP4	I know about the shelters in our neighbourhood to seek safety during bushfires.	Action plan	AP1	2.79	2.89	1.18	0.800	0.099	12.02	<0.001
6	BP8	I have a bag of prepared emergency food and resources to be able to survive for at least 72 h after the bushfire event.		AP2		2.64	1.21	0.658	0.070	12.02	<0.001
7	BP12	Every year before the bushfire season, I consider burning off the flammable materials around my properties in a controlled condition.		AP3		2.85	1.18	0.480	0.063	9.48	<0.001
8	BP5	During a bushfire emergency, I would seek emotional and physical security from close friends and family.	Social support	SS1	3.98	3.78	0.95	0.339	0.124	4.00	<0.001
9	BP6	If I see people seeking help in a bushfire emergency, I will try to help them.		SS2		4.18	0.71	0.907	0.502	4.00	<0.001
10	BP15	If I decide to evacuate during a bushfire disaster, I make sure to leave early, before any roads are impacted by bushfires.	Vehicle safety	VS1	3.86	4.35	0.69	0.441	0.092	6.79	<0.001
11	BP16	Moving up a slope is dangerous in a bushfire as fires tend to travel at faster speeds and be more intense as they move uphill.		VS2		3.75	0.83	0.581	0.235	6.79	<0.001
12	BP17	If I find myself trapped in a car surrounded by bushfires, I will get down below window level to avoid being exposed to the radiant heat.		VS3		3.91	0.73	0.561	0.201	6.73	<0.001
13	BP18	If I find myself trapped in a car surrounded by bushfires, I will cover up my body with woollen blankets.		VS4		3.42	1.11	0.434	0.264	6.04	<0.001

behavioural control. This indicates that individuals who receive social support from family and friends feel more confident in their ability to prepare and perceive greater opportunities to do so.

4.3. Flood and bushfire preparedness levels

Most participants consider themselves well-prepared regarding vehicle safety for flood emergencies (VS1 to VS3 in Table 4; see also Appendix Figures A1 and A5). However, their main concerns and weaknesses lie in local risk awareness (LRA1 to LR3), particularly in knowing the best shelters and routes in their neighbourhood to avoid floods. For bushfire preparedness, participants report feeling more confident in aspects related to social support (SS1 and SS2; see Table 5 and Appendix Figures A3 and A7). However, their perceived abilities are lowest in the action plan domain (AP1 to AP3), which includes knowing the best shelters for bushfires, having emergency food and resources, and managing flammable materials around their properties. The codes for each item were derived from Table 2 (flood scales) and Table 3 (bushfire scale).

Participants' responses to both flood and bushfire TPB items show that attitude (A1 and A2) and anticipated regret (AR1 and AR2) have the highest scores, while the lowest scores are observed in the perceived risk (PR1 and PR2) and Intention (I1 and I2) categories (Tables 4 and 5; see also Appendix Figures A2 and A4). This suggests that although participants believe being educated and prepared for these events would benefit them and their families and help prevent severe consequences, they do not feel vulnerable to the potential risks of floods and bushfires. As a result, they do not feel a sense of urgency and are not committed to preparing for these emergencies. The codes in Tables 4 and 5 are derived from Appendix Table A5 (flood TPB) and Appendix Table A7 (bushfire TPB).

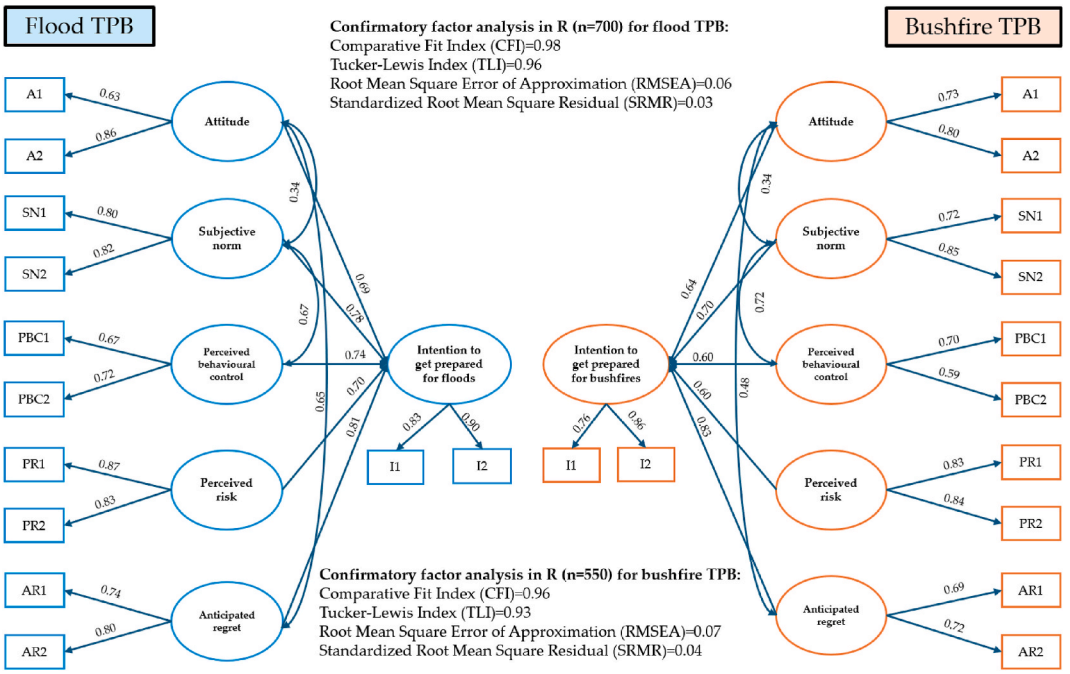

Fig. 3. Theory of planned behaviour (TPB) models for flood and bushfire preparedness.

Table 4
Response distributions, item means, and standard deviations for the flood preparedness scale and TPB items (SD = Strongly disagree, D = Disagree, N = Neither agree nor disagree, A = Agree, SA = Strongly agree).

FP item code	Distribution of responses to flood preparedness scale (%)					Item mean[a]	S.D.	TPB item code	Distribution of responses to flood TPB (%)					Item mean	S.D.
	SD	D	N	A	SA				SD	D	N	A	SA		
AP1	1.3	6.7	19.9	46.4	25.7	3.89	0.91	A1	0.4	0.9	4.0	44.1	50.6	4.44	0.66
AP2	5.3	12.3	28.7	37.9	15.9	3.47	1.06	A2	1.4	1.9	10.1	45.9	40.7	4.23	0.81
AP3	2.6	5.4	29.9	42.7	19.4	3.71	0.93	SN1	1.1	3.3	34.0	37.9	23.7	3.80	0.88
SE1	0.9	4.0	21.6	53.4	20.1	3.88	0.80	SN2	4.0	12.9	31.4	34.6	17.1	3.48	1.04
SE2	0.6	9.3	18.6	53.7	17.9	3.79	0.86	PBC1	1.4	6.6	21.6	51.9	18.6	3.80	0.87
LRA1	3.4	15.0	21.0	43.1	17.4	3.56	1.05	PBC2	2.0	15.1	28.9	37.7	16.3	3.51	1.00
LRA2	9.4	31.1	24.1	26.1	9.1	2.94	1.15	PR1	7.6	21.4	22.4	34.0	14.6	3.27	1.17
LRA3	2.7	8.0	21.9	48.0	19.4	3.73	0.95	PR2	9.4	26.7	25.1	29.9	8.9	3.02	1.14
VS1	1.4	2.1	6.0	34.3	56.1	4.42	0.81	AR1	1.7	2.0	14.3	51.3	30.7	4.44	0.66
VS2	0.6	1.3	12.7	48.3	37.1	4.20	0.75	AR2	2.1	3.1	19.9	51.7	23.1	4.23	0.81
VS3	1.0	3.1	15.6	51.4	28.9	4.04	0.81	I1	4.3	9.6	36.9	35.4	13.9	3.45	0.99
								I2	3.0	8.4	27.6	44.9	16.1	3.63	0.95

[a] Item means were calculated by assigning values as follows: strongly disagree = 1, disagree = 2, neither agree nor disagree = 3, agree = 4, and strongly agree = 5.

Individuals residing in high-risk areas and those with emergency service experience demonstrated significantly higher flood and bushfire preparedness and TPB scores (Table 6 and Table 7; see also Appendix Figure A9 and Figure A10). These findings collectively establish that the preparedness scales and TPB constructs are robust, theoretically grounded, and predictive of real-world behaviours.

To explore the relationship between responses to the image-based questions on risk perception (Fig. 1) and flood and bushfire preparedness scores, both flood and bushfire samples were divided into two groups: below average risk-takers and above average risk-takers. Mean comparisons indicated that below average risk-takers had significantly higher preparedness scores. This difference was statistically significant for both flood preparedness ($t = 3.66$, $p < 0.001$) and flood TPB ($t = 3.85$, $p < 0.001$), as well as bushfire preparedness ($t = 2.72$, $p < 0.01$) and bushfire TPB ($t = 3.02$, $p < 0.01$). These findings reinforce that perceiving a flood or bushfire

Table 5
Response distributions, item means, and standard deviations for the bushfire preparedness scale and TPB items (SD = Strongly disagree, D = Disagree, N = Neither agree nor disagree, A = Agree, SA = Strongly agree).

BP item code	Distribution of responses to bushfire preparedness scale (%)					Item mean[a]	S.D.	TPB item code	Distribution of responses to bushfire TPB (%)					Item mean	S.D.
	SD	D	N	A	SA				SD	D	N	A	SA		
RE1	1.6	3.5	18.9	59.1	16.9	3.86	0.79	A1	0.0	0.4	2.6	38.6	58.6	4.55	0.57
RE2	1.6	9.5	21.8	51.3	15.8	3.70	0.90	A2	0.6	0.9	7.5	44.0	47.1	4.36	0.71
RE3	3.5	14.2	19.6	44.0	18.7	3.60	1.05	SN1	0.6	3.1	33.1	37.3	26.0	3.85	0.86
RE4	2.2	8.7	17.8	54.0	17.3	3.75	0.92	SN2	2.6	14.6	32.0	32.4	18.6	3.50	1.03
AP1	10.9	33.3	21.3	25.1	9.5	2.89	1.18	PBC1	1.8	8.4	22.4	47.8	19.6	3.75	0.93
AP2	15.5	42.0	14.9	18.7	8.9	2.64	1.21	PBC2	2.7	13.1	24.6	42.6	17.1	3.58	1.01
AP3	12.9	30.0	25.3	22.9	8.9	2.85	1.18	PR1	5.6	23.3	25.5	32.6	13.1	3.24	1.12
SS1	3.6	5.8	19.1	52.2	19.3	3.78	0.95	PR2	7.6	28.0	30.2	25.3	8.9	3.00	1.09
SS2	0.6	1.5	10.4	55.1	32.6	4.18	0.71	AR1	0.4	1.8	11.6	49.6	36.6	4.20	0.74
VS1	0.6	0.7	6.6	47.1	45.1	4.35	0.69	AR2	1.3	2.9	17.1	56.6	22.2	3.95	0.79
VS2	0.4	4.7	34.0	41.6	19.3	3.75	0.83	I1	1.6	9.5	36.6	38.9	13.5	3.53	0.90
VS3	0.6	3.1	18.9	59.6	17.8	3.91	0.73	I2	0.9	7.6	26.6	46.2	18.7	3.74	0.88
VS4	6.7	12.2	30.9	33.1	17.1	3.42	1.11								

[a] Item means were calculated by assigning values as follows: strongly disagree = 1, disagree = 2, neither agree nor disagree = 3, agree = 4, and strongly agree = 5.

Table 6
Mean comparisons of flood preparedness and TPB scores by flood-prone residency, emergency services experience, risk-taking level, gender, and age.

	Participant characteristic	Flood preparedness scale				Flood TPB			
		Mean	S.D.	t-stat	p-value	Mean	S.D.	t-stat	p-value
1	Living in flood prone area	3.92	0.93	4.25	<0.001	4.02	0.87	8.57	<0.001
2	Not living in flood prone area	3.73	1.02			3.60	1.05		
3	Experience in working with emergency services	4.06	0.88	5.87	<0.001	4.05	0.90	6.93	<0.001
4	No experience in working with emergency services	3.73	1.01			3.65	1.03		
5	Above average risk-taker	3.70	0.99	−3.66	<0.001	3.61	1.01	−3.85	<0.001
6	Below average risk-taker	3.85	1.00			3.80	1.02		
7	Male	3.84	0.98	2.19	<0.05	3.67	1.06	−1.49	NSS*
8	Female	3.75	1.00			3.75	0.99		
9	Younger	3.77	0.99	−1.03	NSS	3.82	0.98	4.94	<0.001
10	Older	3.81	1.00			3.57	1.06		

*NSS = Not statistically significant; $p > 0.05$.

Table 7
Mean comparisons of bushfire preparedness and TPB scores by bushfire-prone residency, emergency services experience, risk-taking level, gender, and age.

	Participant characteristic	Bushfire preparedness scale				Bushfire TPB			
		Mean	S.D.	t-stat	p-value	Mean	S.D.	t-stat	p-value
1	Living in bushfire prone area	3.71	1.08	2.91	<0.01	3.95	0.95	4.30	<0.001
2	Not living in bushfire prone area	3.55	1.07			3.71	1.01		
3	Experience in working with emergency services	3.86	1.04	4.78	<0.001	3.96	0.97	3.12	<0.01
4	No experience in working with emergency services	3.55	1.08			3.74	1.00		
5	Above average risk-taker	3.52	1.04	−2.72	<0.01	3.69	0.93	−3.02	<0.01
6	Below average risk-taker	3.64	1.10			3.83	1.04		
7	Male	3.67	1.01	3.37	<0.001	3.71	0.97	−2.36	<0.01
8	Female	3.53	1.12			3.82	1.02		
9	Younger	3.54	1.10	−2.55	<0.01	3.84	0.99	3.19	<0.001
10	Older	3.65	1.05			3.69	1.00		

situation as risky for driving is strongly associated with higher preparedness scores (see Tables 6 and 7; and corresponding Appendix Figure A11 and Figure A12).

The mean differences between responses to flood preparedness (FP) and bushfire preparedness (BP) scores and their corresponding TPB scores were also examined between male and female groups, as well as younger (ages 18 to 49) and older (ages 50 and over) participants. The results showed that males had significantly higher scores in flood preparedness, while the younger group had higher score in flood TPB (Table 6; see also Appendix Figure A13). Additionally, males and older groups had significantly higher bushfire

Table 8
Mean comparisons across the four factors of flood and bushfire preparedness scales by gender and age.

	FP scale factors by gender and age	Flood preparedness scale				BP scale factors by gender and age	Bushfire preparedness scale			
		Mean	S.D.	t-stat	p-value		Mean	S.D.	t-stat	p-value
1	Male_ Action plan	3.68	1.00	−0.41	NSS*	Male_ Response efficacy	3.90	0.84	7.51	<0.001
2	Female_ Action plan	3.69	0.98			Female_ Response efficacy	3.61	0.96		
3	Male_ Self-efficacy	3.97	0.75	4.80	<0.001	Male_ Action plan	2.98	1.16	5.53	<0.001
4	Female_ Self-efficacy	3.76	0.86			Female_ Action plan	2.65	1.20		
5	Male_ Local risk awareness	3.56	1.09	4.83	<0.001	Male_ Social support	3.87	0.88	−3.67	<0.001
6	Female_ Local risk awareness	3.32	1.10			Female_ Social support	4.06	0.84		
7	Male_ Vehicle safety	4.20	0.86	−0.72	NSS	Male_ Vehicle safety	3.88	0.87	0.84	NSS
8	Female_ Vehicle safety	4.23	0.77			Female_ Vehicle safety	3.84	0.95		
9	Younger_ Action plan	3.73	0.97	2.34	<0.01	Younger_ Response efficacy	3.62	0.98	−6.40	<0.001
10	Older_ Action plan	3.63	1.01			Older_ Response efficacy	3.87	0.83		
11	Younger_ Self-efficacy	3.79	0.87	−2.48	<0.01	Younger_ Action plan	2.84	1.23	1.68	<0.05
12	Older_ Self-efficacy	3.90	0.77			Older_ Action plan	2.74	1.14		
13	Younger_ Local risk awareness	3.38	1.10	−1.39	NSS	Younger_ Social support	4.02	0.83	1.84	<0.05
14	Older_ Local risk awareness	3.45	1.11			Older_ Social support	3.92	0.90		
15	Younger_ Vehicle safety	4.17	0.81	−3.15	<0.001	Younger_ Vehicle safety	3.75	0.96	−5.97	<0.001
16	Older_ Vehicle safety	4.28	0.79			Older_ Vehicle safety	3.98	0.85		

*NSS = Not statistically significant; $p > 0.05$.

Table 9
Mean comparisons across the six factors of flood and bushfire TPB by gender and age.

	TPB factors by gender and age	Flood TPB				Bushfire TPB			
		Mean	S.D.	t-stat	p-value	Mean	S.D.	t-stat	p-value
1	Male_ Attitude	4.26	0.81	−2.69	<0.01	4.34	0.66	−5.48	<0.001
2	Female_ Attitude	4.38	0.70			4.55	0.62		
3	Male_ Subjective norm	3.59	1.02	−1.66	<0.05	3.63	0.90	−1.30	NSS
4	Female_ Subjective norm	3.68	0.95			3.71	1.02		
5	Male_ Perceived behavioural control	3.74	0.92	2.64	<0.01	3.80	0.86	4.17	<0.001
6	Female_ Perceived behavioural control	3.60	0.95			3.57	1.04		
7	Male_ Perceived risk	3.06	1.22	−2.08	<0.05	3.00	1.10	−3.06	<0.01
8	Female_ Perceived risk	3.20	1.12			3.21	1.12		
9	Male_ Anticipated regret	3.92	0.91	−2.51	<0.01	3.94	0.79	−5.19	<0.001
10	Female_ Anticipated regret	4.04	0.80			4.18	0.74		
11	Male_ Intention	3.45	1.05	−2.64	<0.01	3.53	0.91	−3.38	<0.001
12	Female_ Intention	3.60	0.91			3.72	0.88		
13	Younger_ Attitude	4.38	0.72	2.88	<0.01	4.51	0.62	2.98	<0.01
14	Older_ Attitude	4.26	0.78			4.39	0.67		
15	Younger_ Subjective norm	3.73	0.97	4.06	<0.001	3.77	0.98	3.73	<0.001
16	Older_ Subjective norm	3.51	0.98			3.55	0.94		
17	Younger_ Perceived behavioural control	3.67	0.98	0.74	NSS*	3.63	1.02	−1.40	NSS
18	Older_ Perceived behavioural control	3.63	0.90			3.71	0.91		
19	Younger_ Perceived risk	3.40	1.10	10.06	<0.001	3.29	1.07	5.78	<0.001
20	Older_ Perceived risk	2.78	1.15			2.91	1.13		
21	Younger_ Anticipated regret	4.07	0.79	4.13	<0.001	4.10	0.79	0.98	NSS
22	Older_ Anticipated regret	3.88	0.91			4.05	0.76		
23	Younger_ Intention	3.66	0.95	5.74	<0.001	3.74	0.91	4.33	<0.001
24	Older_ Intention	3.36	0.98			3.51	0.86		

*NSS = Not statistically significant; $p > 0.05$.

preparedness scores, while female and the younger group had significantly higher bushfire TPB scores (Table 7; see also Appendix Figure A14).

Gender and age differences were further examined across the four preparedness scale factors (Table 8) and six TPB factors (Table 9) for both flood and bushfire contexts. Males scored significantly higher in self-efficacy and local risk awareness for floods, and in response efficacy and action planning for bushfires. In contrast, females consistently scored higher across five of the six TPB constructs, including attitude, subjective norm, perceived risk, anticipated regret, and intention to prepare, while males had higher perceived behavioural control.

Age-related patterns also emerged. Younger participants scored significantly higher on all TPB constructs except perceived behavioural control, and showed stronger results in action planning for both hazards and social support for bushfire preparedness. However, despite stronger intentions, their actual bushfire preparedness was lower than that of older adults, who reported higher response efficacy and vehicle safety. Older adults also scored higher in self-efficacy and vehicle safety for flood preparedness (see Appendix Figure A15 and Figure A16).

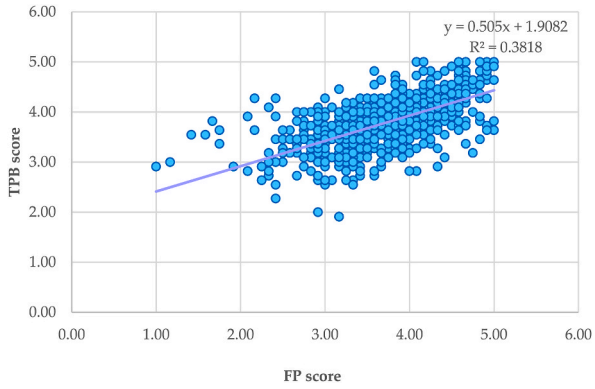

Fig. 4. Correlation between individual scores on flood preparedness (FP) and flood theory of planned behaviour (TPB).

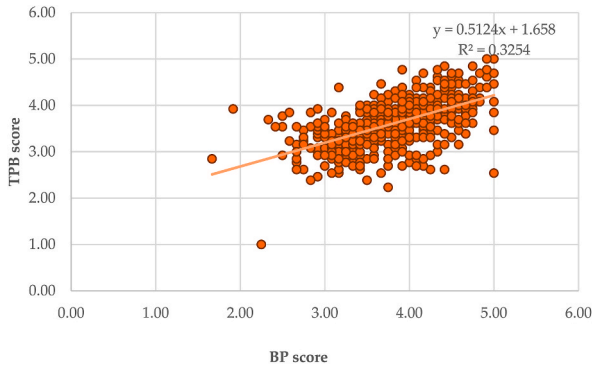

Fig. 5. Correlation between individual scores on bushfire preparedness (BP) and bushfire theory of planned behaviour (TPB).

Further analyses confirmed that preparedness scale scores were significantly associated with TPB constructs, which predict intention to prepare, as demonstrated earlier in the Structural Equation Model (SEM). Figs. 4 and 5 illustrate that FP and BP scores were positively associated with TPB scores, aligning with theoretical expectations. This suggests that individuals with higher flood and bushfire preparedness levels tend to exhibit stronger TPB-related attitudes and perceptions toward preparedness. These findings reinforce the theoretical link between preparedness and TPB constructs, supporting the validity of the flood and bushfire preparedness scale in measuring relevant behavioural and cognitive factors.

5. Discussion

Measuring individual preparedness for natural hazards such as floods and bushfires is a prerequisite for developing effective interventions to improve preparedness [11,12,17,19]. This research offers insights that can be translated into practical policies and strategies to improve and strengthen preparedness efforts at both individual and community levels.

Flood and bushfire preparedness scales were developed using an exploratory approach, through factor analysis of items based on three conceptual dimensions considered to be central to natural hazards preparedness: knowledge and local risk awareness [55], psychological preparedness [20,56–58], and practical action [2]. For the flood preparedness scale, four factors emerged that are consistent with previous research: Action Plan [59], Self-Efficacy [59,60], Local Risk Awareness [55], and Vehicle Safety [61,62]. Similarly, the four bushfire preparedness factors reflect hazard-specific elements of psychological and practical readiness identified in earlier studies: Response Efficacy [63,64], Action Plan [59], Social Support [65–67], and Vehicle Safety [68,69].

Although the same conceptual framework guided the development of flood and bushfire preparedness scales, the final constructs were not identical. Some dimensions overlapped, while others varied meaningfully, demonstrating that preparedness depends on the hazard. These findings underscore the need for hazard-specific approaches, as each hazard involves unique risks, time pressures, and decision-making contexts reflected in participants' responses. For example, the suddenness of flash floods versus the prolonged threat of bushfires influences how individuals prepare. Rather than generic measures, assessments and interventions should reflect each hazard's distinct characteristics and behavioural demands.

Flood preparedness findings revealed a key gap in local risk awareness, underscoring the urgent need to improve understanding of flood risks, evacuation routes, and shelter locations. This can be supported through risk mapping workshops [70,71], interactive tools such as mobile applications [72], virtual reality and game-based evacuation drills [73–75], and community-based workshops and training sessions [10,76,77]. Local councils can enhance these efforts by integrating relevant risk information into routine communications and community engagement strategies.

In contrast, bushfire preparedness findings indicated lower confidence in action planning. Participants reported lacking emergency supplies, being unaware of shelter locations, and inadequately managing flammable materials around their homes. These challenges can be addressed through community preparedness campaigns, including structured bushfire planning programs, seasonal property safety audits, and subsidised emergency kits for low-income households [78]. Virtual reality-based evacuation drills can also enhance readiness by offering immersive, scenario-based learning experiences [73,79]. At the policy level, promoting written household plans and providing financial incentives for property risk mitigation, such as vegetation clearance or home hardening, could further strengthen preparedness. Taken together, these findings highlight the need for tailored, localised, and equity-focused interventions that address the specific demands of each hazard.

While the preparedness scales dimensions were developed using an exploratory approach to measure individual readiness, the TPB constructs were defined based on the Theory of Planned Behaviour [25] to examine the underlying factors shaping individuals' intentions to prepare. In this study, perceived risk and anticipated regret were incorporated as additional components alongside the three core TPB constructs (attitude, subjective norm, and perceived behavioural control) and were found to predict individuals' intentions to prepare for floods and bushfires. This finding aligns with prior research demonstrating the influence of perceived risk and anticipated regret on behavioural intentions within the TPB framework [43,48,49]. Notably, the TPB constructs of subjective norm and perceived behavioural control encompass broader community-related aspects, including social norms, access to information, and local educational opportunities, thereby contributing to a more comprehensive understanding of preparedness intentions within the community.

The TPB analysis revealed strong scores for attitude and anticipated regret but low levels of perceived risk and intention to prepare for both floods and bushfires. Although participants recognised the importance of preparedness, many did not perceive themselves to be personally at risk, reducing motivation to act. This disconnect between awareness and intention to act is a common challenge in preparedness efforts, as people often view emergencies as unlikely to affect them directly [64,80]. To address this psychological gap, risk communication should be enhanced through narrative-based strategies, such as personal stories and local case studies, which help make abstract risks feel more tangible. Interactive workshops and public commitment initiatives can also help turn positive attitudes into concrete actions. From a policy perspective, incorporating behavioural science insights into emergency communication strategies could substantially enhance the effectiveness of public campaigns.

Individuals who live in high-risk areas or have emergency service experience scored significantly higher on both preparedness and TPB constructs. In line with findings by Guo et al. [55] and McNeill et al. [81], the results suggests that direct experience and proximity to risk increase both awareness and motivation to prepare. Accordingly, community-level interventions could include peer-to-peer knowledge sharing, community storytelling, risk narratives, and mentorship programs that connect experienced individuals with other community members. Their knowledge and experience represent a valuable resource for the wider community. These types of initiatives not only convey technical information but also foster trust and confidence, particularly when delivered by individuals with hands-on disaster experience.

Gender and age differences revealed valuable insights for enhancing flood and bushfire preparedness interventions. Male participants reported greater confidence in practical preparedness, while females scored higher on social support and psychological TPB factors, highlighting the potential of social networks to promote preparedness. These findings align with previous studies [3,82,83], which found that women generally reported lower levels of preparedness than men. Gender-sensitive campaigns can address this gap by equipping women with practical skills while leveraging their community influence. Age-related patterns also point to the need for tailored strategies. Younger individuals showed stronger intentions but lower practical readiness. This 'intention-action gap' suggests that while awareness exists, barriers such as limited resources, competing priorities, or the perceived difficulty of preparedness behaviours can hinder follow-through. Therefore, there is a need for tools that turn motivation into action, such as mobile applications, social media campaigns, and gamified programs. Older adults, meanwhile, may benefit more from practical drills, community engagement initiatives, and printed materials to reinforce and enhance their existing preparedness.

This study focused on measuring and improving individual preparedness, providing insights into perceptions and actions regarding flood and bushfire emergencies. Although the TPB constructs capture some elements that are influenced by community factors, including social norms, support, and local educational opportunities, key dynamics like social capital and joint preparedness efforts [59,84] were not measured. While aggregated individual data can inform both targeted interventions and broader understandings of community preparedness and resilience, community-level measures, such as social cohesion, shared infrastructure, communication systems, and collective action, were beyond this study's scope and warrant further research. Cultivating a culture of preparedness can transform communities from reactive to proactive responses, mitigating the societal and economic impacts of hazards [14,15]. Moreover, the predominance of Australian-born participants limits generalisability to culturally and linguistically diverse (CALD) populations, who may face challenges accessing emergency information. Future efforts should engage more diverse groups, including CALD communities and individuals with limited English proficiency [85–88], people with disabilities or chronic illnesses [86,89–94], low-income individuals [95,96], and rural residents [81], to support more inclusive, and equitable preparedness strategies.

6. Conclusions

This study contributed to the body of knowledge by developing and validating standardised self-assessment scales for flood and

bushfire preparedness. It also examined the psychological drivers of preparedness behaviours using the TPB, highlighting key factors such as attitude, subjective norms, perceived behavioural control, perceived risk, and anticipated regret. This comprehensive approach provides a robust framework to understand individual preparedness in the face of flood and bushfire emergencies.

Future studies could investigate the effectiveness and validation of the developed preparedness scales across different cultural and regional contexts to assess their broader applicability. Research could explore how the scales perform across various demographic groups, including those from multicultural backgrounds, to determine whether the constructs measured are universally relevant or need adaptation for specific populations. Additionally, it would be valuable to examine the barriers to preparedness, focusing on the challenges faced by groups with lower preparedness levels. Research could also explore the role of community-based programs in fostering long-term preparedness, particularly how social networks and local leadership influence participation and engagement. Lastly, studies could investigate the effectiveness of different communication strategies in diverse demographic groups to identify the most impactful methods for raising risk awareness and encouraging action.

CRediT authorship contribution statement

Sara Fazeli: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Taha H. Rashidi:** Writing – review & editing, Supervision, Resources, Project administration, Investigation, Funding acquisition. **Mohammad Mojtahedi:** Writing – review & editing, Supervision, Project administration, Investigation. **Milad Haghani:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

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.

Acknowledgement

The funding contribution of the Australian Research Council, Grant No. DE210100440, is acknowledged. The authors are also grateful to the two anonymous reviewers for their insightful feedback, which contributed to strengthening the quality of this work.

Appendix

Table A1
List of omitted items due to poor factor loadings after performing exploratory factor analysis for flood preparedness scale

Code	Item content	Envisioned category
FP5	During a flood emergency, I would seek emotional and physical security from close friends and family.	Action plan
FP6	If I see people seeking help in a flood emergency, I will try to help them.	Support and safety
FP8	I have a bag of prepared emergency food and resources to be able to survive for at least 72 h after the flood event.	Action plan
FP10	A 15 cm height of water can cause a typical car to float, so I will lose my driving control.	Vehicle safety
FP11	In case of a flood emergency, I would wait for advice from emergency services before I choose what to do.	Action plan

Table A2
List of omitted items due to poor factor loadings after performing exploratory factor analysis for bushfire preparedness scale

Code	Item content	Envisioned category
BP7	I believe having an emergency kit with essential supplies for bushfires is necessary.	Action plan
BP9	In case of a bushfire emergency, I would wait for advice from emergency services before I choose what to do.	Action plan
BP11	I would not travel by vehicle through bushfires.	Action plan
BP13	In a situation where I am surrounded by smoke or flames and cannot turn around to drive, I will position my car towards the oncoming fire front.	Vehicle safety
BP14	In a situation where I am surrounded by smoke or flames and cannot turn around to drive, I will position my car behind a barrier, such as a wall or rocky outcrop, to seek protection from dense bush.	Vehicle safety

Table A3
Exploratory and confirmatory factor analyses for developing flood preparedness scale

Code	Flood preparedness scale items	Factor loadings											
		1 (Action plan)			2 (Self-efficacy)			3 (Local risk awareness)			4 (Vehicle safety)		
		EFA (n = 300)	CFA (n = 400)	CFA (n = 700)	EFA (n = 300)	CFA (n = 400)	CFA (n = 700)	EFA (n = 300)	CFA (n = 400)	CFA (n = 700)	EFA (n = 300)	CFA (n = 400)	CFA (n = 700)
FP7	I believe having an emergency kit with essential supplies for floods is necessary.	0.72	0.66	0.58									
FP14	Before I evacuate, I use sandbags to make a wall (at least the height of expected water) across doorways.	0.64	0.55	0.66									
FP15	Before I evacuate, it would be helpful to block drainage holes (e.g. showers, sinks, toilets) in home to stop back flow of water.	0.48	0.53	0.60									
FP1	In a flood emergency, I am able to make quick decisions to ensure my safety and the safety of others.				0.67	0.82	0.82						
FP2	I am confident that I can stay calm and composed in the challenging situation of a flood emergency.				0.80	0.69	0.73						
FP3	I know about the best routes in our neighbourhood to avoid floods.							0.68	0.76	0.76			
FP4	I know about the shelters in our neighbourhood to seek safety during floods.							0.67	0.63	0.67			
FP12	I know the level of risk at the area where I live, and take precautions to safeguard my property against floods.							0.67	0.70	0.68			
FP9	I would not travel by vehicle through flood waters.										0.47	0.49	0.44
FP13	If I decide to evacuate during a flood disaster, I make sure to leave early, before any roads are affected by flooding.										0.48	0.73	0.72
FP16	If I find myself trapped in a car in floodwaters, unable to open the car door due to water pressure, it would be helpful to roll down the window, climb onto the roof (children first), position for stability (prepare to swim), and contact emergency services.										0.44	0.41	0.39

Table A4
Exploratory and confirmatory factor analyses for developing bushfire preparedness scale

Code	Bushfire preparedness scale items	Factor loadings											
		1 (Response efficacy)			2 (Action plan)			3 (Social support)			4 (Vehicle safety)		
		EFA (n = 300)	CFA (n = 250)	CFA (n = 550)	EFA (n = 300)	CFA (n = 250)	CFA (n = 550)	EFA (n = 300)	CFA (n = 250)	CFA (n = 550)	EFA (n = 300)	CFA (n = 250)	CFA (n = 550)
BP1	In a bushfire emergency, I am able to make quick decisions to ensure my safety and the safety of others.	0.89	0.70	0.75									
BP2	I am confident that I can stay calm and composed in the challenging situation of a bushfire emergency.	0.82	0.73	0.73									
BP3	I know about the best routes in our neighbourhood to avoid bushfires.	0.50	0.80	0.76									
BP10	I know the level of risk at the area where I live, and take precautions to safeguard my property against bushfires.	0.41	0.60	0.62									
BP4	I know about the shelters in our neighbourhood to seek safety during bushfires.				0.81	0.74	0.80						
BP8	I have a bag of prepared emergency food and resources to be able to survive for at least 72 h after the bushfire event.				0.71	0.64	0.66						
BP12	Every year before the bushfire season, I consider burning-off the flammable materials around my properties in a controlled condition.				0.45	0.47	0.48						
BP5	During a bushfire emergency, I would seek emotional and physical security from close friends and family.							0.60	0.40	0.34			
BP6	If I see people seeking help in a bushfire emergency, I will try to help them.							0.60	0.80	0.91			
BP15	If I decide to evacuate during a bushfire disaster, I make sure to leave early, before any roads are impacted by bushfires.										0.46	0.55	0.44
BP16	Moving up a slope is dangerous in a bushfire as fires tend to travel at faster speeds and be more intense as they move uphill.										0.47	0.64	0.58
BP17	If I find myself trapped in a car surrounded by bushfires, I will get down below window level to avoid being exposed to the radiant heat.										0.50	0.62	0.56
BP18	If I find myself trapped in a car surrounded by bushfires, I will cover up my body with woollen blankets.										0.50	0.46	0.43

Table A5
Factor loadings, mean, and standard deviation for items in each TPB factor for flood preparedness

	Item content	Factor (latent variable)		Mean (factor)	Mean (item)	S.D.	Factor loading	S.E.	z-value	p-value
1	I believe that being educated about flood risks is important.	Attitude	A1	4.33	4.44	0.66	0.634	0.039	15.30	<0.001
2	Preparing myself for flood would benefit my family and people around me.		A2		4.23	0.81	0.860	0.110	15.30	<0.001
3	My friends and family support my efforts to get educated about flood risks.	Subjective norm	SN1	3.64	3.80	0.88	0.795	0.038	21.46	<0.001
4	Most people who are important to me do consciously preparing themselves for floods.		SN2		3.48	1.04	0.822	0.057	21.46	<0.001
5	I am confident in my ability to prepare myself for potential flood risks.	Perceived behavioural	PBC1	3.65	3.80	0.87	0.670	0.056	14.46	<0.001
6	There are lots of opportunities to get educated about flood emergency in my local area.	control	PBC2		3.53	1.00	0.716	0.085	14.46	<0.001
7	I am concerned about the potential exposure of my asset to floods.	Perceived risk (Susceptibility)	PR1	3.14	3.27	1.17	0.874	0.053	20.53	<0.001
8	I feel personally vulnerable to potential consequences of flood emergencies.		PR2		3.02	1.14	0.828	0.045	20.53	<0.001
9	Preparing for floods can prevent my family from severe consequences.	Anticipated regret	AR1	3.99	4.07	0.82	0.742	0.046	19.19	<0.001
10	Minimising regret of severe loss and damages caused by floods is a motivation for me to prepare myself for floods.		AR2		3.91	0.86	0.799	0.059	19.19	<0.001
11	I am determined to get educated about flood safety in the next six months.	Intention	I1	3.54	3.45	0.99	0.830	0.035	26.99	<0.001
12	I am committed to actively prepare myself for floods.		I2		3.63	0.95	0.898	0.039	26.99	<0.001

Table A6
Regression estimates and covariances for TPB factors predicting intention to prepare for floods

	Relationship	Regression				Covariance			
		Estimate	S.E.	z-value	p-value	Estimate	S.E.	z-value	p-value
1	Attitude ~ Intention to prepare	0.694	0.028	12.50	<0.001	N/A	N/A	N/A	N/A
2	Subjective norm ~ Intention to prepare	0.778	0.038	17.42	<0.001	N/A	N/A	N/A	N/A
3	Perceived behavioural control ~ Intention to prepare	0.737	0.038	13.62	<0.001	N/A	N/A	N/A	N/A
4	Perceived risk (Susceptibility) ~ Intention to prepare	0.696	0.052	16.64	<0.001	N/A	N/A	N/A	N/A
5	Anticipated regret ~ Intention to prepare	0.806	0.036	16.81	<0.001	N/A	N/A	N/A	N/A
6	Attitude ~ Subjective norm	N/A	N/A	N/A	N/A	0.343	0.010	4.58	<0.001
7	Subjective norm ~ Perceived behavioural control	N/A	N/A	N/A	N/A	0.673	0.016	7.20	<0.001
8	Attitude ~ Anticipated regret	N/A	N/A	N/A	N/A	0.648	0.010	7.13	<0.001

Table A7
Factor loadings, mean, and standard deviation for items in each TPB factor for bushfire preparedness

	Item content	Factor (latent variable)		Mean (factor)	Mean (item)	S.D.	Factor loading	S.E.	z-value	p-value
1	I believe that being educated about bushfire risks is important.	Attitude	A1	4.46	4.55	0.57	0.732	0.053	13.76	<0.001
2	Preparing myself for bushfire would benefit my family and people around me.		A2		4.36	0.71	0.795	0.099	13.76	<0.001
3	My friends and family support my efforts to get educated about bushfire risks.	Subjective norm	SN1	3.67	3.85	0.86	0.718	0.044	16.09	<0.001
4	Most people who are important to me do consciously preparing themselves for bushfires.		SN2		3.50	1.03	0.852	0.088	16.09	<0.001
5	I am confident in my ability to prepare myself for potential bushfire risks.	Perceived behavioural	PBC1	3.67	3.75	0.93	0.695	0.106	10.30	<0.001
6	There are lots of opportunities to get educated about bushfire emergency in my local area.	control	PBC2		3.58	1.01	0.585	0.089	10.30	<0.001
7	I am concerned about the potential exposure of my asset to bushfires.	Perceived risk (Susceptibility)	PR1	3.12	3.24	1.12	0.826	0.072	14.03	<0.001
8	I feel personally vulnerable to potential consequences of bushfire emergencies.		PR2		3.00	1.09	0.835	0.070	14.03	<0.001
9	Preparing for bushfires can prevent my family from severe consequences.	Anticipated regret	AR1	4.08	4.20	0.74	0.690	0.067	13.35	<0.001
10	Minimising regret of severe loss and damages caused by bushfires is a motivation for me to prepare myself for bushfires.		AR2		3.95	0.79	0.719	0.083	13.35	<0.001
11	I am determined to get educated about bushfire safety in the next six months.	Intention	I1	3.64	3.53	0.90	0.755	0.050	18.15	<0.001
12	I am committed to actively prepare myself for bushfires.		I2		3.74	0.88	0.856	0.061	18.15	<0.001

Table A8
Regression estimates and covariances for TPB factors predicting intention to prepare for bushfires

	Relationship	Regression				Covariance			
		Estimate	S.E.	z-value	p-value	Estimate	S.E.	z-value	p-value
1	Attitude ~ Intention to prepare	0.640	0.037	10.49	<0.001	N/A	N/A	N/A	N/A
2	Subjective norm ~ Intention to prepare	0.695	0.055	11.45	<0.001	N/A	N/A	N/A	N/A
3	Perceived behavioural control ~ Intention to prepare	0.596	0.061	9.25	<0.001	N/A	N/A	N/A	N/A
4	Perceived risk (Susceptibility) ~ Intention to prepare	0.602	0.077	10.70	<0.001	N/A	N/A	N/A	N/A
5	Anticipated regret ~ Intention to prepare	0.829	0.050	12.58	<0.001	N/A	N/A	N/A	N/A
6	Attitude ~ Subjective norm	N/A	N/A	N/A	N/A	0.336	0.012	4.07	<0.001
7	Subjective norm ~ Perceived behavioural control	N/A	N/A	N/A	N/A	0.717	0.023	7.06	<0.001
8	Attitude ~ Anticipated regret	N/A	N/A	N/A	N/A	0.477	0.010	4.24	<0.001

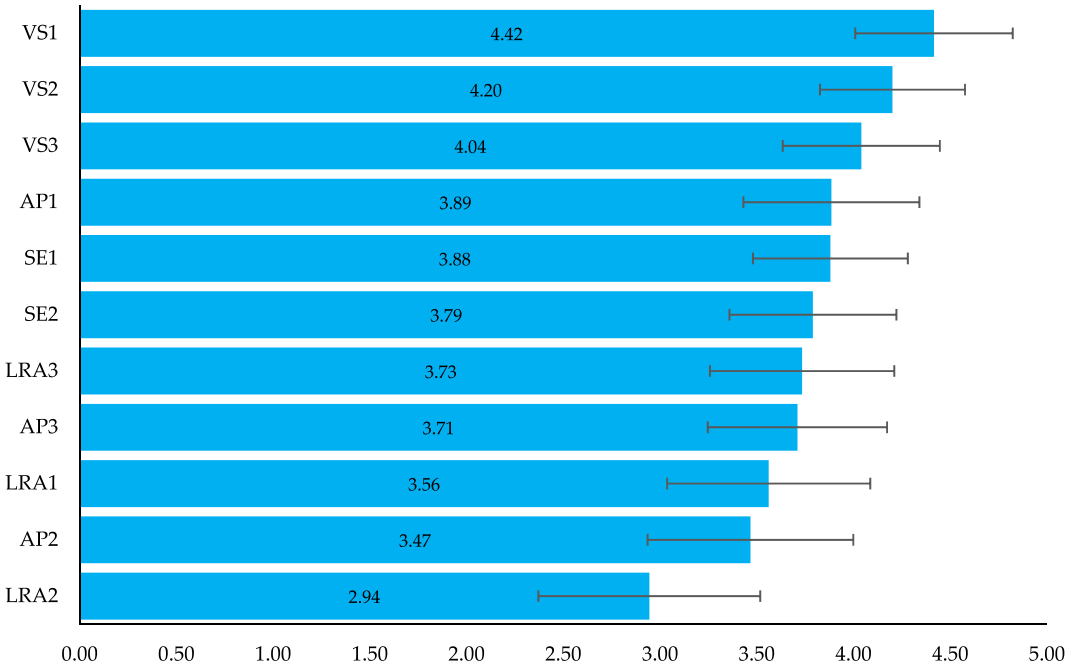

Fig. A1. Mean responses and standard deviations for flood preparedness scale items.

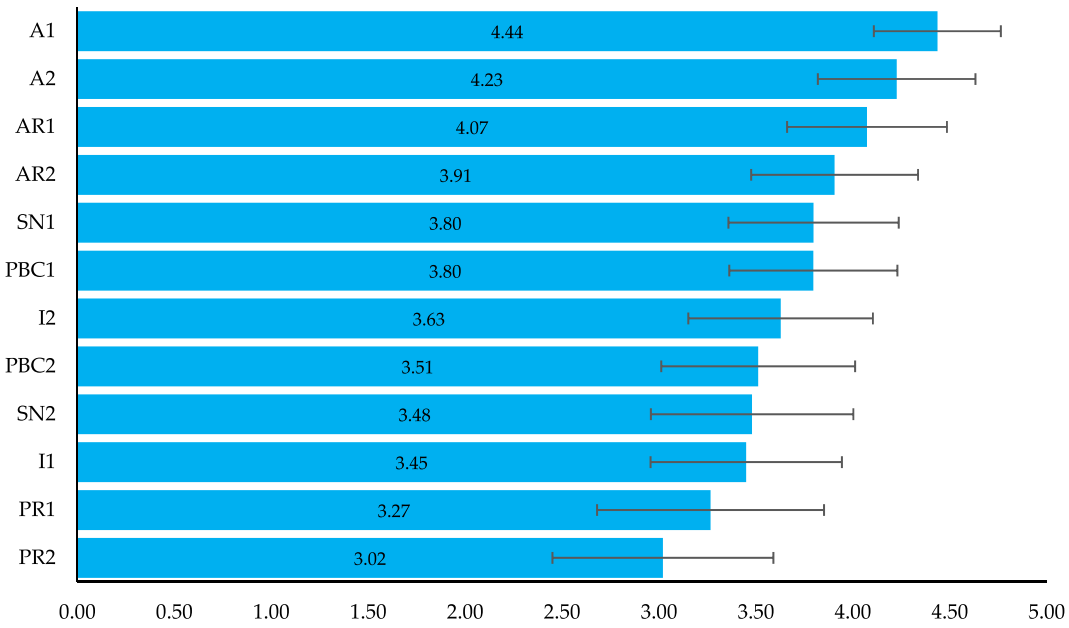

Fig. A2. Mean responses and standard deviations for flood TPB items.

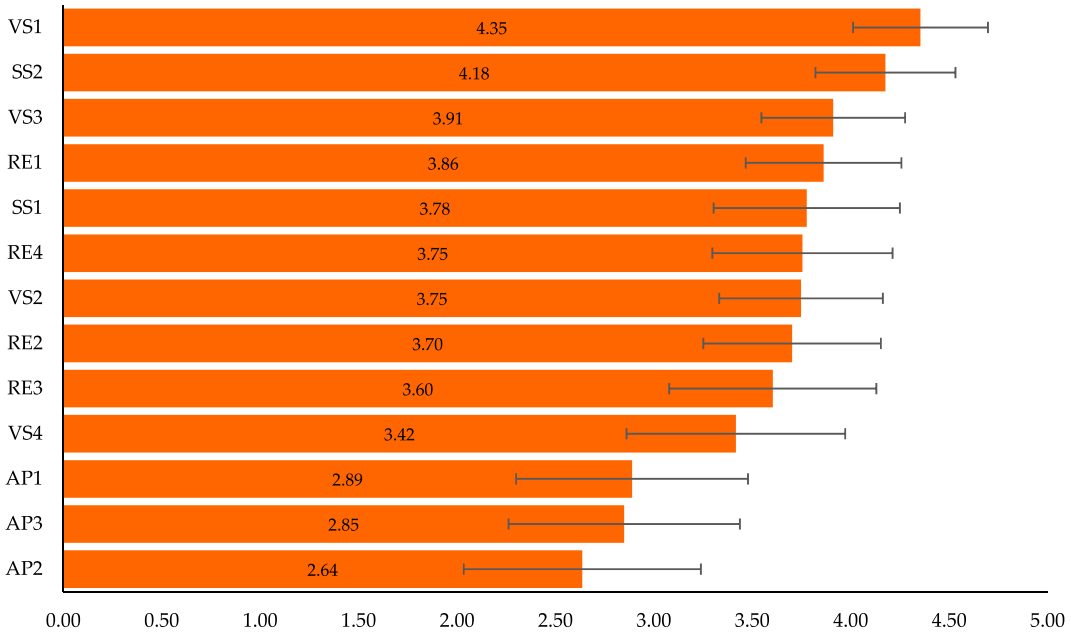

Fig. A3. Mean responses and standard deviations for bushfire preparedness scale items.

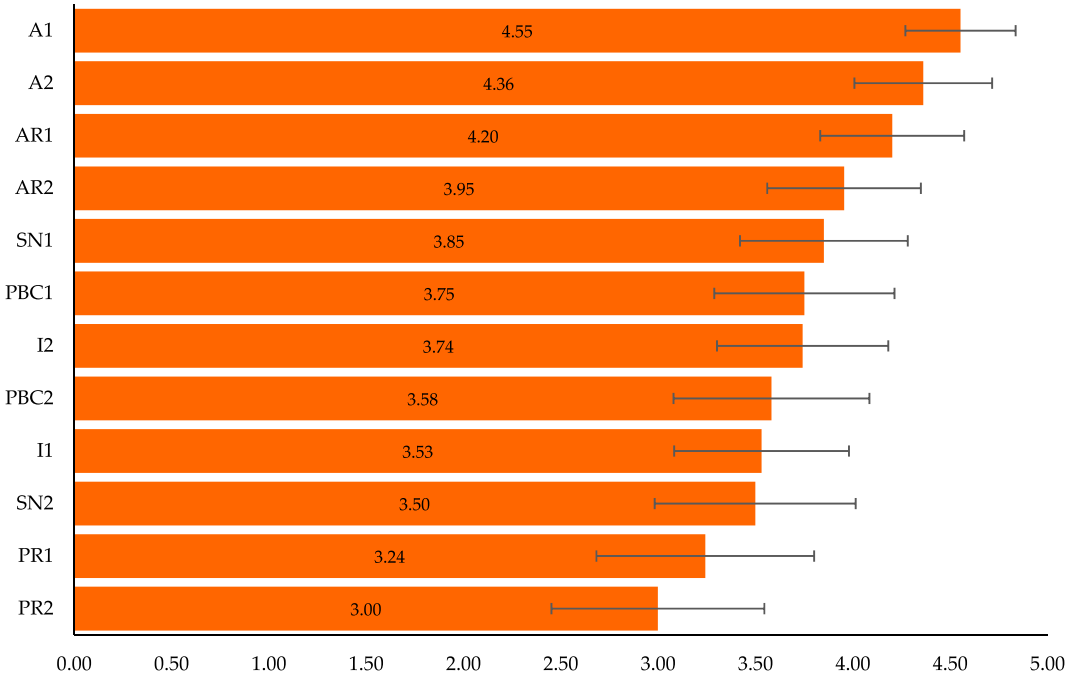

Fig. A4. Mean responses and standard deviations for bushfire TPB items.

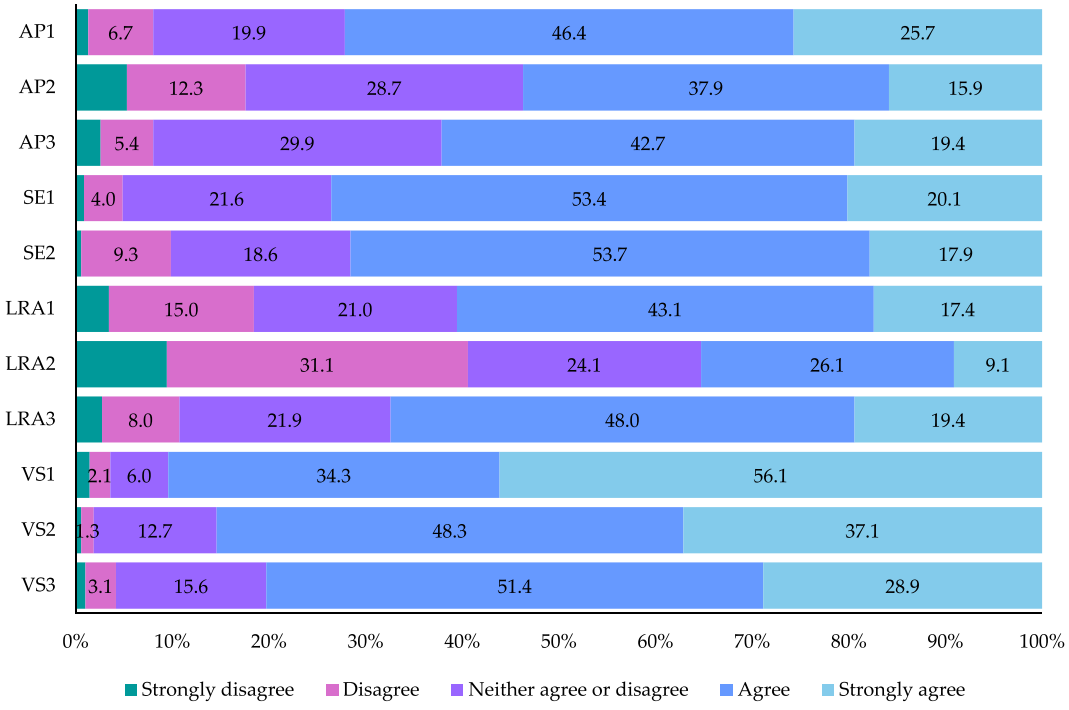

Fig. A5. Response distributions for flood preparedness scale items.

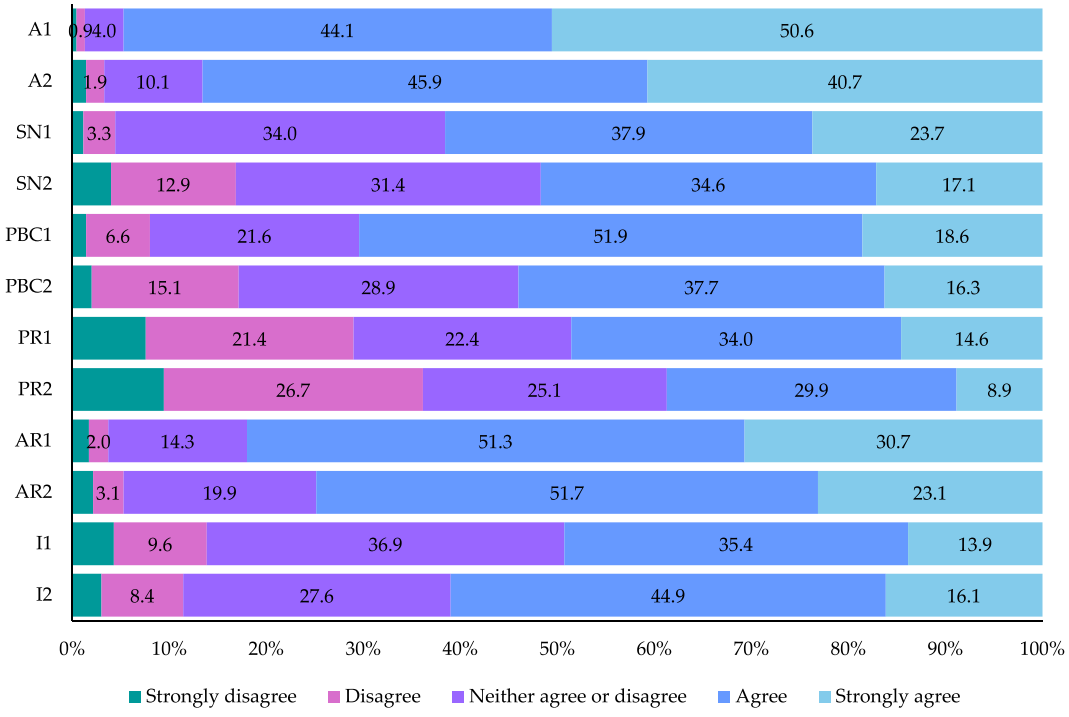

Fig. A6. Response distributions for flood TPB items.

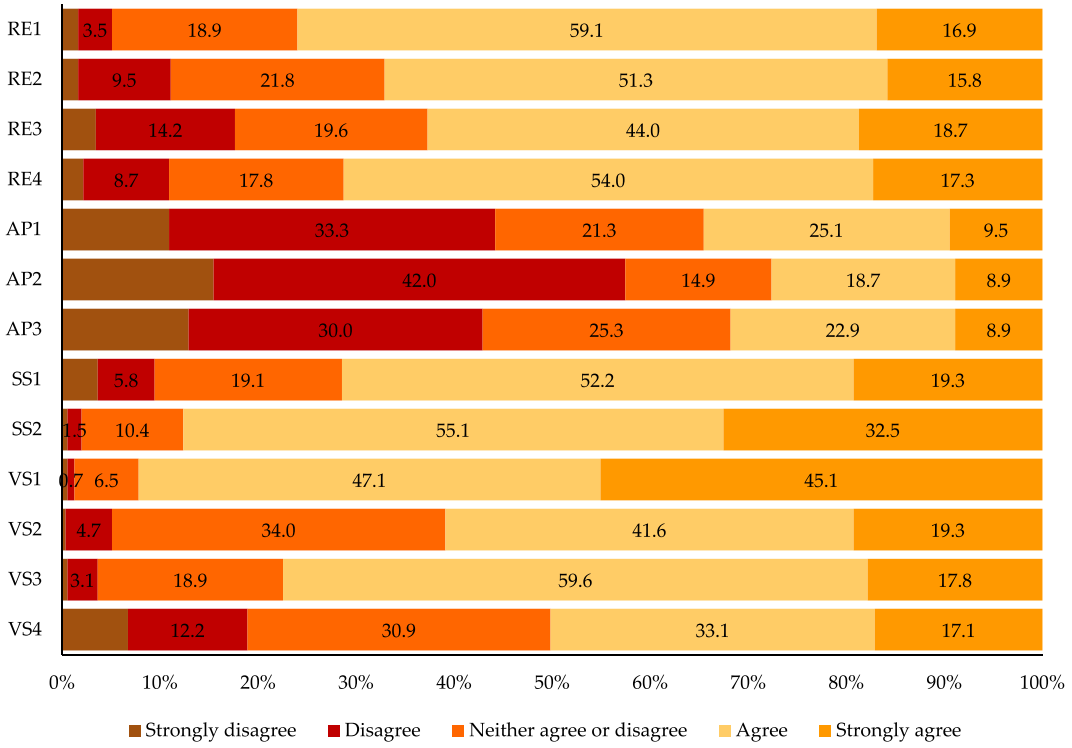

Fig. A7. Response distributions for bushfire preparedness scale items.

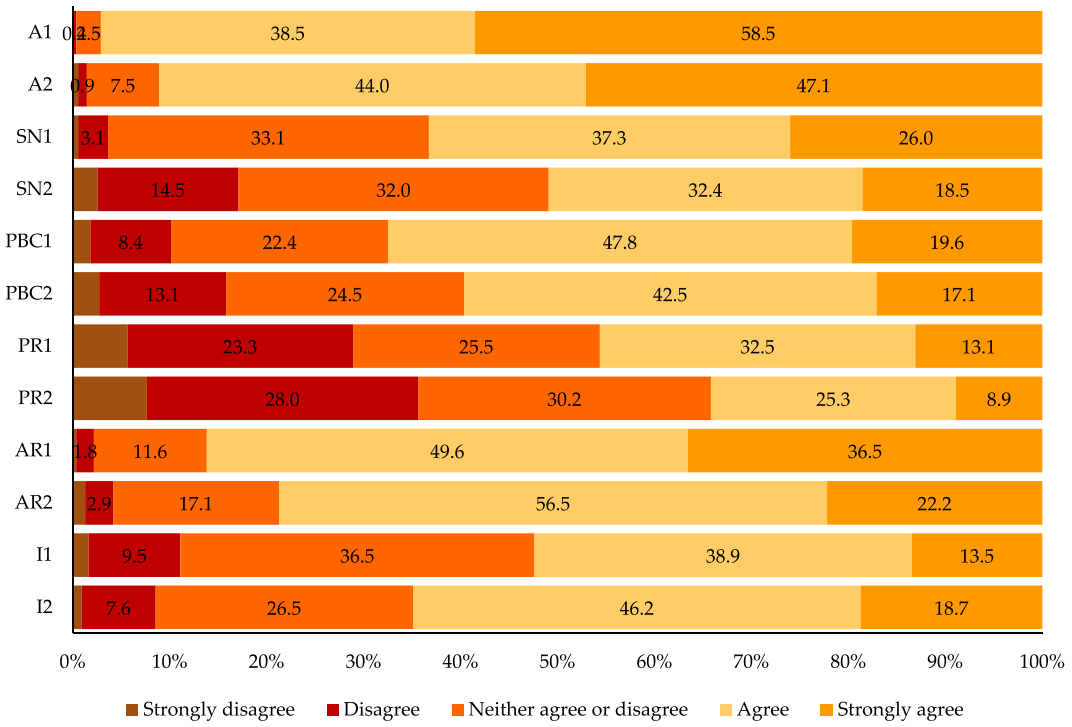

Fig. A8. Response distributions for bushfire TPB items.

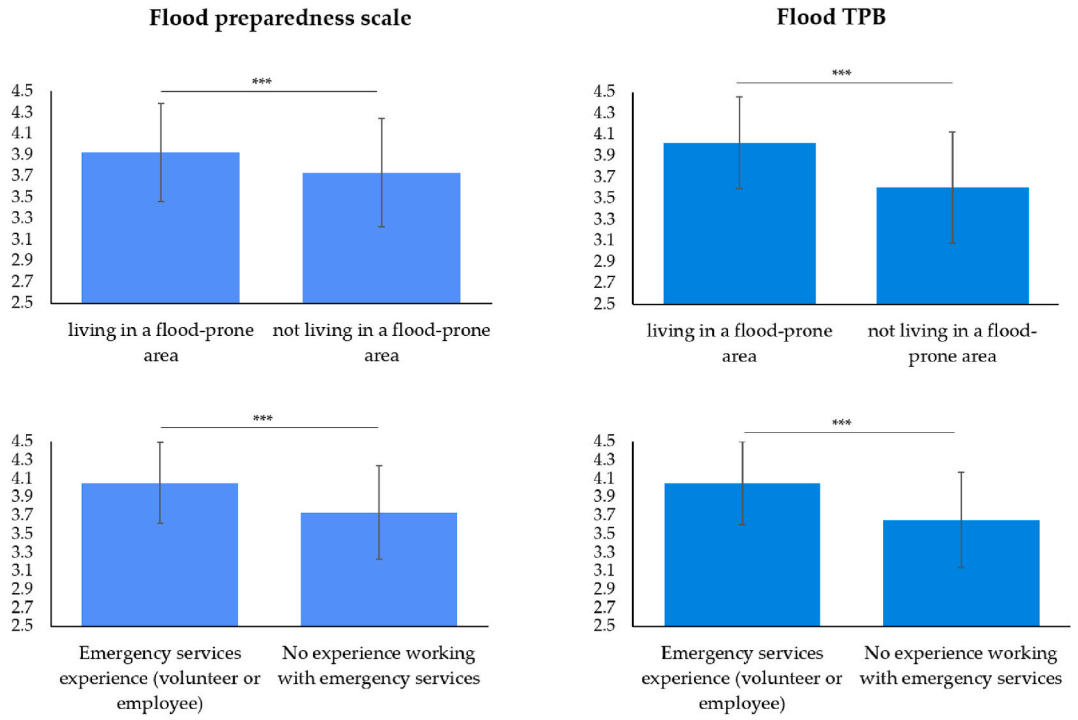

Fig. A9. Mean comparisons of flood preparedness and TPB scores by flood-prone residency and emergency services experience (*** = significant).

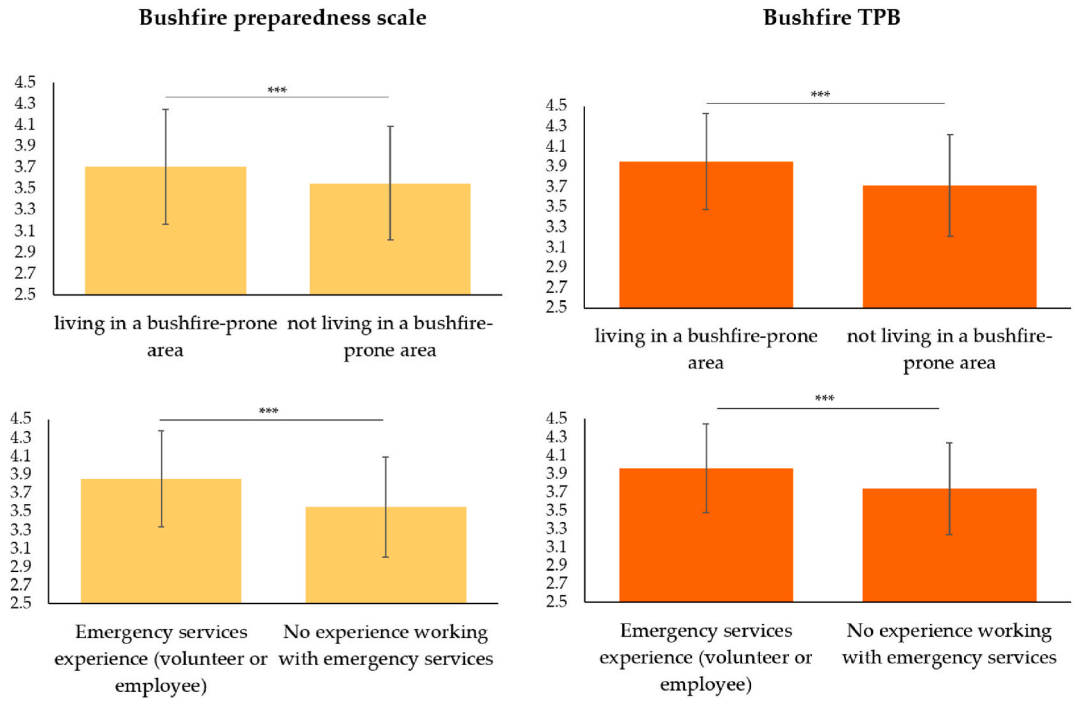

Fig. A10. Mean comparisons of bushfire preparedness and TPB scores by bushfire-prone residency and emergency services experience (*** = significant).

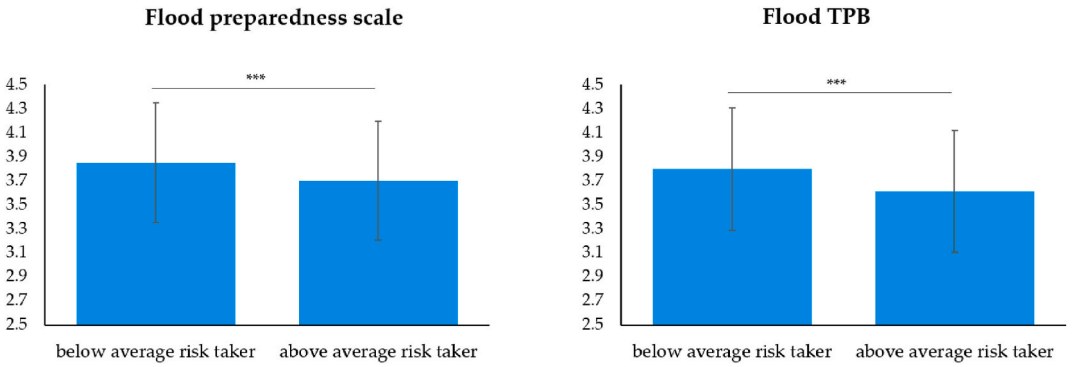

Fig. A11. Mean comparisons of flood preparedness and TPB scores by risk-taking level (*** = significant).

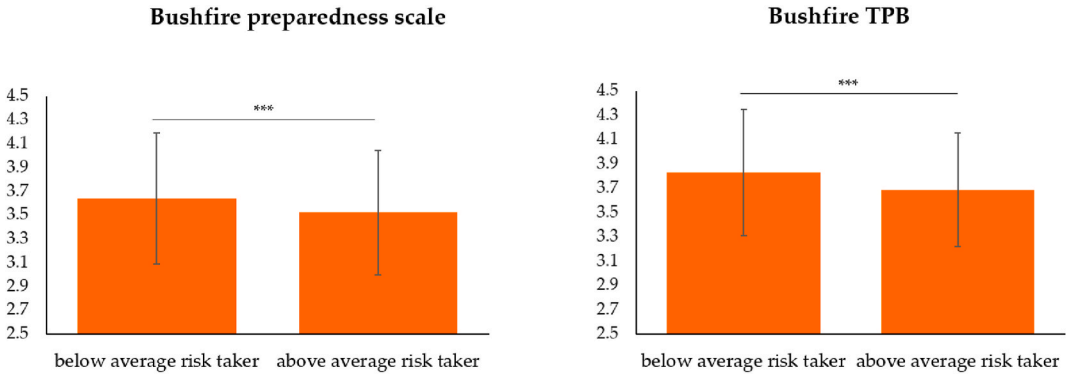

Fig. A12. Mean comparisons of bushfire preparedness and TPB scores by risk-taking level (*** = significant).

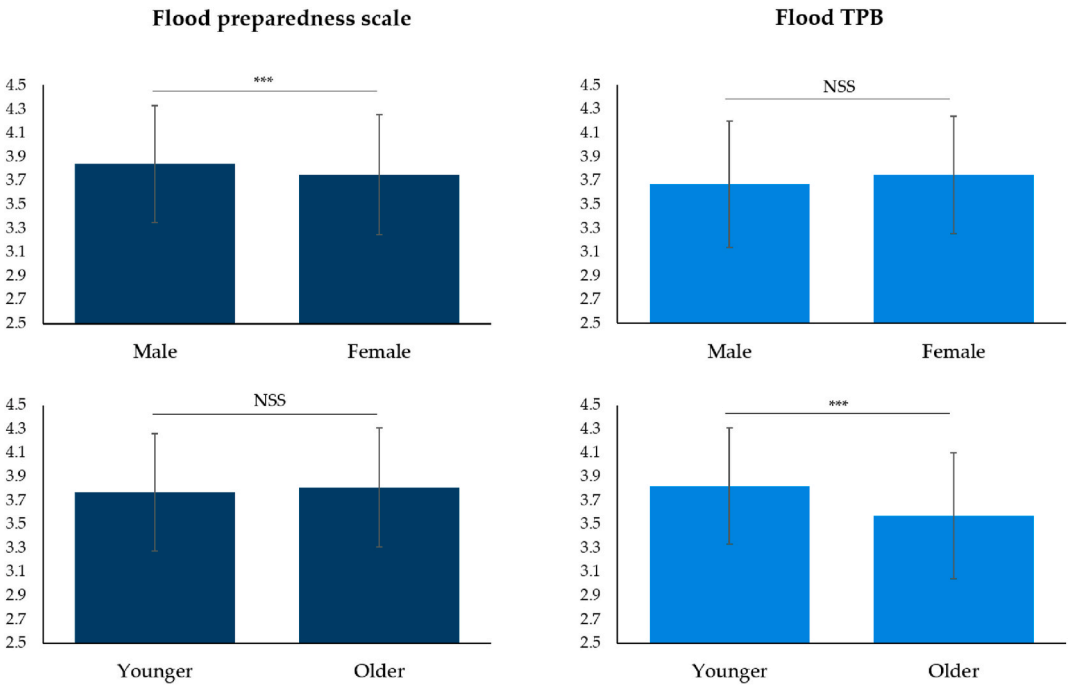

Fig. A13. Mean comparisons in flood preparedness (FP) and theory of planned behaviour (TPB) scores by gender and age (*** = significant, NSS = not statistically significant).

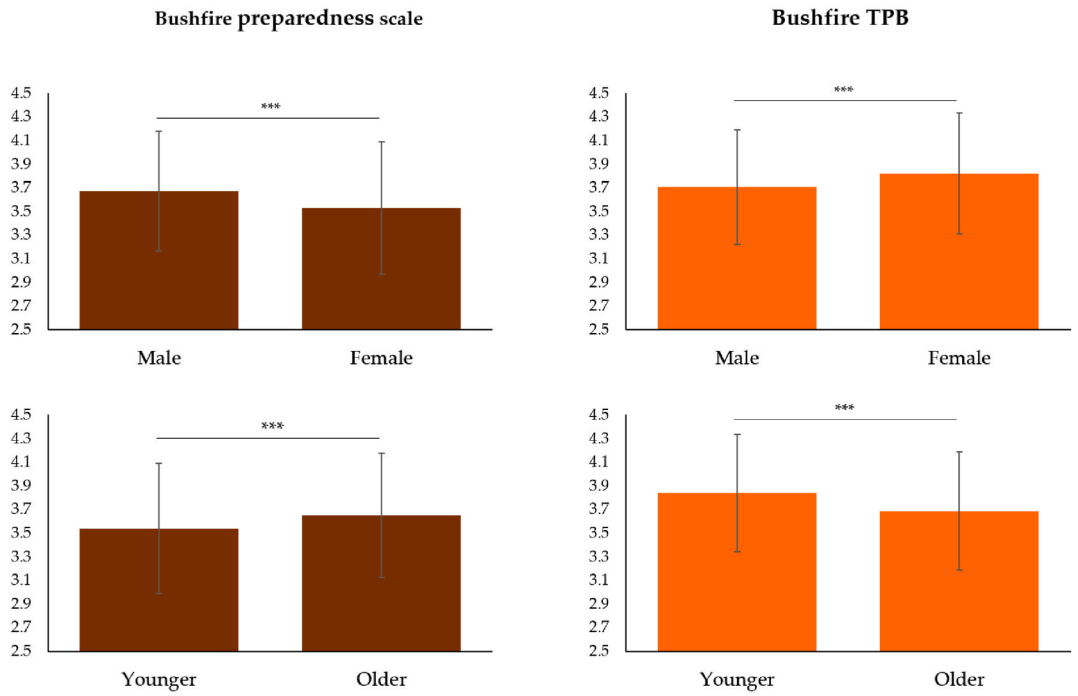

Fig. A14. Mean comparisons in bushfire preparedness (BP) and theory of planned behaviour (TPB) scores by gender and age (*** = significant, NSS = not statistically significant).

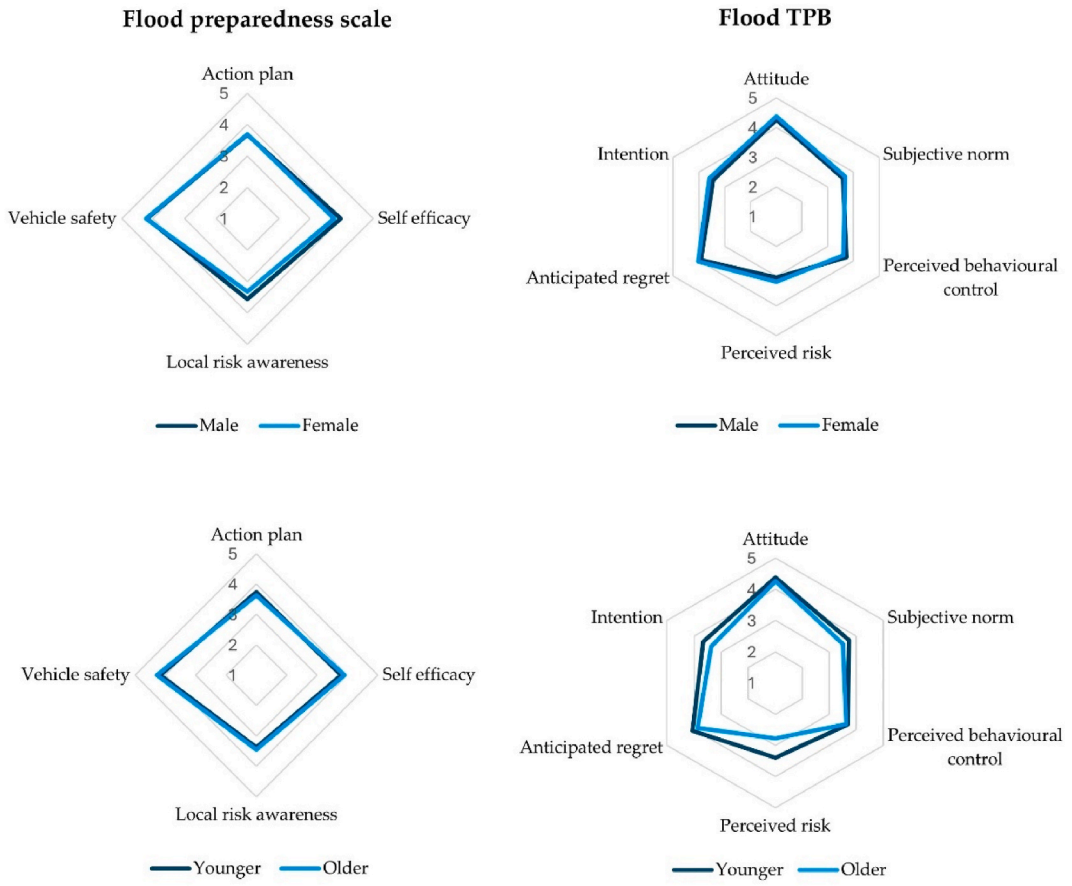

Fig. A15. Mean comparisons across the four factors of flood preparedness scale and the six factors of flood TPB by gender and age.

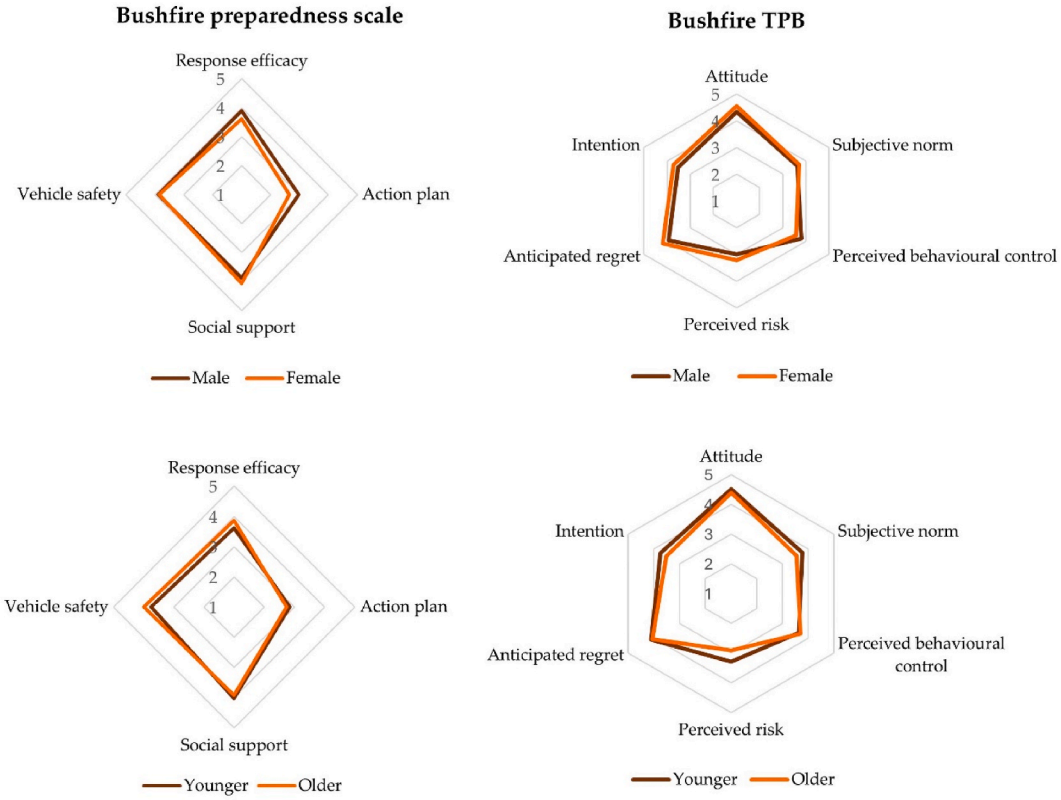

Fig. A16. Mean comparisons across the four factors of bushfire preparedness scale and the six factors of bushfire TPB by gender and age.

Data availability

Data will be made available on request.

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