Chapter 9 Australian Case: Black Summer Bushfires

Mona Salam[1], Shuang Wu[2], Iina Lohi[3], Alison Wain[4], Robert Fleck[5], Sara Wilkinson[6], Saaed Banihashemi[7], Aso Hajirasouli[8], Lois Towart[9].

9.1 Introduction

Anthropogenically induced climate change, associated with increased atmospheric CO2 concentrations and the greenhouse effect, have led to a hotter, drier climate worldwide. With increasing temperatures, the intensity and severity of global wildfires are increasing (see Figure 1 below). Wildfires are labelled bushfires in Australia. In the last few years, however, a sharp increase in global Megafires has been observed, with over 75 million hectares of combined land being burned since 2020 (Australia ~36.5m (2019-22) (Li et al., 2023); Brazil ~5.5m (2020) (Pivello et al., 2021) Russia ~21.5m (2021) (Bondur et al., 2023); USA ~3.2m (2022) (Center, 2022); Canada ~8.8m (2023) (WSWS, 2023)).

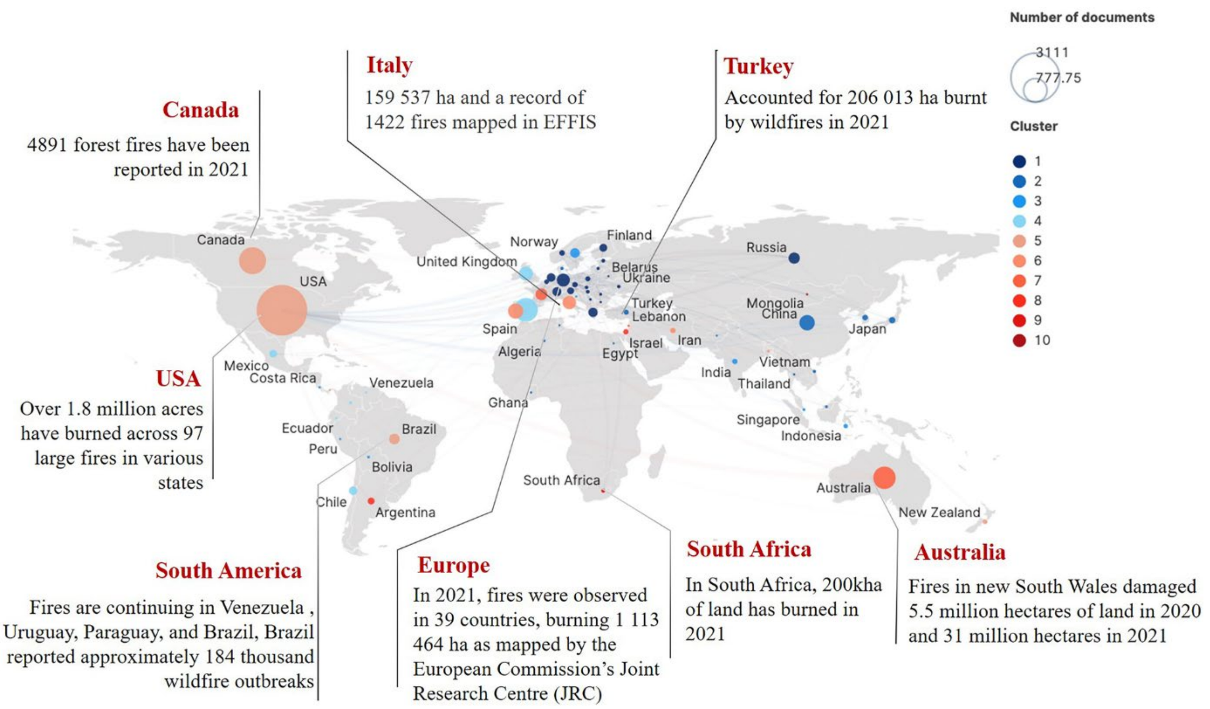

Figure 1 Global distribution of wildfire studies and the extent of burned land and destruction in major countries [Image source (Li et al., 2023)].

Wildfires are an important environmental process in Australia, with several flora dependent on wildfires to stimulate fresh plant growth. However, the recent mega fires experienced worldwide and on the Australian continent were more significant and hotter than previously experienced. Due to the high fuel loading associated with the endemic eucalypt forests, extended and frequent periods of drought, low relative humidity and high solar radiation, Australia has a reputation for being extremely fire-prone (Nolan et al., 2016). The recent Black Summer Bushfires (2019-2020) were particularly severe, with over 30 million hectares of burned land, leading to the destruction of over 3000 homes, the loss of 33 human lives (Cowled et al., 2022), and the death of over three billion native animals (Dickman, 2021). In response to the loss of property and human life, there is a need to design and distribute fire-ready retrofit guides for properties to reduce the risks associated with both stay-and-defend and evacuation practices.

The prevalence of formal bushfire home retrofit toolkits in Australia has evolved over the past few years, primarily because of the Black Summer Bushfires at a community level and through the economic backing of government, private funding, and the Insurance Council of Australia. Various program or toolkit methodologies have come into existence for assessing personal and building vulnerability and retrofit options – including social and environmental profiling (Auld, 2020), assessment of bushfire vulnerabilities of regions and communities (Cramp & Scott, 2019; Parsons et al., 2021), audience segmentation guides (Villeneuve et al., 2018), and building sustainability guides (Council, 2020). Bushfire resilient home rating tools are now coming into existence (initially developed by the Bushfire Building Council Australia and newly rebranded to the Resilient Building Council of Australia in 2023[1]). They aim to inform residents of their homes' potential bushfire resilience issues. This is the first step towards making changes. However, there is still limited centralised information on what homeowners can do to improve the bushfire resilience of their homes.

This research was funded in 2022 under the Black Summer Bushfire Recovery Grants Program. The research reviewed the current global, National, State, local and independent guidance on building for bushfire resilience. The broader research uses two case study regions, Bega Valley Shire in New South Wales and Noosa Shire in Queensland, to assess the suitability of available

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[1] https://rbcouncil.org/resilience-ratings/

bushfire retrofit guidance to be adapted and implemented by vulnerable people in fire-prone areas.

9.2 Megafires: effects on the Australian landscape and built environment

Megafires cause devastation beyond the norm and cause long-lasting effects on people and the built environment, as well as on biodiversity and the broader landscape and ecological function of entire regions. The effects have been linked to higher rates of landscape-scale decline and environmental regeneration failure (Godfree et al., 2021). Their effects extend beyond single fire events and have ecological impacts beyond individual species (Keith et al., 2022), extending to significant chemical and physical changes to soil, water, and air (Akdemir et al., 2022; Legge et al., 2022). For example, fine particulate matter in the air caused by large fires has been linked to environmental *"ammonification, eutrophication, loss of biodiversity and a decreased resistance to drought and frost damage*" (Akdemir et al., 2022). Megafires have caused catastrophic damage to human settlements and infrastructure within flammable vegetation zones, reflected in subsequent economic disasters and environmental loss (He et al., 2022; Ullah et al., 2021). The period between October 2019 and February 2020 witnessed extensive bushfires in the south-eastern part of the country, peaking in size during December and January (Attiya & Jones, 2022). These were the most significant bushfires in the south-eastern as the burnt area exceeded that of the Ash Wednesday fires in 1983 and the Black Saturday fires in 2009 combined, destroying nearly 6,000 buildings, the loss of 34 human lives, and the death of over 3 billion terrestrial vertebrates (Sharples et al., 2016). In terms of directly burnt landscape-level losses, the 2019-20 black summer bushfires on the east coast of Australia devastated 21% of the Australian temperate forest biome, possibly moving many ecosystems toward classification as 'threatened' under the International Union for Conservation of Nature (IUCN) Red List of Ecosystems (Bland et al 2017, in Le Breton et al., 2022).

Commencing in November and December 2019 within the Blue Mountains vicinity west of Sydney, these bushfires extended across multiple New South Wales (NSW) sectors, encompassing the northern, central, and southern coastal regions, affecting bushlands, state forests, and national parks. Earmarked as the most severe fire incidents documented in NSW's history, over 140 fires covered an area of approximately 70,000 square kilometres, destroying 2176 homes (Ullah et al., 2021). The fires generated an orange-red haze enveloping NSW. They escalated pollution levels in numerous zones, including Sydney's metropolitan area, influencing air quality levels in urban zones such as Sydney, Lower Hunter, Central Coast, and Illawarra (Attiya & Jones, 2022).

9.3 Australia's housing and vulnerability to bushfire damage

The trend for urban planning has meant that the divide between urban and rural has become more blurred, and peri-urban areas now account for around 15% of Australia's housing stock (Sutton et al 2009, in Norman et al., 2021). In Australia, bushfire resilient homes are an architectural issue faced in rural and peri-urban areas and tree-change and sea-change settlements, the latter of which has been increasing in trend for the past 50 years (Obaldiston 2012, in Norman et al., 2021). This has taken previously urban dwellers into more bushfire-prone areas to live. Whilst some of these homes may have been recently built, much of Australia's housing stock has already existed before significant improvements were made to building codes for better bushfire climate resilience. Many people in Australia live in housing built before the advent of the bushfire building standards in the Australian building practice.

The impact of bushfires on this housing trend is primarily centred on the locational choices made by people with personal aspirations connected to living close to nature, living in less dense or developed settlements, and/or close to the land. However, it would not matter how well the design of building can withstand bushfire; no house is entirely fireproof, and there is little chance of survival if caught in the path of a mega-fire. These personal aspirational values are mostly forgotten in urban sustainability retrofit frameworks, many of which purport the need for medium-density housing urban morphologies and home energy retrofits rather than direct climate-resilient retrofits that reduce bushfire attacks (Saffari & Beagon, 2022; Simpson et al., 2020). Internationally and within Australia, there is increasing pressure to move towards planning and building more climate-resilient housing, reflected in the development of bushfire, flood, and cyclone planning policies and guidelines within the different state jurisdictions. However, a disconnect remains between planning policy and building regulations and standards. The gold standard regulating bushfire-resilient housing in Australia is the Australian Standard for Building in Bushfire Prone Areas (Standards, 2018), initially instigated in 1991 through the development of *'Planning Conditions and Guidelines for Subdivisions'* by the Victorian Country Fire Authority.

The general timeline of pivotal events leading to improved standards in bushfire building methods is shown in Figure 2 below.

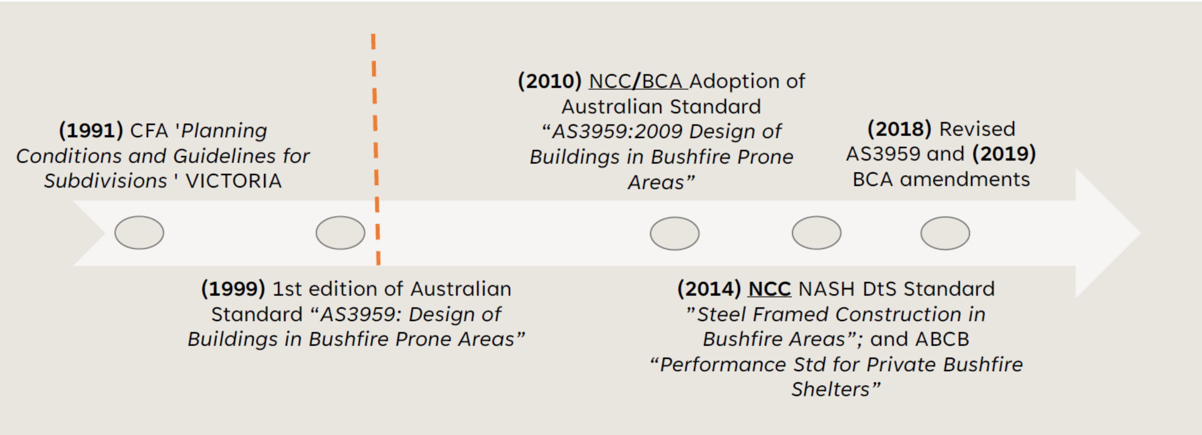

Figure 2: Timeline of the formal development of bushfire building standards in Australia (the dashed orange line indicates Year 2000).

The development of the Australian Standard has led to bushfire building standards formally adopted by the National Construction Code (NCC, 2022) and the Building Code of Australia (BCA, 2023). The NCC provides the core regulatory framework for all building construction in Australia. Even though AS3959 (Standards, 2018) was first developed in 1999, it was not entirely written into the National Construction Code until after its second edition in 2009. It was written into the 2010 Building Code of Australia after the tragic Black Saturday Bushfires in Victoria.

Results of a research study published in 2022 found that most of the damage to homes in a significant bushfire in the Blue Mountains NSW in 2013 occurred for those built pre-1990's. These homes suffered "*more than twice the level of impact*" as houses built post year 2000 (Price & Roberts, 2022). This study concluded that *"Houses built to standards imposed from 2000 onwards fared better than previous standards",* indicating a line in the sand about when bushfire building performance was significantly improved in Australia; it seems to sit somewhere around the turn of the millennium. The Price and Roberts study found that *"post-2000 houses assessed at Flame Zone level were vulnerable",* inferring that building practices can be improved to deal more effectively with "flame zone contact" from bushfires. This same study also found that most residences in bushfire-prone areas in the Blue Mountains were built to pre-date the AS3959 (Standards, 2018) regulations, meaning existing houses are unlikely to achieve the required bushfire protection levels. Whilst there is significant research into controlling the number of bushfires and their severity and reducing the impact on structures through fuel-free zones around buildings, there has been less investment in research and development into bushfire resilient building materials and systems (Hendawitharana et al., 2023).

9.3 Bottom-Up vs. Top-Down Bushfire Resilience Programs

In Australia, top-down bushfire resilience programs are primarily divided into those overseen by fire service agencies and disaster management authorities at all levels of government jurisdiction. The way that funding is allocated is based on regional statistics viewed through disaster resilience ratings such as the Australian Disaster Resilience Index (ADRI) (Parsons et al., 2016), as well as through direct need through government agencies such as the National Emergency Management Authority and the Australian Federal Government. Education-based programs are invariably based on the notion of disaster management as being a 'shared responsibility', a concept that is an essential pillar of the international Sendai Framework for disaster risk reduction.

A key local government program adopted by local governments across various parts of Australia, the 'Climate Wise Communities' (Cramp & Scott, 2019), aims to educate and inform residents about local community and personal risks and offers incentives to improve the resilience of homes. It has become more common for local councils to help facilitate bottom-up resilience programs amongst community members by promoting the formation of local area disaster management committees. However, since the Black Summer Bushfires, in some areas, such as Cobargo in Bega and Mallacoota in the Gippsland region[2], local community members have begun their bushfire resilience response (Lloyd & Hopkins, 2022; McDonough, 2022).

The validity of the growing interest in Indigenous-led cultural burning to reduce wildfire risk has been noted by various scholars both in Australia and in Europe (Atkinson & Montiel-Molina, 2023; Berkes et al., 2000; Folke, 2004; Tedim et al., 2016), and although not yet embraced by a top-down approach in government, already has found many advocates and

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[2] https://madrecovery.com/

community activists who have ensured it's practical uptake in various parts of Australia (Atkinson & Montiel-Molina, 2023; Freeman et al., 2021; Williamson, 2020).

9.4 Bushfire Risk Assessment Tools in Australia

The Australian Standard AS3959:2018 (Standards, 2018) *Construction of Buildings in Bushfire Prone Areas* provides the National metric for assessing the severity of bushfire risk – the BAL (bushfire attack level) rating. Calculating a building's BAL requires the following information for a property:

1. The Fire Danger Index (FDI) of the State/Region.
2. Classified Vegetation Type(s).
3. Distance of site from Classified Vegetation Type(s).
4. Effective slope under Vegetation Type(s) calculated in degree, ratio and percentage.

Slopes are further categorised as upslope, downslope, or a combination of upslope and downslope.

The assigned ratings are BAL-LOW, 12.5, 19, 29, 40, or FZ (Flame Zone), with increased BAL indicating a higher level of structural vulnerability. Once the BAL of a property has been measured, suitable construction regulations are applied to minimise the risks of ember attack and radiant heat exposure to the building. Figure 3 below illustrates the level of construction required for the BAL zones.

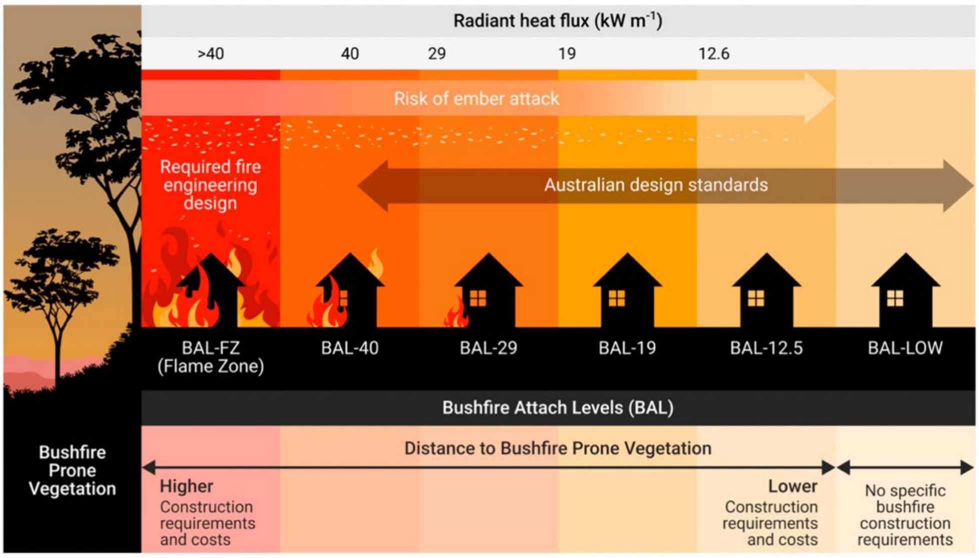

Figure 3: Visual representation of Bushfire Attack Level (BAL) assessments to frame the Australian Standards (Bowman & McCormack, 2023)

In addition to the BAL rating, more consumer-facing bushfire risk assessment tools have been developed to extend beyond identifying surrounding hazardous vegetation to encompass property maintenance, building construction, and disaster management risks. These tools are developed and continue to be updated by State fire service and government agencies, CSIRO (Commonwealth Scientific and Industrial Research Organisation)[3], local council initiatives such as 'Climate Wise Communities'[4], and independent organisations such as Resilient Building Council[5] (formerly Bushfire Building Council Australia). Using these tools to identify and eliminate multi-factor risks can reduce or mitigate the impact of bushfire damage to bushfire-prone properties.

9.4.1 Identifying Hazardous Vegetation

Hazard reduction burns are common practice and managed by State fire services. However, it is still important for people in bushfire-prone areas to identify the proximity of their property to what has been classified as hazardous vegetation. The CSIRO BAL Calculator uses the AS 3959-2018 to generate a high-level assessment and visualisation of the risk of hazardous vegetation in relation to topography around a property (Figures 4 and 5). The NSW Rural Fire Service also published a Vegetation Classification Chart with photographic examples of the hazardous vegetation classified by AS 3959 (Standards, 2018). These tools are a starting point for individuals to self-assess before a fire consultant is engaged to make a certifiable BAL assessment.

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[3] https://www.csiro.au/en/research/natural-disasters/bushfires

[4] https://climatewisecommunities.com.au/

[5] https://rbcouncil.org/resilience-ratings/

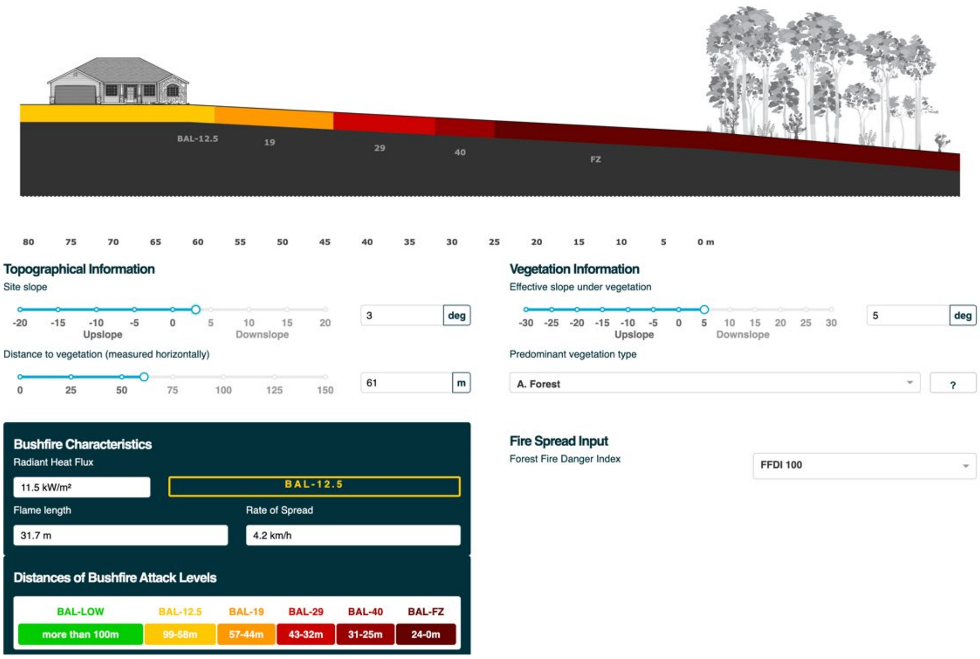


Fig. 4 - CSIRO Bushfire Attack Level Assessment Tool, accessed 2023 to demonstrate BAL 12.5.

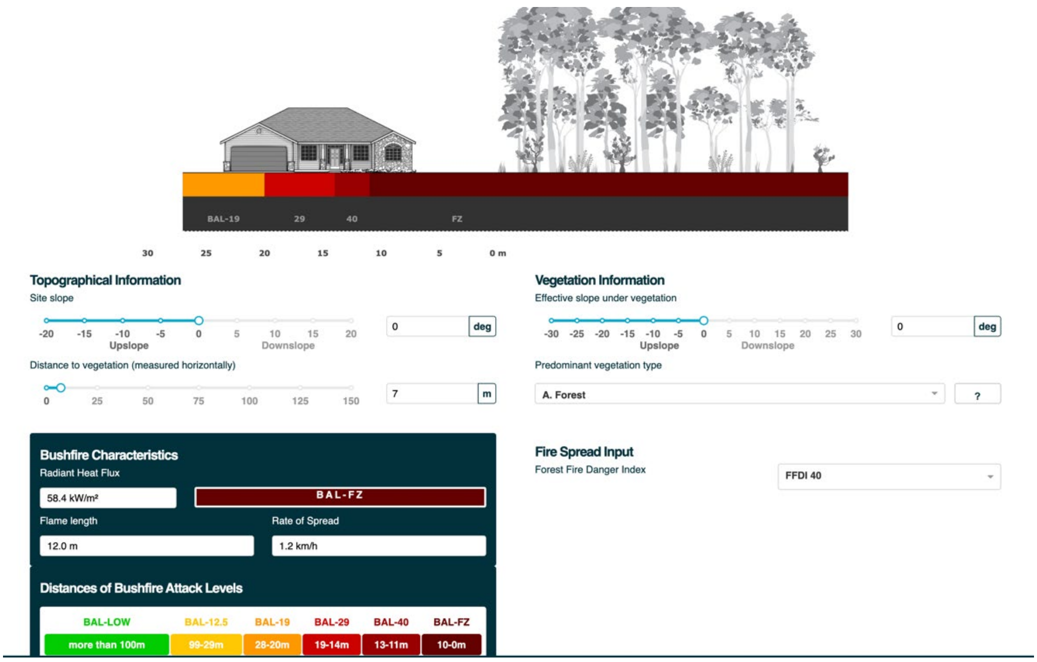


Figure 5: CSIRO Bushfire Attack Level Assessment Tool, accessed 2023 to demonstrate BAL -FZ.

The FDI for NSW Local Government Areas is published by the NSW Rural Fire Services[6] and available to the public. For example, the FDI for Bega Valley NSW is 100, and by being away from the vegetation, the BAL level is 12.5, as shown in Figure 4 above, requiring lower retrofitting adjustments (see *lower construction requirements and costs* in Figure 3 above). On the other hand, the FDI for Queensland is 40, as noted in the AS3959 Table 2.1 (Standards, 2018) (represented in Table 1 below) and also available for the public through road signs in the Summer season and can be accessed online[7]. This low value of FDI equates to a lower BAL of 12.5. However, the proximity of vegetation to residential properties could raise the BAL to its highest levels, as shown in Figure 5 above, requiring costly retrofitting measures.

Table 1: Representation of Table 2.1- Jurisdictional and Regional Values for FDI in AS3959 (Standards, 2018)

State/Region	FDI
Australian Capital Territory	100
New South Wales	
a) Greater Hunter, Greater Sydney, Illawarra/Shoalhaven, Far South Coast and Southern Ranges fire weather districts	100
b) NSW alpine areas	50
c) NSW general (excluding Greater Hunter, Greater Sydney, Illawarra/Shoalhaven, Far South Coast and Southern Ranges fire weather districts)	80
Northern Territory	40
Queensland	40
South Australia	80
Tasmania	50
Victoria	
a) Victoria alpine areas	50
b) Victoria general (excluding alpine areas)	100
Western Australia	80

[6] https://www.rfs.nsw.gov.au/site-search?query=FDI&collection=nsw-rfs

[7] https://research.csiro.au/bushfire/assessing-bushfire-hazards/hazard-identification/fire-danger-index/

9.4.2 Property maintenance

Property maintenance plays a significant role in hazard reduction for people residing in bushfire-prone areas. In rural and remote areas of Australia where bushfires are prevalent, the dominant housing type is the single detached dwelling, which comes with land to manage in addition to the dwelling. The AS3959 (Standards, 2018) does not address risks and compliance at the property scale. Therefore, the supplementary guidance can be accessed from State fire services. Table 2 below summarises the guidance reviewed to highlight the different house types addressed.

Table 2 - Summary of the hazards and recommendations for property maintenance in bushfire-prone areas.

Hazards	Flammable vegetation in and around the property Flammable vegetation debris Outdoor furniture Gas cylinders and valves
Recommendations	Maintain landscaping around the dwelling Unobstructed property access for firefighters Adequate water supply for firefighters, i.e., rainwater tanks, pool water and hose reels
References	“Planning For Bush Fire Protection”, NSW Rural Fire Service, 2019 Queensland Fire and Emergency Service "Guide for applying the Bush Fire Risk Treatment Standards” Department of Fire and Emergency Services (Western Australia), 2020 “Fire Ready Kit”, Country Victoria Authority, 2022

The NSW Rural Fire Service also identifies the need for an Asset Protection Zone (APZ), defined as “a buffer zone between a bushfire hazard and buildings”, which would need to be maintained to reduce and manage potential fuel loads during a bushfire. This approach is consistent with the majority of recommendations from State fire services to clear all possible fire loads and hazards around the dwelling of a property. Queensland Fire and Emergency Services (QFES) (Services, 2021) Tasmania Fire Service (TFS) (Service, 2023) and the Climate Wise Communities (Cramp & Scott, 2019) online assessment tools ask the question of “leave or defend” to scale the level of preparedness required during a bushfire. For people who elect to leave, having an evacuation plan, notifying emergency contacts and preparing a survival kit are essential in reducing risk. To defend, property owners will need to have adequate firefighting equipment as well as remove all possible fuel loads in and around the house as per the property maintenance guidelines identified.

A range of consumer-facing resources continue to be published to improve the resilience of both new and old housing stock in Australia against bushfire disasters. These resources adapt the AS3959 (Standards, 2018) building codes to provide more tailored information, visual diagrams and implementable actions for new housing stock and retrofitting older housing stock. The guidance for retrofitting varies from State to State as the dominant housing types vary. Table 3 below summarises the guidance reviewed to highlight the different house types addressed.

Table 3. Summary of retrofit toolkits and bushfire building guidance reviewed.

Retrofit Toolkit:	***Author/s, Year Published***	***Distribution Method***	***Intended Users***	***Disaster Types***	***House Types***	***State Of Origin:***
Minderoo Climate-resilient Housing Toolkit	(CRJO, 2020)	Online, hardcopy and community outreach	Local government regions and consumers	Bushfire	weatherboard, old brick veneer, metal clad, newer brick veneer and timber clad	NSW/ACT NATIONAL
Green Rebuilt Bushfire Retrofit toolkit	(Renew, 2020)	Online and community outreach	Consumers	Bushfire	New build fire-resilient house	NATIONAL
"Fortis House" model	(RBC, 2020)	Online and hardcopy	Consumers needing to rebuild because of bushfire property loss	Bushfire	New build fire-resilient house	NSW
"One House" model	(CRJO, 2020)	Unpublished	Consumers and insurers wishing to reduce multi-hazard risks	Multi-hazard	New build fire-resilient house	QLD
Bushfire Best Practice Guide	(CSIRO, 2020)	Online only	Consumers, building industry	Bushfire	Nonspecific	VIC, NATIONAL
Bushfire Resilient Building Guidance for	(Authority, 2020; CSIRO, 2020; Leonard et al., 2020)	Online and hardcopy	Consumers, building industry	Bushfire	Two-storey slab on ground house,	QLD, NATIONAL

Queensland Homes					raised house on a sloped site, Queenslander house, partly raised timber and slab-on-ground brick veneer house	
A guide to retrofit your home for better protection from a bushfire	(Authority, 2014)	Online and hardcopy	Consumers, building industry	Bushfire	Nonspecific	VIC, NATIONAL

The construction guidance for newly built housing, such as the 'Fortis House' model (RBC, 2020), includes construction details and material specifications in more depth than the retrofitting guidance, which is more generic to adapt to multiple housing types. People living in bushfire-prone areas can utilise these tools to self-assess and determine their level of risk, which will determine the level of retrofitting or protection required from bushfires. Although these tools are publicly available online, how they are promoted or distributed to at-risk communities needs to be further considered in evaluating the accessibility of the information they provide.

9.4.5 Usability of Assessment Tools

The Council of Australian Governments has identified the following key outcomes for community education around bushfire risks:

- Current information about disaster risk and mitigation, including relevant local knowledge tailored to different target audiences, is available on websites and in other forms.
- Strong networks across sectors and regions share information and build skills and understanding at all levels.
- Communities are supported through appropriately targeted training and awareness activities, including those that highlight volunteers' role in enhancing local capacity to mitigate and cope with disasters.
- Vulnerable individuals have equitable access to appropriate information, training, and opportunities.

- Compatibility of information-sharing technologies is promoted.

(Adapted from the National Strategy for Disaster Resilience (NEMC, 2011)).

It is essential to consider how vulnerable groups access information about bushfire risks and prevention guidance. The majority of bushfire guidance is available online, with further links to printable documents. However, there is also the need for adequate community outreach and engagement to distribute and promote this information.

9.5 Vulnerable Groups affected by bushfire damage

During major bushfire events, certain groups of people are considered more vulnerable due to age, health status, socioeconomic conditions, mobility limitations, communication barriers and access to resources (Governments, 2018). These vulnerabilities can impact the ability of vulnerable people to respond to and recover from bushfire events.

It is important to identify the risks and limitations of vulnerable groups to provide inclusive and targeted disaster-resilient strategies. The United Nations Office for Disaster Risk Reduction's (UNDRR) *Sendai Framework for Disaster Risk Reduction 2015–2030* (UNDRR, 2015) has identified culturally diverse, non-English-speaking communities and isolated rural communities" as being disproportionately affected during natural disasters. As such, engaging these vulnerable groups with disaster reduction planning efforts and access to educational resources is critical in building community resilience. Table 4 below summarises the key risk factors of vulnerable groups.

Table 4 - Summary of the key risk factors to vulnerable groups through a literature review of key disaster emergency policies.

Vulnerable Groups	Risk Factors	References
Older People over 65	Chronic illnesses Cognitive illnesses Physical disabilities Limited access to resources Technological barriers Access to care and support	"Older people in emergencies: Considerations for action and policy development" (Organisation, 2011) "Vulnerable people in emergencies policy" (Government, 2018) "UN 2013 global survey explains why so many people
People with Disabilities	Mobility limitations Cognitive limitations Limited access to care and support	

	Lack of emergency plan	living with disabilities die in disasters "(Reduction, 2013)
Isolated Rural Communities	Access to resources Limited evacuation routes	
Women	Gender bias Domestic violence Social inequity Financial disadvantages	"Understanding the experiences of women in disasters: lessons for emergency management planning" (Chowdhury et al., 2022) Sendai Framework for Disaster Risk Reduction (Reduction, 2015)
Culturally Diverse, Non-English-Speaking Communities	Language barriers Lack of familiarity with the local environment Access to resources	

In Australia, one in six people are over 65 (Statistics, 2020), which aligns with the average global trend of an ageing population. Further, 34% of Australians over 65 live in rural and remote areas, defined as all areas outside of Major Cities (Statistics, 2012), with a higher risk of bushfire exposure. Older Australians also have more compounding risks that may impact their ability to retrofit their homes and maintain their properties for disaster resilience.

9.6 Research Methodology

The above section discussed the challenges vulnerable homeowners face regarding retrofitting decisions in fire-prone areas. This research proposes a tailored bushfire retrofit assessment methodology addressing the multifaceted concerns encompassing the personal heritage, accessible design, building, construction and landscape aspects. The research design adopted the embedded multiple case study design following the replication logic (Yin, 2017). This research design approach allows the use of multiple data sources to enable the researchers to cross-reference multiple interpretations and produce a reliable understanding of the phenomenon under investigation (Creswell & Poth, 2018). The data collection methods included: (1) insightful focus group interactions with homeowners within New South Wales (NSW) and Queensland (QLD) local government areas (LGAs), (2) site visits to homeowners who are seeking to enhance the bushfire resilience of their homes, (3) conducting interviews with homeowners to gather their insights about retrofitting options, and (4) follow-up site visits and interviews with homeowners to discuss the tailored bushfire assessment and retrofitting measures. These site visits aim to obtain a holistic comprehension of the prevailing conditions of the visited properties to propose a prioritised list of retrofit measures against bushfire hazards, establishing a foundation for informed decision-making and proactive protection. Figure 6 below illustrates the data collection process.

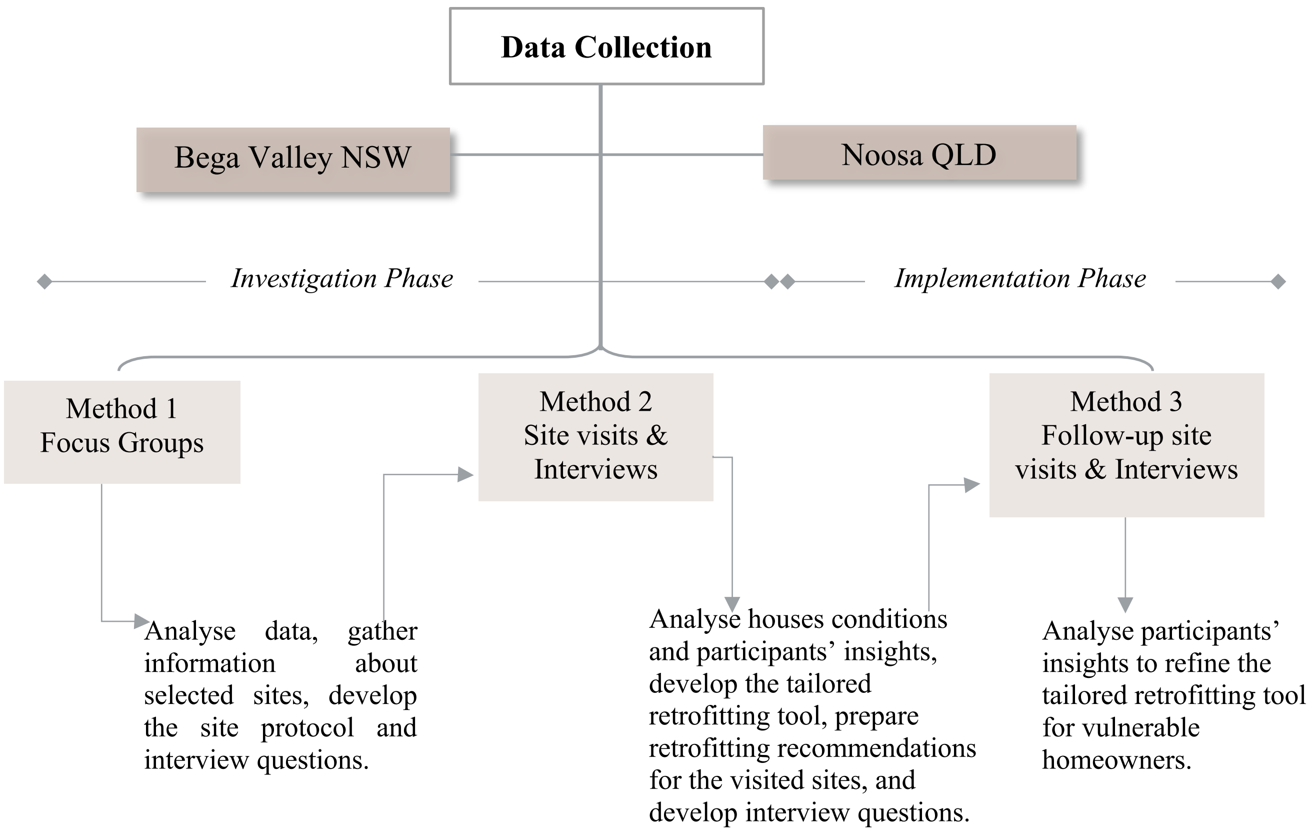


Figure 6: Data collection methods and process

Focus groups are commonly used to achieve predefined goals, such as evaluating community needs, devising policy strategies, or assessing consumer reactions to products (Stewart & Shamdasani, 2015). Focus groups investigate group dynamics influencing individual perceptions and decisions while postulating that group interactions generate richer information than individual interviews (Kamberelis & Dimitriadis, 2013). The research utilised two focus group workshops with residents over 55 in Bega and Noosa LGAs to understand local perspectives on climate resilience retrofitting, educate on available bushfire risk assessment resources, and build community relationships. These workshops also enabled ongoing engagement with participants as case studies for implementing the field study to develop the tailored bushfire retrofit assessment toolkit. Three homeowners from each focus group agreed to have their property assessed by the researchers.

Site visits adopted the structured observation approach that uses operational quantifiable dimensions to gather information about the unit of study (Mack, 2005). After reviewing the toolkit shown in Table 3, a site data collection protocol was developed, including nine sections covering property details, roof and walls, windows and doors, subfloor, external features, outdoor area, garage, storage, and garden. Each section had a table listing the features, types, house condition and existing gaps, and a page of reference photos to facilitate documentation. For example, pictures of the roof types commonly used in Australia are attached to the roof section. The protocol aims to help researchers capture the house condition, construction materials and any hazardous vegetation around the property during the site visits. Interviews with the case study participants included four semi-structured open-ended questions to get insights about retrofitting, personal heritage, and disaster management. The interviews were conducted using a standard procedure (Patton, 2002) to facilitate interviewing different participants more systematically. The focus groups, site visits and interviews represent the research investigation phase. The next phase is the implementation phase, which will be conducted after the data analysis. The aim of the implementation phase is to (1) discuss with participants the retrofitting recommendations, (2) gather their insights on the usefulness of our tailored retrofitting guides, and (3) discuss future retrofitting plans. A more detailed discussion about the components of the tailored bushfire retrofit assessment toolkit is provided in the subsequent sections.

9.6.1 Personal Heritage Considerations

The fabric of people's homes and possessions embodies their personal heritage and identity, as well as that of their families. Fire can massively damage this heritage, either directly through burning or indirectly by depositing layers of soot that carry visual and olfactory reminders of the trauma of fire, which can trigger both physical illness and psychological trauma (Harms et al., 2021). Material possessions and environments trigger and support the recall of stories and memories, underpin the sharing of family and cultural practices such as cooking, faith-based practices and celebrations. They facilitate the creation of links between generations through the use of handed-down family implements and the identification of intergenerational traits and talents (Woodham et al., 2017). This means that tangible, material heritage, as well as being significant for individuals and families, is also crucial to retrieving and perpetuating their intangible heritage. This means that when tangible material heritage is affected by fire, the intangible aspects of personal and family heritage also suffer damage and loss.

Older people, particularly women, tend to fill the role of guardians of the past, often not just for themselves but for their extended families. Therefore, one home in a bushfire-prone area can be the storehouse for the personal heritage of a much wider group living in distributed localities. While some older people recognise this keeping role, others have not clearly articulated the importance of personal heritage to themselves and their families or thought through the range of items that constitute their personal "archives" (Woodham et al., 2017). Personal heritage items that are not used regularly can also be stored in "out of the way" places that are not well protected from fire and smoke.

Research compiled by Edge consultants during the development of the first iteration of the CRJO toolkit suggested that older Australians can be reluctant to invest in retrofitting their homes for bushfire resilience. Attitudes observed in the research included people assuming that their property is already sufficiently protected from fire, that the government will protect them, and that if anything should happen, they will be protected by their insurance (CRJO, 2020). Recent events, however, have shown that most properties in fire-prone areas were not adequately protected and that the government of the day was ill-prepared to protect citizens in fire-prone areas. Insurance, for those who had it, did provide money to clean and rebuild homes, but in the aftermath of the 2019 fires, insurance has become vastly more costly and, in some fire-prone locations, unobtainable. Current insurance and building practices are also founded on the assumption that the material environment can be relatively easily replaced, if not by exact replicas of the past at least by analogues that are functionally as good, if not better. However, this ignores the importance of the past to well-being and the sense of alienation and defeat that can be caused by the loss of both significant individual items and the overall ambience of an environment that has been built, grown and curated, often over decades, to express in tangible form the preferences, needs and beliefs of the occupants of that environment (Miller et al., 1998). Merely replacing affected material with new fabric does not erase the impact of loss. In fact, it may erase the things that can help people come to terms with their loss (Kousa & Pottgiesser, 2020). This means that preventing damage to personal heritage is a vital part of maintaining personal and family resilience and through that, maintaining the capacity for people to be part of wider community resilience activities and processes. This research is therefore exploring the potential of personal heritage to provide older Australians with stronger motivation to undertake retrofitting on their homes, as it is a component of their lives that has a profound impact on the well-being of themselves and their families, and the impersonal structures of insurance-based repair and replacement cannot readily replace it.

9.6.2 Accessible Design Home Modifications

The majority of older housing stock in Australia has not been designed with any consideration to measures of accessibility and universal design principles (Carnemolla, 2012). Although bushfires disproportionately impact older people and people with disabilities, current guidance on bushfire-resilient retrofitting is not tailored to the liveability considerations and capabilities of older people and people with physical disabilities.

In Australia, new principles for universal housing design are being introduced by the National Construction Code in the Liveable Housing Design Standard (LHDS). These design standards state that a universally designed house should "be easy to enter, be easy to move in and around, be capable of easy and cost-effective adaptation; and be designed to anticipate and respond to the changing needs of home occupants." (National Dialogue on Universal Housing Design, 2010). Although these standards only apply to new housing and have not been adopted by all States, they provide a clear framework for inclusive housing design and retrofitting.

Key standards in the LHDS include step-free entry access, corridor clearances of 820mm, and modifications for accessible bathrooms. These standards ensure the ease of mobility around the house for older people, which can impact their movements during evacuation from emergencies. Home modifications that prolong the time older people can live in their homes and age in place can increase their sense of well-being and improve their Health-Related Quality of Life (Carnemolla & Bridge, 2016). Being able to maintain a sense of independence as well as remain in their communities to access local support will likely contribute to the resilience of older people in bushfire-prone areas, though more evidential research is needed on this. There is potential to integrate home modifications for accessibility with retrofit recommendations for bushfire resilience for a more tailored approach for older people and people with physical disabilities.

9.6.3 Building, Construction and Landscape

The single dwelling Australian homes are generally one or two-storey timber or steel frame houses with typical external wall cladding brick veneer, timber weatherboard, or fibre cement cladding, and roof cladding is either concrete or terracotta tiles or corrugated metal roof sheets (NCC, 2022) (see Figure 7 below for external wall and roof cladding types). Window frames are timber or light aluminium, often accommodating single glass panes as thin as 3 mm, upgraded recently to a thicker glass pane of 5 mm and double-glazed configurations to provide better protection against sunlight and heat (Bowditch et al., 2006). Costin (2021) mapped other common features of Australian homes, such as the raised floor structures enclosing the subfloor area with a vented short brick wall to allow for ventilation either partially screened with timber battens or left entirely open. The veranda is often a timber or steel-framed deck with timber or polymer flooring. Other features related to the external cladding are the 450-600 mm wide eaves and more recent 'eave-less' designs, timber or light steel fascia, eave soffits are usually cement-sheet lined or timber-ventilated, and galvanised or pre-painted steel gutters leading to above or below-ground water tanks.

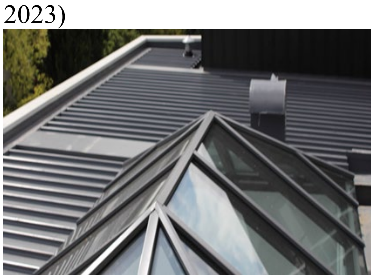
a) Brick veneer house
Image source: (Domain, 2023)

b) Timber weatherboard house
Image source: (Realestate, 2023)

6c) Fibre cement house
Image source: (WareHouse, 2023)

d) Concrete roof tiles
Image source: (Supplies, 2023)

e) Terracotta roof tiles
Image source: (Supplies, 2023)



f) Corrugated metal roof sheets
Image source: (Roofing, 2023)

Figure 7: Examples of typical external wall and roof cladding materials used in Australian houses

The building envelope type plays an important role in preventing ember and smoke incursion in fire-prone areas. Several studies highlighted that the ember attack significantly impacted homes lost in bushfires and sadly led to the loss of lives (Costin, 2021; Shahparvari et al., 2019; Ullah et al., 2021; Whittaker et al., 2020). In high winds, ember penetration can affect houses even before fire flames arrive (Honey & Rollo, 2011). While research mentioned that ember penetration into urban areas is harmful at a distance of 700 m from the fire flames, the 2003 Canberra fire records show that houses located 2 km away were severely affected by fire-generated wind even before the flame arrived (Ghaderi et al., 2020). However, other studies argue that the ember attack alone cannot be held accountable for the damaged houses based on observations of undamaged houses adjacent to those secured from the attack (Honey & Rollo, 2011). Ghaderi et al. (2020) and Honey and Rollo (2011) research show bushfires create weather phenomena, like fire tornadoes, and the presence of structures influences fire intensity and dynamics, which reshapes fire behaviour from steady heat to dynamic pulsations, uplifting vortices, and extreme airflows. As such, Costin et al. (2021) and Roberts et al. (2017) argue that AS3959 (Standards, 2018) lacks comprehensive provisions for safeguarding houses against ember ingress during wind-driven fire events. For instance, the metal sheet roof cladding in older homes is frequently nailed rather than screwed, and newer homes often use pop rivets for capping and flashings instead of screws (Costin, 2021). Even if sheeting or capping remains intact, gaps might form at sheet ends and overlap, allowing embers to enter (Costin, 2021; Honey & Rollo, 2011). These authors recommend (1) filling gaps between flashings and corrugating with non-combustible materials like rock wool and (2) fastening tile roofs mechanically, as they are commonly minimally secured or not tied down in areas with low wind.

Similarly, the external wall cladding in older homes with no sarking might have gaps in weatherboard overlaps, eave-to-wall junctions, and wall corners. These areas can be vulnerable to ember ingress due to upward ember movement (Honey & Rollo, 2011). The AS3959 (Standards, 2018) requires the subfloor areas to be shielded by steel mesh and close-fitting battens, gaps or cracks in brick walls should be filled, and the junction between walls and main wall cladding should be inspected. Fascia, eave, and guttering areas are vulnerable to ember attack due to wind angles of 45-60 degrees from horizontal (Honey & Rollo, 2011). Typically, soffits are non-combustible cement sheets, and gutters are galvanised or painted steel. In high heat, steel might bend, leading soffit sheets to detach from the roof, creating gaps for embers ingress (Honey & Rollo, 2011). The AS3959:201 (Standards, 2018) advocates using shutters or screens for windows and doors, however, the small gaps allowed in door frames for movement should be sealed with high-temperature-resistant seals as the standard rubber seals are insufficient (Costin, 2021). Although the above discussed retrofit recommendations are considered extra measures based on studies conducted after the Black Summer bushfire, applying these retrofitting options remains challenging due to the homeowner's willingness and financial capability.

Utilising the multiple case study approach (Yin, 2017), this research has the potential to explore the current conditions of specific types of houses and properties of older people living in bushfire-prone areas in Bega and Noosa, aiming to investigate the external cladding conditions and landscape surrounding the properties. As explained in the above sections, the type and proximity of the vegetation around houses are key factors in identifying the BAL and the required retrofitting measures. Therefore, building construction and landscape are assessed under the provision of the BAL (bushfire attack level) assessment guidelines in AS3959:2018 Construction of buildings in bushfire-prone areas (Standards, 2018). That is, each site will be assessed in terms of the surrounding effective slope, native vegetation, building materials and construction features using multiple types of data, including (1) a property assessment protocol capturing the house design, building materials, and surrounding landscape, (2) collecting photos of the property to capture the condition and access route in and out of the property, and (3) conducting a 30 min semi-structured interview with homeowners to further elaborate on perceptions towards retrofitting plans, personal heritage and engagement with their local community.

9.7 Conclusions

The frequency and intensity of mega fires and bushfires are increasing globally. Australia is very vulnerable to bushfires. Various changes have been instigated to increase resilience to bushfire, from management of bushfire responses at state and local levels to the development of bushfire toolkits for homeowners to improve the resilience of their property. This chapter has explored and proposed the development of a retrofit toolkit to increase bushfire resilience and proposed a bushfire retrofit assessment toolkit tailored for older Australians as they represent 16.6% of the population, a percentage which is increasing. Older Australians have a higher vulnerability compared to younger people. Their physical and mental health may differ, and their economic circumstances may be fixed and access to technology may be lower than others. Two case study regions, Bega Valley Shire in New South Wales, and Noosa Shire in

Queensland were used to assess the suitability of available bushfire retrofit guidance to be adapted and implemented by vulnerable people in bushfire prone areas.

Existing toolkits offer a set of resources to improve and inform decision-making. Residents need to consider what to protect and how to protect it. For example, the cost and protection of personal heritage within homes is important. Personal heritage has high personal value and can be hard to put an economic value on. The form of personal heritage is very variable in terms of size and scale, flammability and so on. ~~Cost and protection of personal heritage are important factors~~. Different housing typologies, for example, brick construction compared to timber construction have different responses to heat and fire. Furthermore, the age of the construction of the buildings reflects different standards in fire protection, which are increasing over time.

The top-down and bottom-up approaches in the management of bushfire resilience programs highlights the different approaches and their respective strengths and weaknesses. The main strengths of national programs is the level of support provided and adherence to national standards, whereas the local programs tend to be more personalised to that community and location and have higher community engagement. Significantly, indigenous led cultural burning is gaining traction in the bottom-up scale of management. Existing bushfire risk assessment tools are described and the ways they increase protection and reduce risk. Existing State level property maintenance recommendations take into account local housing typologies and, highlight the target audience, and different disaster types, and different formats for distribution.

A weakness for some people is that most materials are distributed online which may not be easily accessible to older people or those who have English as a second or third language. Furthermore many toolkits are not targeted at minority groups. Accessibility is more important for older people and bushfire impacts mobility impaired people more than others. New housing adopts the latest standards; however, many existing houses are less suited for access and retrofit is desirable.

The chapter concluded with a critical review of the typical specifications for housing in Australia, the standards, materials and construction methods adopted. Importantly, in bushfire evaluation the surrounding landscape needs to be considered, as presence of flammable materials in external areas will increase fire danger. The variety of materials and methods that are used over time, plus the adaptations and alterations undertaken by owners make bushfire retrofit a challenging and multifaceted decision. Rarely are two houses the same in respect of fire protection and vulnerability, in addition the physical and mental health of the occupants impacts their safety. Whilst current standards reflect best practice constant re-evaluation is needed as the climate changes.

The methodology adopted for the development of the toolkit for older Australians focusses on a minority group who are vulnerable. The research design involves focus group workshops and site visits and interviews to gain a deep understanding of their situations and the form a toolkit would need to take to meet their specific needs. Existing toolkits are designed for the general public not a minority group.

The political and practical implications are that, at State and Federal level elections occur every few years and groups with different political views may come to power. Consequently, the amount of funds attached to programmes and the support for them can vary. The quality and impact of the toolkits will improve over time as practical guidance becomes more available for more targeted and informed decision making. The increasing incidence of these destructive climate induced fire events makes this work essential.

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