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Guidelines for good practices for human protection

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Wildland-Urban Interface Fire Touristic Infrastructure Protection Solutions - Guidelines for good practices for human protection

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Lund 2024

Report 3262

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Wildland-Urban Interface Fire Touristic Infrastructure Protection Solutions

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Table of Contents

Introduction 8
1. Understanding tourist behaviour 11
1.1. Response to Wildfire: Evacuation and Shelter-in-Place 11
1.2. Literature review 12
1.3. Characterization of the population 15
1.3.1. Property attachment 16
1.3.2. Past experience and preparedness 16
1.3.3. Safety culture 17
1.3.4. Risk perception 17
1.3.5. Socio-demographic factors 17
1.3.6. Group dynamics 19
1.3.7. Interaction with authorities 19
1.3.8. Place of residence and length of stay 19
1.3.9. Transportation mode 20
1.3.10. Information 20
Final remarks with regards to reviewed human characteristics 23
2. Empirical data collection 24
2.1. Interviews with stakeholders 24
2.1.1. Methods & sample 25
2.1.2. Sampling procedure and study participants 25
2.1.3. Data collection 25
2.1.4. Qualitative data analysis 26
2.2. Results 27
2.2.1. Lack of knowledge 29
2.2.2. Physical vulnerability 29
2.2.3. Discrepant tourist expectations 29
Final remarks with regards to stakeholder interviews 30
3. Archetypes of tourist behaviour 31
Final remarks with regards to tourist archetypes 33
4. Tourist population vulnerability assessment tool – TOURSAFE 34
4.1. Purpose of the tool 34
4.2. Tool development and testing of TOURSAFE 35
Wildfire frequency 37

Peak wildfire season and tourism 37
Communication 37
a. Language 37
b. Channels 37
c. Functionality 37
d. Communication type 37
Tourist and resident types 37
Transportation & assembly 37
Human vulnerability 37
Reaching remote populations 37
Financially inclusive emergency planning 37
Challenges and opportunities 37
Final remarks with regards to the vulnerability assessment tool 38
5. Guidelines for good practices for human protection 39
5.1. Wildfire frequency 39
5.2. Peak wildfire season and tourism 40
5.3. Communication language 40
5.4. Communication channels 41
5.5. Functionality of communications 41
5.6. Communication type 43
5.7. Tourist and resident types 45
5.8. Evacuation and shelter-in-place strategy 45
5.9. Transportation & assembly 46
5.10. Human vulnerability 47
5.11. Reaching remote populations 48
5.12. Financially inclusive emergency planning 48
5.13. Challenges and opportunities 48
6. Acknowledgements 51
References 52
Appendix 58
I. Human vulnerability assessment questionnaire 58
II. Tool testing – case study 65
III. Human vulnerability assessment tool 72

Introduction

Wildfires pose a serious threat to populations in the wildland-urban interface (WUI), where vegetation and urbanized populated areas intersect (Benichou et al., 2021). Such wildfire emergencies are particularly dangerous to populations who are not experienced, prepared or aware of the necessary protective actions. One such group of populations are tourists. Emergency managers and incident commanders/controllers should carefully consider different strategies in case a wildfire approaches a populated area. To do so, it is important to consider the behaviour of people when deciding the most suitable emergency strategies, as they can include wait-and-see, stay-and-defend, shelter-in-place, and leave early (Cova et al., 2009; Strahan, 2020). Fundamentally, the effectiveness of evacuation plans hinges on understanding human decision-making processes in such situations (Paveglio et al., 2015).

To better understand human behaviour and decision making in wildfire emergencies, several behavioural models are usually considered: protective action decision model (Lindell & Perry, 2012), affiliation model (Sime, 1983), behavioural sequence model (Canter et al., 1980), among others. Each of the models propose a simplification of human behaviour that can be adapted to fire emergencies and evacuation and subsequently studied in greater detail, which allows to simulate these behaviours in an evacuation modelling environment. For broader scale problems that aim to not discount elements of people's environment but consider them holistically. Accounting for a mixture of behavioural models' principles may allow for a more realistic, everyday life-like scenarios of human behaviour. This includes thinking about the typical routines and behaviours of residents, tourists, and their different types individually and in groups.

To simplify and adapt these conceptual behavioural models in a way that could be useful for evacuation modelling and would reflect realistic behaviours, a set of archetypes can be developed (Strahan et al. 2018). The use of archetypes in WUI modelling could be explained drawing parallels to performance-based design. In conventional building design, performance-based design offers a methodical approach to ensuring safety by quantifying and comparing specific parameters such as Available Safe Escape Time (ASET) and Required Safe Escape Time (RSET). While building codes are sets of regulations and standards established by authorities to ensure minimum safety requirements for buildings, these codes outline specific, prescriptive measures that must be followed during the design, construction, and operation of buildings. Compliance with building codes involves adhering strictly to these predetermined rules and guidelines. For instance, a building code might specify the minimum number and size of exits, the materials allowed for construction, and the fire resistance rating of structural elements. In contrast, performance-based design focuses on achieving desired safety outcomes by evaluating the performance of a building under various

scenarios rather than simply meeting predefined criteria. This approach involves assessing how a building will function in real-world conditions, considering factors such as occupant behaviour, fire dynamics, and evacuation strategies. Performance-based design utilizes advanced simulation tools and analyses to predict the behaviour of fire and smoke, the effectiveness of evacuation routes, and the overall safety of occupants. Instead of strictly adhering to prescriptive rules, performance-based design allows for flexibility and innovation in meeting safety objectives.

WUI wildfire and evacuation simulations are a type of performance-based design at its core. However, in the case of WUI wildfires, the complexities are heightened, including larger affected areas, multiple fire fronts, and unpredictable environmental conditions. In addition, spatial and temporal areas of interest are not as clearly defined as they would be in a building evacuation simulation, meaning it is challenging to define where and when the simulated scenario starts and ends. Here, the performance-based design concept becomes even more indispensable. Therefore, archetypes are categorisations of human characteristics in relation to their behaviour that help understand the effects on WUI evacuation efficiency, helping to determine whether Wildfire Available Safe Egress Time (WASET) is sufficient in relation to Wildfire Required Safe Egress Time (WRSET) (Ronchi et al., 2017; Vacca et al., 2020). See Figure 1 for illustration of both the elements and the complexity that wildfire evacuations present in comparison to buildings.

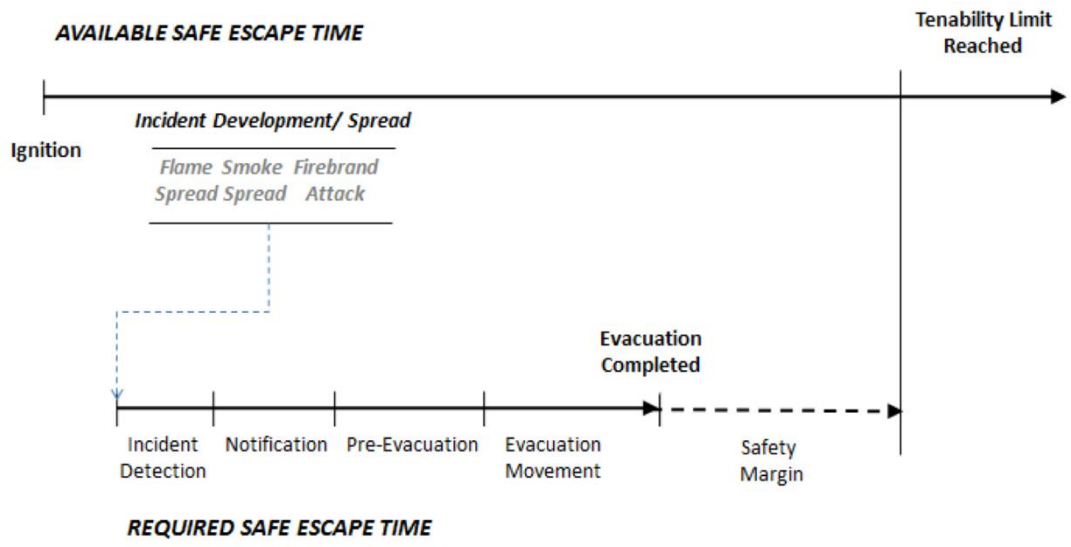

Figure 1 WASET/WRSET as proposed by Ronchi et al. (2017).

Evacuation or other strategies can improve response in wildfires (reducing the WRSET or improving shelter-in-place strategies) if at-risk populations engage in training and education around evacuation or shelter-in-place. This may be common among residents

in the area where wildfires are a considerable risk. However, certain populations such as tourists and other transient people may miss out on local preparedness opportunities. In turn, tourist and transient populations may lack knowledge of the risks associated with fires and the appropriate protective actions to be taken (Drabek, 1995). Cross-border regions are often characterized by a mix of different cultures, languages, infrastructure, and emergency strategies, creating a challenging environment from the wildfire safety perspective. Tourists may come from areas that are not wildfire-prone, thus meaning that they are potentially exposed to a risk they are not familiar with. As tourist areas present a unique challenge from the evacuation planning standpoint, it is therefore necessary to investigate the specific vulnerability of tourists in wildfire scenarios, identifying human characteristics (or factors, used interchangeably in this report) that play a role in decision making of individuals and could be seen as an opportunity for disaster managers to recognize and take action that mitigates such vulnerabilities, therefore making the evacuation procedure more controlled and disaster managers more in control.
To achieve this, there is an urgent need for tools that would help to better safeguard the populations with considerable numbers of tourists in cross-border areas affected by wildland fires.

This report presents the process of the development of such a tool, which includes:

- **Review of the literature** that describes human behaviour and derives a list of human characteristics that play a role in decision making in wildfire emergencies (1. Understanding human behaviour).
- **Collection of qualitative data** using interviews with stakeholders, documenting their perspectives of human vulnerability in touristic areas based on their experience in the field of wildfire safety (2. Empirical data collection).
- **Adaptation of the archetype models** to tourist behaviour based on literature reviews and interviews to illustrate how different tourist populations may behave in wildfire emergencies (3. Archetypes of tourist behaviour).
- **Development of the tourist population vulnerability assessment tool** based on the review of the human characteristics and decision-making outputs from evacuation modelling results (4. Tourist population vulnerability assessment tool).
- **Good practice guidelines for safeguarding populations** with considerable number of tourists in cross-border areas at risk of wildfires (5. Guidelines for good practices for human protection).

1. Understanding tourist behaviour

Serious wildfires have occurred in tourist destinations worldwide, indicating that tourists may encounter numerous difficulties when confronted with such events, potentially rendering them a vulnerable demographic in such situations. Notable examples are the 2016 Madeira fire in Portugal (Ronchi et al., 2017), the 2023 Maui Fire (USA) (Gupta, 2023) and the 2023 Rhodes Fire (Greece) (Bubola & Kitsantonis, 2023). These events have shown that tourists are reporting fear, lack of knowledge of evacuation or shelter-in-place procedures, lack of access to information about protective actions and often suffer from injuries. In some cases, where multiple hazards are present, reluctance to use alerting systems to draw attention was reported (Gupta, 2023). The anecdotal evidence therefore highlights the need for a clear connection between hazard, communication its channels and types and protective action to be established (Kuligowski et al., 2023; Doermann et al., 2021).

Two dedicated reports covering the details of the past large outdoor fires have explored several wildfires involving tourist populations (Ronchi et al., 2021; Wang et al., 2022). A collection of accounts from past wildfires (including data sourced from official and non-official sources) offers an insight into the complexity of emergency management operations in retrospect and illustrate, in some cases, how the behaviour of local populations and tourists may not be heterogenous or at least represent different motivations. For example, in Mati, Greece 2018 wildfire instance, both tourists unfamiliar with the area and local residents sought refuge along the coastline to escape the blaze. Other examples show that strategies for tourists differ to the strategies for residents' protective action. In Cadiz, Spain in 2016, hotels were evacuated while local people were confined / sheltered-in-place.

To better understand how to make touristic cross-border WUI areas safer for tourist and local populations, an in-depth analysis of human characteristics and their role in wildfire emergency decision making is needed. In this chapter, a process for such investigation is presented, including: an overview of the response to wildfire, a literature review of human characteristics in decision making, and operationalization of the characteristics for WUI modelling.

1.1. Response to Wildfire: Evacuation and Shelter-in-Place

There are several choices that people can make in response to wildfire, namely wait-and-see, stay-and-defend, shelter-in-place, and leave early (Cova et al., 2009; Strahan, 2020). For the work presented in this report we focus on two of these choices: evacuation and shelter-in-place, as in the context of tourist populations we assume prevailing lack of readiness for the event. This means that both stay-and-defend and

leave early options would not be chosen often, as they require knowledge and readiness for a wildfire event, which would be more typically available to the residents.

While guidelines in wildfire-prone areas may advise authorities on when to notify communities to evacuate, breakdowns in communication or a different preferred policy in different regions in Europe and across the globe might require individuals making that call themselves or prefer to shelter-in-place. When people are left to make their own decision without the authorities' intervention, the decision to evacuate or remain in place can stem from diverse factors. Based on existing literature, a common motive appears to be the desire to make the best choice, which can also be influenced by economic considerations such as the financial ability to evacuate and sustain absence, as well as concerns for family safety, personal survival, and property protection. Thus, exploring deeper internal motivations is necessary to fully understand human decision-making in wildfire situations. Such knowledge can help intervene and support people in emergencies in a way that is effective.

1.2. Literature review

The study utilized the Preferred Reporting Items for Systematic reviews and Meta-Analysis extension for Scoping Reviews (PRISMA-ScR) method, employing a structured checklist and workflow to ensure a systematic and comprehensive scoping review of the literature. The flowchart of the process of PRISMA-ScR performed in this work can be seen in Figure 2.

Different search terms were used to find relevant papers in two databases. Initially, a set of keywords such as 'wildfire,' 'bushfire,' 'forest fire,' 'campfire,' 'brush fire,' 'tourist*,' and 'evacuation' was employed. Then, additional keywords like 'transient', 'decision-making', 'behavior', and 'behaviour' were added to narrow down the search. Duplicate papers were eliminated during the identification stage without screening. The screening stage comprised three steps.

First, four inclusion criteria were used to screen the titles and abstracts of papers. Papers progressed to the next stage if they met one or more of the following criteria:

1) offering insights into tourists' behaviour during emergencies.
2) providing insights into human behaviour in wildfires.
3) discussing disaster communication or management.
4) addressing archetypes in the context of wildfires.

Second, the remaining records underwent full-text assessment, and papers were excluded based on the following criteria:

1) lack of an English full text.
2) exclusive focus on modelling.

3) review articles that did not offer significant insights applicable to areas with tourists.

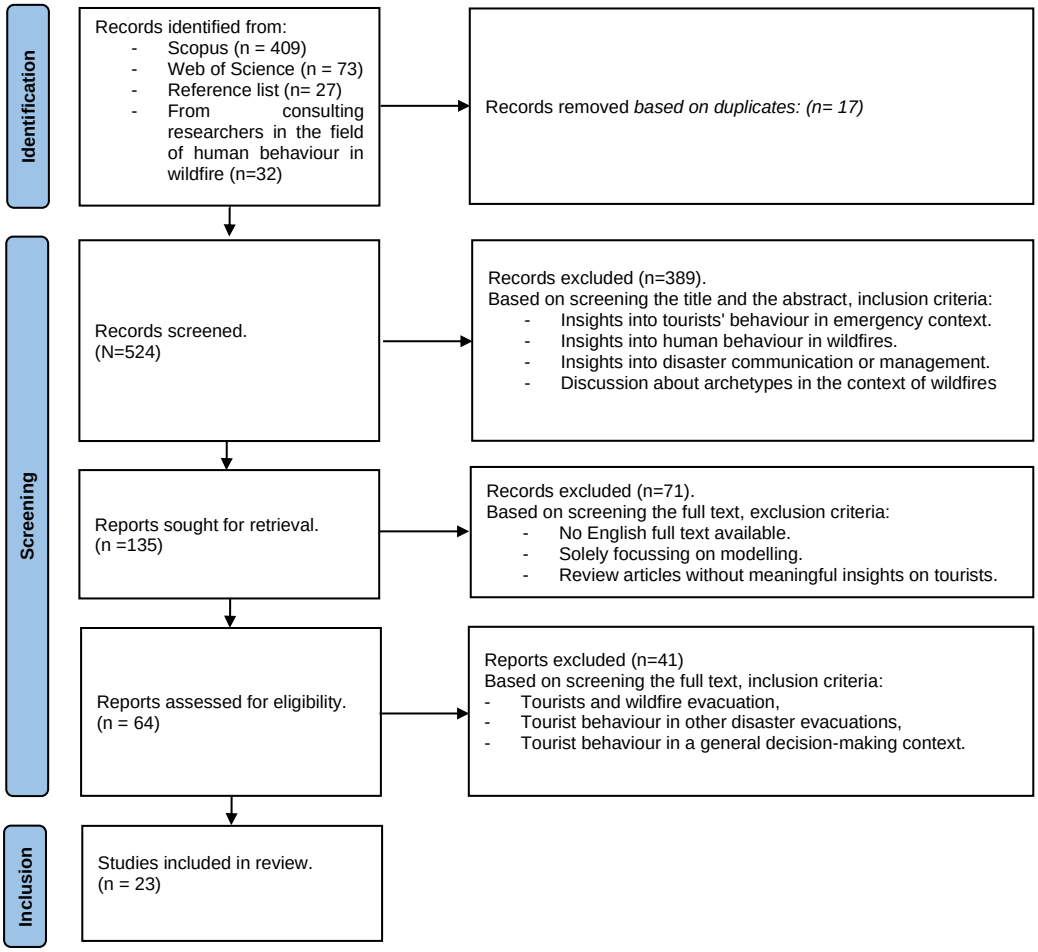

Figure 2 PRISMA scoping review flow chart, including the steps of identification, screening and final inclusion based on exclusion/inclusion criteria. Source: Labhiri et al., 2024.

In the third step, papers were considered relevant if their content continued to match any of the following categories:

1) wildfire evacuation involving tourists.
2) tourist behaviour in evacuations related to other hazards.
3) human behaviour in wildfires.
4) tourist behaviour in general decision-making contexts unrelated to emergencies.

The scoping review involved searches in two prominent scientific literature databases, Scopus, and Web of Science, chosen for their reputation as primary sources of credible information in the field being investigated. Due to the scarcity of papers specifically addressing tourist evacuation behaviour during wildfires, additional papers were included that focused on either general evacuation behaviour (outside of emergency conditions) or tourist evacuation behaviour in other types of disasters. Moreover, a

collection of papers was identified by reviewing the reference lists of the initially selected papers.

During screening, citations within selected papers were also examined using a snowball approach. They were deemed relevant if they met the previously mentioned inclusion criteria. Relevant citations were then cross-referenced to avoid duplication. Main findings from selected sources were extracted using a dedicated review template (refer to Table 1), ensuring consistent and thorough data extraction. The template comprised twenty-five questions outlining criteria for information extraction, ensuring systematic storage of data and a standardized review process.

Table 1 The review template adopted to extract information related to tourist evacuation behaviour from the selected papers. Source: Labhiri et al., 2024.

1- Author(s)
2- Year
3- Title
4- Short description
5- Type of paper
6- Method of data collection
7- Method of data analysis
8- IF Data paper, type of data
9- IF Data paper, is data available openly / upon request?
10- IF Data paper, sample size
11- Country(ies) of study and/or region
12- Is the area of study prone to wildfires?
13- Does the peak wildfire season coincide with the peak tourism season?
14- Is the area investing in wildfire resilience*?
15- Is the study area explicitly mentioned as prone to tourism in general? High / low levels? Domestic/ international tourism?
16- Any specific mention of tourists in the paper?
17- Any information about the characteristics / demographics of the population involved (e.g., age, language, experience with wildfires, income, household types/size education, safety culture, etc.)
18- Does the study differentiate among recurrent vs seasonal** vs first-time tourists?
19- If tourists are mentioned, summarize content (including inferring type of tourists)
20- Reference to a behavioural theory(ies)?
21- Main findings of study of interest to define archetypes, such as behaviours reported, issues associated with evacuation or shelter/defend-in-place behaviour, or physical state of populations; in other words, what qualitative observations were used in the study that can help us think about the archetypes?
22- List of variables which can be identified through this study
23- Possible archetype categorizations identifiable through this study; if the study has identified archetypes, what are they?
24- Study limitations (summary) / perceived study limitations
25- Paper(s) in the reference list to be screened

**This question was added to check if the area considered wildfire safety as a priority. Investments on wildfire safety were used as a proxy to investigate this issue.*

*** Recurrent is intended as someone who travels to a place at any time of the year (e.g., someone owning a summer house), seasonal can be recurrent or not, but just in a given season.*

1.3. Characterization of the population

After conducting the literature review, all variables identified were compiled into a list. This list underwent further refinement based on two main criteria: 1) prioritizing variables frequently mentioned in the literature, along with those with broader relevance; and 2) where possible, consolidating variables into the most relevant ones for the research's purpose to maintain manageability. Variables pertaining to tourist evacuation behaviour in wildfires were supplemented with those identified in four seminal reviews on resident evacuation behaviour (Folk et al., 2019; Huang et al., 2016; Kuligowski, 2020; McLennan et al., 2019). These reviews were examined to determine which variables affecting resident evacuation behaviour were applicable to tourists. Subsequently, the process involved verifying which variables had not yet been found in the reviewed articles pertaining to tourists.

The following ten variables representing population characteristics were subsequently identified:

1. Property attachment
2. Past experience and preparedness
3. Safety culture
4. Risk perception
5. Individual socio-demographic factors
    a. Income
    b. Education
    c. Race and ethnicity
    d. Functional limitations
    e. Gender
    f. Age
6. Group dynamics
7. Interaction with authorities
8. Place of residence and length of stay
9. Transportation mode
10. Information.

Each of the above characteristics and their relationship to tourist decision-making process during wildfire emergencies are discussed below.

1.3.1. Property attachment

This variable pertains to individuals' emotional connection or ownership of an object or place. Property attachment is often negatively correlated with evacuation behaviour (Huang et al., 2016; McLennan et al., 2019). International tourists typically exhibit lower property attachment compared to local residents, making them more inclined to evacuate (Huang et al., 2016). Residents' higher property attachment is often driven by concerns about the monetary value of their property, leading them to prioritize its protection, even from potential looters (McLennan et al., 2019). This suggests that individuals without property ownership may be more likely to comply with evacuation orders compared to locals (McLennan et al., 2019).

1.3.2. Past experience and preparedness

This variable concerns past experiences and preparedness, impacting decision-making during wildfires. Previous encounters with wildfires or readiness levels can influence responses. This includes the "cry wolf effect," where prior unnecessary evacuations decrease compliance with evacuation orders, and evacuation training positively affects decision-making (Matyas et al., 2011; McLennan et al., 2019).

Preparedness encompasses knowledge of protective measures and evacuation procedures to minimize hazards. Tourists with past positive experiences are less likely to evacuate due to lower risk perception, even indirectly through friends' or family members' experiences (Matyas et al., 2011). However, those without prior experience may be less likely to evacuate due to curiosity, as observed in cyclones (Banerjee et al., 2023). Tourists without wildfire experience may pause during evacuations for photography (Vaiciulyte et al., 2019).

Additionally, evacuation likelihood influenced by preparedness and experience may vary based on residency in wildfire-prone areas (Vaiciulyte et al., 2022). Furthermore, tourists familiar with the wildfire area are more inclined to follow familiar routes over shorter ones (Limanond et al., 2011).

Finally, hurricane research indicates that past experiences shape tourists' trust in information sources during evacuations, like local tourism offices and hotel staff (Cahyanto & Pennington-Gray, 2015). This applies to wildfires too, as tourists' previous encounters influence their reliance on specific sources of information, affecting their evacuation choices.

1.3.3. Safety culture

Safety culture in this context refers to tourists' awareness of wildfire hazards and how they perceive and utilize safety information. Hurricane research found that tourists who didn't consider the possibility of this hazard before traveling were less likely to evacuate (Matyas et al., 2011), possibly due to their limited understanding of the hazard and its consequences. Similarly, a study on wildfires in Corsica revealed differences in safety culture between residents, who have a risk-awareness culture ingrained from school, and tourists, who showed limited understanding of fire hazards (Vaiciulyte et al., 2019).

1.3.4. Risk perception

Risk perception relates to individuals' perception of personal threat from a hazard, like injury or death (Kinateder et al., 2015). Higher risk perception strongly correlates with evacuation likelihood (Folk et al., 2019; Huang et al., 2016; Katzilieris et al., 2022; Kuligowski, 2020; McLennan et al., 2019), and it is often influenced by factors such as past experiences and access to information. Research shows tourists without hurricane experience, are on shorter trips, or have not performed pre-travel hurricane checks perceive higher risk (Matyas et al., 2011). First-time tourists also perceive higher risk and may evacuate more readily (Cahyanto et al., 2014; Matyas et al., 2011). Fear levels among coastal tourists traveling by personal vehicles vary (Villegas et al., 2013), although this finding is more relevant to hurricanes and tsunamis than wildfires.

Cahyanto et al. (2014) and Villegas et al. (2013) found that tourists with children typically have higher levels of risk perception. Similarly, Banerjee et al. (2023) discovered a positive relationship between tourists' risk awareness and their perception of risk during cyclones. Their study revealed that tourists' decisions to stay were often influenced by insufficient risk perception to prompt evacuation. However, this issue could potentially be addressed by disseminating warning messages in multiple languages. Banerjee et al. (2023) reported a positive correlation between disseminating warnings in multiple languages and the risk perception of a diverse group of tourists from various countries.

1.3.5. Socio-demographic factors

Socio-demographic factors variable encompasses a wide range of attributes including income, age and gender, race and ethnicity, education, functional limitations that influence risk perception and the decision to evacuate. Each of these are discussed below.

Income

Income is a factor that can impact evacuation decisions, with lower-income tourists being less likely to evacuate (Katzilieris et al., 2022; Cahyanto et al., 2014). Additionally,

low income may lead international tourists to choose shelter accommodations over hotels (Cohn et al., 2006).

Age and gender

According to Matyas et al. (2011), there's a positive correlation between age and willingness to evacuate. However, older tourists might face language barriers, making access to evacuation warnings challenging (Christianson et al., 2019). Additionally, female tourists may have a higher likelihood of evacuation, possibly due to perceiving greater risk associated with hazards (Cahyanto et al., 2014; Cahyanto & Pennington-Gray, 2015). However, gender's impact may be less pronounced in tourist families, as decisions are often made jointly (Litvin et al., 2004). Furthermore, female tourists tend to find information sources more credible and are more inclined to use information from sources like family, locals, local tourism offices, and authorities compared to male tourists (Cahyanto & Pennington-Gray, 2015).

Race and ethnicity

The race and ethnicity variable explores how individuals of specific cultural backgrounds behave during evacuations relative to the broader population. Perry & Green (1982) found that race and ethnicity influence risk perception and evacuation decisions. Minority groups tend to perceive lower risk and attribute events to external factors beyond their control (e.g. luck or fate), resulting in less chosen evacuation or protective action. Additionally, ethnic minority membership correlates with higher community involvement and lower trust in authorities, affecting information reception during fire events and subsequent evacuation behaviour (Perry & Green, 1982; Vaiciulyte et al., 2019).

Education

Education levels can impact evacuation choices. Limanond et al. (2011) found in their study on tsunami evacuations that international tourists with high school or bachelor's degrees were more inclined to follow the crowd in their evacuation route selection compared to those with higher education levels. Conversely, individuals with advanced degrees (Master's/Ph.D.) tended to prioritize signage over crowd behaviour.

Functional limitations

People with functional limitations, such as mobility, sight, hearing, or cognitive impairments, may face heightened vulnerability during wildfire evacuations. While many individuals can self-evacuate, those with functional limitations may encounter difficulties and require assistance. Challenges may arise from inadequate transportation options or from physical and cognitive limitations (Kuligowski, 2020; McLennan et al., 2019).

1.3.6.Group dynamics

Group dynamics refers to the collective characteristics and interactions among people, which can impact the evacuation process. Research on hurricanes suggests that families with children often perceive higher risk, increasing the likelihood of evacuation (Cahyanto et al., 2014; Villegas et al., 2013). However, some families may choose to stay if they lack knowledge about protective action or refuge areas. Additionally, the number of minors in a household can significantly influence evacuation decisions; Katzilieris et al. (2022) found a negative relationship between the number of minors and the decision to evacuate. This could be because larger families may face challenges gathering members or preparing, potentially causing delays in decision-making or evacuation.
On the opposite side of the age spectrum, Cahyanto et al. (2014) found that tourists with older companions are less likely to evacuate, likely due to concerns about their health worsening during evacuation. Larger travel groups tend to evacuate more often than smaller ones. However, debates within emerging tourist groups can cause evacuation delays (Drabek, 1999).

Furthermore, Cohn et al. (2006) noted that residents often opt to stay with friends and family instead of evacuating to shelters. However, individuals without personal networks or financial means to stay in hotels typically choose shelters.

1.3.7.Interaction with authorities

Interaction with authorities involves communication and compliance with evacuation orders by populations. Paveglio et al. (2015) identified distrust in government and emergency instructions among different types of WUI resident archetypes. Additionally, Vaiciulyte et al. (2019) found that while tourists may generally comply with authorities, some may defy orders and delay evacuation to capture wildfire footage. The interdependence within tourist groups can impact evacuation decisions, with certain individuals resisting evacuation policies (Banerjee et al., 2023).

1.3.8.Place of residence and length of stay

The place of residence indicates tourists' original location before traveling, which can influence their behaviour and likelihood of evacuation. Factors such as language and cultural differences are crucial in understanding tourist behaviour. Vaiciulyte et al. (2022) emphasized the connection between locals' place of residence and their likelihood of evacuation. Studies focusing on international and national tourists found that international tourists are more inclined to evacuate compared to national tourists (Matyas et al., 2011; Cahyanto et al., 2014). Additionally, the relationship between tourists' information needs and their intention to seek information may vary depending on their place of residence (Aliperti & Cruz, 2019). Tourists from collectivist countries,

which prioritize group over individual, tend to adhere to social norms and seek information more readily (Quintal et al., 2010). Consequently, tourists from collectivist countries are more likely to seek information and comply with official evacuation orders.

The length of stay at the tourist destination is also a potential factor in predicting evacuation behaviour of tourists during hazards. Matyas et al. (2011) proposed that a shorter length of stay or visiting a location for the first time may increase the likelihood of evacuation due to unfamiliarity with the area, particularly in the context of hurricanes. Moreover, the length of stay can influence the chosen evacuation route. For example, Limanond et al. (2011) found that during a tsunami event, most international tourists staying for less than six months were inclined to follow the crowd, while those staying longer than six months preferred a route they were familiar with. They also noted that tourists with longer durations of stay, ranging from six months to over a year, were more likely to opt for a familiar route (Limanond et al., 2011).

1.3.9.Transportation mode

Transportation mode refers to how tourists travel and how it affects their evacuation behaviour. The availability of private vehicles can impact tourists' chosen evacuation routes. Villegas et al. (2013) argued that transportation mode may influence risk perception during hurricanes. For example, traveling with a personal vehicle might reduce perceived risk by minimizing negative imagery of potential outcomes (Villegas et al., 2013). However, Cahyanto et al. (2014) found that tourists with personal vehicles might be more inclined to evacuate compared to those with rented vehicles due to property attachment.

Additionally, the choice of transportation mode during an evacuation, such as on foot or using a vehicle, may vary depending on the type of hazard and its location (Arce et al., 2017). Limanond et al. (2011) demonstrated that during a tsunami, international tourists utilizing public transport in the area tend to follow the crowd when deciding on evacuation routes. Conversely, those driving private or rented vehicles are more inclined to adhere to evacuation instructions (Limanond et al., 2011).

1.3.10. Information

The information variable encompasses factors influencing how tourists receive, understand, and access information during emergencies. Arce et al. (2017) note that tourists often expect evacuation warnings from official channels, media, internet, and news, rather than unofficial sources. International tourists rely more on hotel staff and social networks for information compared to national tourists (Cahyanto & Pennington-Gray, 2015). However, seeking additional information may cause evacuation delays.

Environmental and social cues can reduce individuals' "wait-and-see" attitude (Vaiciulyte et al., 2022).

International tourists view local tourism offices as credible and often use them for information (Cahyanto & Pennington-Gray, 2015). They also tend to rely on local authorities for information more than national tourists. Arce et al. (2017) suggest that access to information through signage directed at international tourists may depend on factors like language, visibility, location, relevance, size, and materials. Consistent presentation of information is crucial to effectively prompt evacuation, as inaccuracies may lead to non-compliance (Drabek, 1996). This includes disseminating warnings in multiple languages (Banerjee et al., 2023).

In summary, Table 2 offers an example of how the variables discussed above can be put into practical use by an evacuation model user. In this example, variables can be assessed using a Boolean answer (e.g. yes/no), a qualitative answer (e.g. large/medium/small) or quantitative answer (e.g. a numerical value). This is a deliberate simplification that is intended to facilitate practical use for the existing evacuation models and tools. However, some of these variables have potential to be operationalised with much more precision.

Table 2 Example for variable use for evacuation modelling purposes. Source: Labhiri et al., 2024.

Variable	**Categories of variables**
Property attachment	Boolean (Yes/No), Qualitative scale (large/medium/small), Quantitative scale (numerical scale)
Past experience and preparedness	Boolean (Yes/No), Qualitative scale (large/medium/scarce), Quantitative scale (numerical scale)
Safety culture	Boolean (Yes/No), Qualitative scale (large/medium/small), Quantitative scale (numerical scale)
Risk perception	Qualitative scale (high/medium/Low), Quantitative scale (numerical scale)
Socio-demographics Education	Boolean (Yes/No), Qualitative scale (large/medium/low), Quantitative scale (numerical scale)
Income	Boolean (Yes/No), Qualitative scale (large/medium/low), Quantitative scale (numerical scale)
Age	Qualitative scale (Adult/Older/Minor, Quantitative scale (exact age)
Gender	Male/Female/Non-binary
Functional limitations	Boolean (with/without), Qualitative scale (proportion of limitations), Quantitative scale (detailed list of limitations)
Ethnicity	Boolean (majority/minority), Qualitative scale (large/medium/low), Quantitative scale (proportion of populations)
Group dynamics	Boolean (affected by others in their group (senior, children)/ not affected by others), Qualitative scale (large/medium/small impact of others in their group), Quantitative scale (detailed proportion of people affected)
Interaction with authorities	Boolean (compliant/ non-compliant), Qualitative scale (largely compliance, medium compliance, low compliance), Quantitative scale (detailed proportion of people's compliance)
Place of residence and length of stay	Boolean (familiar with place of residence/ unfamiliar with place of residence), Qualitative scale (large/medium/small familiarity), Quantitative scale (detailed proportion of people's familiarity)
Transportation mode	Boolean (access to private vehicle/ no access to private vehicle), Qualitative scale (large/medium/small access to vehicles), Quantitative scale (detailed proportion of people's access to vehicles)
Information	Boolean (access to information/no access to information), Qualitative scale (large amount of info/medium/limited amount of info), Quantitative scale (detailed proportion of people's access to information)

Final remarks with regards to reviewed human characteristics

The summary of human characteristics in relation to decision-making in wildfire emergencies is constructed based on the existing research and the best approximation to tourist behaviour is made. However, considerable knowledge gaps exist. For instance, data is lacking on behaviours of tourists whose first language is not English and the behaviour of people who are facing language barriers. There is also limited knowledge around the tourists' route choice in case of an emergency. It is unclear what impacts tourist and local populations' willingness to share resources during evacuation, such as means of transport, and whether it would have an effect on tourist evacuation delays. There is also limited understanding of peoples' limited mobility, hearing, vision, and cognitive abilities' impact on evacuation decisions. The impact of the behaviours exhibited by tourist groups deserve a more thorough investigation too, as they may themselves present a degree of variation in size, age, shared safety culture and a mixture experiences, preparedness and knowledge. It is important to note that this work does not assume linear relationships between variables because some of the variables, for instance safety culture and risk perception, presence of children and risk perception, as well as interaction with authorities and experience are interconnected.

2. Empirical data collection

2.1. Interviews with stakeholders

While some general human characteristics that influence their behaviour in wildfire emergencies can be, to some extent, identified from the literature and adapted to tourist behaviour, it is important to contextualise this knowledge. To investigate and gather more accurate understanding about the behaviours of tourists in cross-border wildfire prone areas, and the differences of these behaviours in relation to the locals, key project stakeholder were involved. It is important that such contextual knowledge is informed from across all levels of touristic infrastructure holders. This is because their experience of managing wildfire emergencies where they encounter tourists will vary. Often, the degree to which they could observe the behaviours, interact with tourists and the challenges they deal with while interacting with tourists will vary depending on their role and the length of their professional experience.

The goal therefore was to capture an overall understanding of the differences of safety culture of tourists in relation to the residents. Safety culture generally thought to include knowledge and understanding of local fire risks, preparedness, access to information, ability to evacuate or shelter-in-place, behaviour, among others. As tourists in cross-border regions may come from areas with no or low wildfire risk awareness, key stakeholder perspectives and observations are seen as unique experience and insight that is fundamental in safeguarding vulnerable people.

Cross-border emergency management may be particularly complex. Coordinating responses among different jurisdictions, language barriers, and varying levels of preparedness across borders demand a harmonized and collaborative approach. Effective communication channels, shared protocols, and standardized evacuation procedures are very important aspects to consider when addressing the complexity of managing wildfire emergencies in touristic cross-border regions. With the help of the interviews and qualitative data, potential and existing challenges that could increase the overall population vulnerability in wildfire scenarios can be identified, allowing a more holistic understanding of tourist population vulnerability and existing capacity to safeguard them.

A qualitative study investigating the perspectives, attitudes, and subjective thinking of key stakeholders (e.g. emergency managers, tourist infrastructure managers, etc.) regarding the perceived tourist vulnerability was carried out. This pool of perspectives was further complemented with interviews with researchers who are familiar with issues regarding human behaviour in wildfire emergencies.

2.1.1. Methods & sample

A qualitative study was devised to capture the insights of key stakeholders involved in emergency planning and management within touristic regions in the first instance in Spain and France, but also broadened to experiences across the globe. Focusing on cross-border areas where tourist infrastructure significantly influences the local economy, the study aimed to gather perspectives through interviews, utilizing various means based on individuals' availability. The objective was to organize, structure, and interpret qualitative data, including attitudes and perspectives, obtained from stakeholders. Specifically, the study group comprised stakeholders with direct experience in wildfire incidents involving tourists, alongside experts in wildfire evacuation, chosen to validate existing knowledge reflected in wildfire evacuation literature.

2.1.2. Sampling procedure and study participants

Participants were recruited through non-probability convenience sampling, meaning that they were selected based on their availability and accessibility to the researcher, rather than through a random selection process. The network of the WUITIPS project was chosen for recruitment of the participants. This allowed to interview people across the following roles: 4 researchers, 4 tourist managers, 2 municipality administrators, 3 from the fire and rescue services, 2 managers of a natural park, and 5 regional administrators of the area under consideration. A total of 13 participants had more than 10 years of experience in the fire safety domain, 1 had between 3-5 years, 1 between 1-3 years and the rest (5 participants) had no previous experience in the fire safety domain. Country of residence and occupation included 15 people from Spain, 1 in France, 1 in Australia, 1 in Canada, 1 in the UK and 1 in New Zealand.

The sample size was determined based on the principle of saturation. Although this concept has been a topic of debate in scientific literature (Braun & Clarke, 2019; Saunders et al., 2018), in this study, saturation was embraced, indicating that new data did not contribute to the development of additional themes. Thematic analysis involved continuously generating new themes relevant to the research questions and study objectives. Once the research objectives were adequately addressed, recruitment of additional participants ceased. This approach was established prior to commencing data collection, resulting in a sample size of 20 participants.

2.1.3. Data collection

Various methods were employed for data collection. Interviews were conducted via online platforms (4 interviews), face-to-face interactions (9 interviews), or through a specialized online survey (7 interviews). The face-to-face interviews were held at the

locations where the wildfire incidents occurred. A researcher recorded observations during the interviews, which typically ranged from 15 to 40 minutes in duration.

A set of 6 questions (see below) were prepared beforehand to make sure to prompt answers related to human vulnerability. The questionnaire covered aspects related to the individual and group factors which can play a role in human vulnerability in case of fires in touristic areas, the main characteristics of tourists that differ from locals from the perspective of a wildfire emergency and how to use information regarding the population type in a given touristic area to perform vulnerability assessment.

1. What is your occupation?
2. For how many years have you worked in the fire safety domain?
3. What is your country of residence? In which country is your area of occupation?
4. What are the main individual and group factors which you think can play a role in human vulnerability in case of fires in touristic areas? Please list and explain your top 5 factors (in order of importance according to you, from the most important to the least important).
5. What are the main characteristics of tourists which you would think would differ from locals from the perspective of a wildfire emergency scenario?
6. How would you use the information regarding the population type available in a given touristic area to perform a vulnerability assessment?

Questions were translated into four languages—English, Spanish, Catalan, and French—to accommodate respondents' familiarity with different languages in the research area. Nineteen out of twenty responses provided answers to all questions. The questions were crafted to prompt reflections on the specified topics and to elicit evaluations from respondents regarding the significance of various factors influencing tourist vulnerability.

This study followed the principles outlined in the Declaration of Helsinki (World Medical Association, 2013), it went through the ethical assessment checklist at Lund University, and it was deemed not necessary to submit a full national ethical application as it does not entail processing of personal data.

2.1.4. Qualitative data analysis

This study utilized inductive reflexive thematic analysis (Braun & Clarke, 2012) meaning that the themes emerged directly from the data, the researcher was reflexive of potential biases and therefore co-coded and collaborated with another researcher when devising the themes, and the data was analysed systematically as per steps indicated

below. This study followed a similar approach to another qualitative study on fire safety (Smedberg et al., 2022).

The thematic analysis proceeded through the following phases:

1. Data Familiarization: Upon data collection, responses were imported into NVivo 12 software (QSR, 2018). The primary researcher reviewed all responses to gain familiarity with the data.
2. Initial Code Generation: Meaningful codes were created to label the data in alignment with the study's objectives, employing descriptive or semantic coding (Braun & Clarke, 2012).
3. Theme Identification: Once codes were established, themes were identified within the data. Similar codes were grouped together or transformed into sub-themes (Braun & Clarke, 2006).
4. Theme Definition and Naming: Themes were named and clearly defined.
5. Theme Review: A second reviewer independently assessed the codes, themes, and sub-themes, expanding or modifying them as necessary.
6. Theme Confirmation: The final list of themes was deliberated among the authors and finalized.

2.2. Results

The three themes and fifteen sub-themes that emerged from the data are described in more detail in the following sections, but the Table 3 summarises the analysis results providing some context in verbatim.

Table 3 Themes and sub themes constructed on tourist vulnerability to wildfires from the perspective of the stakeholders of tourist infrastructures. Source: Ronchi & Vaiciulyte, 2024.

Theme	Sub-theme	Code example
Lack of knowledge	Knowledge of (wild)fire risk	Tourists do not realize the danger
		"Most tourists come from areas where there are not so many forest fires and do not perceive the risk"
		Tourists do not have basic fire safety understanding
	Safety culture	Lack of understanding what wildfire is and could mean to the population residing in its way. "Generally, the origin of fire is from the tourists in the camps. They show very low fire safety culture."
		Lack of general preparedness and knowledge of what to do in a case of wildfire
	Knowledge and access to communication means	Social media channels work well to inform residents, tourists may not have access to this, or other means of communication used by locals

Theme	Sub-theme	Code example
Lack of knowledge		"There is no direct way to let tourists know where to check the level of risk and make them aware of possible restrictions."
	Knowledge of territory	(tourists show) "lack of knowledge of geography of the environment"
	Knowledge of emergency procedures	(we saw) "unorganized evacuations: (tourists) escape instead of confine"
	Language barrier	Language difficulties (foreign tourists)
		Language used to communicate with tourists is not always the one they will understand
Physical vulnerability	People carrying luggage	"People may want to evacuate with their luggage which makes them slower, require more space, makes them bulky"
	Vulnerable populations	"demographics depending on nature of tourism, a lot of elderly or younger than usual"
		(Tourists may have) "mobility difficulties, families with small children or elderly people"
	Intoxication	People may be intoxicated and remain asleep
	High population density	"Number of population changes completely in tourist seasons (5000 people vs 450000 people or 20,000 vs 250,000 people in the larger area)."
	Access to transportation means	(tourists) "lack access to individual vehicles, relying on local vehicle system"
		(tourists have) "vehicles constraints"
	Location issues	Logistics to rescue tourists in remote location is complicated
Discrepant tourist expectations	Willingness to stay together	Tourists want to be together, and this may create issues when they are not initially in the same location.
		In stressful situations the tendency is to group by affinities
	Expectation to be taken care of	"We have had a tourist asking for breakfast while we were without electricity trying to defend our property from the fire."
		Tourist do not pay necessarily attention to the information provided as they do not care about the property.
		Residents would try extinguishing efforts, while tourists would not want to care
	Financial consequences	Tourists care about vacation cost and continue getting the vacation service.
		Tourists may not be willing to leave everything behind, they had to leave their camper vans, had only time to collect small essential personal items

2.2.1. Lack of knowledge

One of the most emphasized aspects regarding tourist vulnerability is their limited knowledge. This can stem from their unfamiliarity with wildfire risks, originating from regions not prone to such events and lacking wildfire safety culture compared to local residents. Another important sub-theme that emerged is the accessibility and familiarity with communication channels, spanning various platforms such as social media and phone messaging. Tourists may also encounter challenges due to their lack of familiarity with the area, potentially leading to navigation difficulties during evacuations. Factors such as the type of tourists (e.g., seasonal, recurrent) and the duration and nature of their stay (e.g., short or extended) can influence this dynamic. More generally, insufficient awareness of emergency procedures significantly contributes to tourist vulnerability. Instances were cited where tourists either evacuated when instructed to remain in place, or vice versa. The language barrier emerged as a notable concern, particularly as tourists may not share a common language with emergency managers or the language used in emergency communications. This issue is particularly pertinent in cross-border regions, where tourists from diverse backgrounds, including neighbouring countries, may frequent.

2.2.2. Physical vulnerability

Physical human vulnerability, or a set of physical aspects as related to tourists' safety were mentioned by the participants in this study. This theme includes specific individual factors which can affect the ability of tourists to move efficiently in evacuation, for example, if tourists insist on retrieving and carrying luggage, if they mobility limitations or they are intoxicated (e.g. after alcohol consumption). It was also highlighted that population densities may increase dramatically in touristic areas - in the order of 10 times or more. This alone creates a set of challenges when it comes to both estimating the number of people potentially in danger, assessing tourists' location (especially in cases where tourists go to remote areas) as well as evacuation planning. This is in addition to the fact that not all tourists may have access to means of transportation in case of evacuation, thus leading to rely on publicly arranged transport.

2.2.3. Discrepant tourist expectations

The final theme centres on the differing expectations tourists hold during their visits to tourist facilities or areas, often conflicting with the real-life situations they encounter. For example, tourists express a preference for remaining or assembling in close groups during emergency situations, potentially posing challenges when they are not initially in close proximity (particularly notable in scenarios involving defend-in-place strategies). Additionally, there is an expectation among tourists to taken care of, leading them to be less inclined to engage in protecting properties they do not own during a wildfire

emergency. They also anticipate that tourist services will continue despite the ongoing emergency. The contrast in expectations between tourists and residents was emphasized by the participants in this study, including differences in their willingness to assist in property defence or take proactive protective measures. Financial implications emerged as a significant sub-theme influencing tourist vulnerability. Tourists have a financial stake in their vacation accommodations, potentially leading to behaviours such as re-entry or non-compliance with evacuation instructions from emergency managers, especially among tourists who own or have rented camper vans.

Final remarks with regards to stakeholder interviews

As with any qualitative research results, the findings should be interpreted with caution as they are drawn from individual and subjective experiences that can be difficult to generalise. However, the interviews and analysis of the data in this study are grounded in a thorough literature review (discussed in Section 1) which strongly corresponds with the qualitative data findings. Furthermore, the interviews in this study are one of the many elements used to inform the tourist population vulnerability assessment tool and good practice guide and serves as a useful tool for contextualisation for cross-border tourist areas.

3. Archetypes of tourist behaviour

A list of human characteristics identified in Section 1 and the interview findings were used to apply Strahan et al.'s (2018) archetypes to tourist behaviour in wildfire emergencies, resulting in an updated version of the Strahan et al.'s archetypes discussed here. Archetypes are categories of common types of people which can be modelled within an evacuation simulator. The concept of an archetype is used here with the goal of facilitating a more comprehensive and accurate assessment of vulnerability in touristic areas.

Defining evacuation archetypes for modelling purposes is a useful approach for model calibration, since evacuation models rely on an accurate calibration of the human behaviour-related inputs (Ronchi & Gwynne, 2019) and verification and validation strongly affects the accuracy of their predictive capabilities (Ronchi et al., 2023; Ronchi, Wahlqvist, et al., 2021).

For example, in their work on self-evacuation of resident archetypes in Australia, Strahan et al. (2018) defined seven archetypes:

1) "R*esponsibility deniers"*: believe that they are not responsible for their personal safety or that of their property.
2) *"Dependent evacuators"*: expect that the emergency services will protect them and their property because they lack capacity to do it themselves.
3) *"Considered evacuators"*: carefully consider evacuation and are committed to it as soon as they are aware of a wildfire threat.
4) *"Community guided"*: seek guidance from neighbours, media, and members of the community who they regard as knowledgeable, well informed and providing reliable advice.
5) *"Worried waverers"*: prepare and equip their property, train to defend it but worry they lack practical experience to fight a wildfire and may potentially put their personal safety at risk.
6) *"Threat deniers"*: do not believe that their personal safety or property is threatened by a wildfire.
7) *"Experienced independents"*: are highly knowledge, competent, and experienced, as well as perceive themselves to be responsible and self-reliant when defending-in-place.

After carefully considering what characteristics are important in tourists' behaviour, and collective qualitative data from the key stakeholders in touristic area management in wildfires, an adapted list of the archetypes was constructed as follows (as in: Labhiri et al., 2024):

Archetype 1: Threat deniers (Tourist denying the threat)
This type of archetype can be referred to the tourists who do not believe that the wildfire will impact their safety. This will result in them disregarding the information received about the incoming wildfire threat received from emergency services, media, residents, or other tourists. This type of tourist has very little experience about wildfires, limited safety culture and low risk perception. They are not familiar with the area and the wildfire safety procedure.
Outcome: The archetype of *Tourists denying the threat* is committed to remain in case of evacuation.

Archetype 2: Responsibility deniers (Tourist denying responsibility)
As for the case of residents, this type of tourist does not believe they are responsible for their own safety. They do not feel that they need to rely on themselves, and therefore expect that others (e.g., authorities or tourist managers) take care of their safety. They have limited experience with wildfires, no training, limited safety culture, and limited preparedness. They are not influenced by media, residents, or other tourists.
Outcome: The archetype of *Tourists denying responsibility* will stay as long as others will take care of their evacuation. This may imply long evacuation delay, depending on the actions of others. They are neither aware of the best route nor are familiar with the area and procedures.

Archetype 3: Experienced Independent (Experienced Tourist)
This type of tourist has experienced wildfires before and has a good level of preparedness, safety culture and training. They are familiar with the protective actions to be taken when a wildfire is in the area, having extensive knowledge of wildfire safety from their place of residence or previous travels to the area. They rely mostly on themselves and are strategically prepared on what actions to take. They are not largely affected by the decisions of others. They consider themselves more knowledgeable about wildfires than emergency services, media, residents, or other tourists.
Outcome: The archetype of *Experienced Tourist* will decide to evacuate quickly, are aware of the best route/procedures and are familiar with the area.

Archetype 4: Community Guided (Community Guided Tourist)
This archetype refers to tourists that are strongly affected in their decisions by their positive perceptions of the knowledge of emergency services, media, residents, and other tourists. They have limited wildfire experience and are not self-reliant despite being aware of the situation.
Outcome: The archetype of *Community Guided Tourist* is fully reliant on the evacuation decisions on the community.

Archetype 5: Worried waverer (Worried Tourist)
This archetype refers to tourists that are concerned about the wildfire threat and its impact on their safety. These tourists are knowledgeable about wildfires and informed/prepared about the event. They consider information from emergency services, media, residents, or other tourists as useful.
Outcome: The archetype of *Worried Tourist* is committed to evacuating as they consider this as the best option for their personal safety.

Archetype 6: Dependent evacuator (Dependent Tourist)
This archetype refers to tourists that rely on emergency services to protect their personal safety. The largely rely on emergency services rather than media, residents, or other tourists. This group of tourists had no previous experience with the wildfire threat, lack knowledge and information about wildfires and no training.
Outcome: The archetype of *Dependent Tourist* is committed to evacuating and rely extensively on emergency services in their decisions.

Archetype 7: Considered evacuator (Considered Tourist)
This archetype refers to tourists that perceive wildfires as a current and future threats since they have them extensively into their lives from their place of residence or previous travels to the area. They had experience of evacuation in the past and had some limited training. They are influenced by information in the media, but to a smaller extent by emergency services, residents, or other tourists.
Outcome: The archetype of *Considered Tourist* is strongly committed to evacuation as soon as they become aware of the threat.

Final remarks with regards to tourist archetypes

It should be noted that the translation of work by Strahan et al. (2018) of the resident archetypes to tourists' archetypes would need further scrutiny, since they are built on literature with notable gaps and application for touristic populations. Thus, for instance, certain archetypes originally designed for residents may be less applicable to tourists. As more data is collected and published in scientific literature with regards to tourist behaviours, the archetypes may need to be reviewed.

4. Tourist population vulnerability assessment tool – TOURSAFE

4.1. Purpose of the tool

An important issue that was identified more generally throughout this research was that often communities may have limited information regarding the types of tourists they host, therefore making it difficult to assess potential human vulnerabilities associated with tourists' populations. For this reason, it is hoped that the proposed tool could be a starting point towards good practices for human protection in tourist areas, which will inform and foster an increased level of awareness of vulnerabilities among heterogeneous tourist populations and motivate a more informed tourist hosting.

Acknowledging the complex nature of emergency management, the TOURSAFE tool is designed to support stakeholders who collaborate to ensure effective and coordinated responses to emergencies. The intended users of the TOURSAFE tool include municipal emergency managers, civil protection agencies, fire departments, community representatives, and public information officers. We provide a suggested list of actors who may find this tool useful, albeit the list is not exhaustive or prescriptive in nature.

1. Municipal Emergency Managers: Responsible for coordinating emergency preparedness and response efforts within a city or town. They work closely with local government officials, public safety departments, and community organizations.
2. Civil Protection Agencies: These agencies are responsible for the protection and safety of civilians during emergencies and disasters. They include national and regional emergency management organizations.
3. Fire Departments: Key players in emergency response, especially in incidents involving fires, hazardous materials, and rescue operations.
4. Community Representatives: Local leaders, neighborhood associations, and non-governmental organizations (NGOs) play vital roles in disseminating information, providing support to vulnerable populations, and facilitating community resilience.
5. Public Information Officers: These professionals manage communications with the public and media, ensuring accurate and timely dissemination of information during an emergency.

Each of these groups plays a critical role in various stages of emergency preparedness, response, and recovery. The TOURSAFE tool provides these users with the guidance information they need to assess tourists' vulnerability, enhancing their ability to protect and assist the communities they serve.

4.2. Tool development and testing of TOURSAFE

The development of this tool has involved steps that have already been described in this report in detail. Here, the purpose is to explain how the development process of the tool was not linear; rather, different parts evolved in relation to one another. Current wildfire vulnerability assessment methods mostly rely on physics-based factors, e.g., weather-related, and fuel-related factors (Intini et al., 2020) and focus on ecosystems and assets. This tourist population vulnerability assessment tool and the guidelines for good practices for human protection that accompany it instead place the focus on human characteristics and their needs.

For example, the literature review (Section 1) has helped identify the characteristics of human vulnerability and the existing archetypes of human behaviour in previous research. As a following step, interviews with key stakeholders (Section 2) were carried out to better understand how the identified characteristics are reflected practically in their own work with tourist populations. This step has helped identify the challenges that are related to different tourist characteristics and informed the adaptation of the tourist behaviour archetypes. The archetypes informed nuanced thinking in why compliance with wildfire response could become complicated for some tourists, and the effect on evacuation delays of different groups, as well as their group behaviour overall.

Following this, a tourist vulnerability assessment questionnaire was developed with the aim of incorporating collected information into a format that discusses in depth the specific vulnerabilities associated with tourists. This is based on the practice of Vulnerability-Capacity Assessment (IFRC, 2006), which involves gathering, examining, and organizing data about a specific community's susceptibility to risks in a systematic way. This information is then used to identify the vulnerabilities to the hazard in focus and the abilities of the community to deal with them. The purpose of the process is to establish guidelines for good practices for human protection that can inform efforts to decrease people's vulnerability to potential disasters and enhance their ability to cope with and recover from them. The questionnaire follows a thematic as it progresses, detailed in Table 4.

The questionnaire has received feedback from the project partners at the conceptual and definitive stages. The main criteria for the final list of questions was the question’s relative importance for the impact on tourist safety, as well as keeping the overall questionnaire manageable in length to minimize the time it takes to complete it, which is approximately 20 minutes. Full list of questions and answer options, and the way they have been operationalised are presented in the Appendix.

Each response option to a question was developed based on the assumption that the answers can be placed on a spectrum, where at each extreme most / least vulnerability can be represented. Thus, to operationalise the questionnaire, the response options were assigned scores – from lowest to highest (representing least to most vulnerability). It is intended that the user should score as low as possible for the vulnerability to be 'low' for each theme presented in Table 4, then medium and high vulnerability scores were also assigned. Once the user of the tool answers all the questions, they are presented with their relative vulnerability scores across the 9 questionnaire themes that correspond to an icon and a relevant colour based on the score (Table 4).

The evaluation of scores and their corresponding vulnerability (low, medium, high or green, yellow, red respectively) are presented with tailored guidelines for good practice for human protection corresponding to the issues identified through the questionnaire answers. The advice in full can be seen in Section 5. An example of advice output can be found in the Appendix II.

Each theme is accompanied with a relevant narrative, or explanation of the theme at hand, which is also a literature-based justification of the background information related to the question, showing that the question is overall of importance. The guidelines were constructed for individual answer options drawing parallels between fire safety in built environment, communities and across different disciplines (for detailed description see Section 5).

The tool was tested both in English and Spanish with key stakeholders, and feedback on functionality, usefulness, clarity of the questions, appropriateness of the answer options, overall use of the tool and the advice was received and implemented. The tested case study is available in the Appendix II.

Table 4 Questionnaire thematic and operationalization. Colour scheme denotes green as "low", yellow as "medium" and red as "high" in terms of vulnerability for a particular theme. The scoring system presented indicates the underlying arbitrary scoring for each level of vulnerability, where the lowest value is the lowest score a user can obtain, and the highest value being the highest score.

Theme	Icon	Scoring system		
Wildfire frequency		1	2	3-4
Peak wildfire season and tourism		1	2	3-4
Communication a. Language b. Channels c. Functionality d. Communication type		3	4-15	16-52
Tourist and resident types		5-10	11-15	16-20
Transportation & assembly		1-2	3-5	6-8
Human vulnerability		1-3	4-5	6-8
Reaching remote populations		1	2	3-4
Financially inclusive emergency planning		2	3-6	7-8
Challenges and opportunities		0-3	4-8	9-20

The process of the tool development can be seen in Figure 3. The link to the tool is available in the Appendix III.

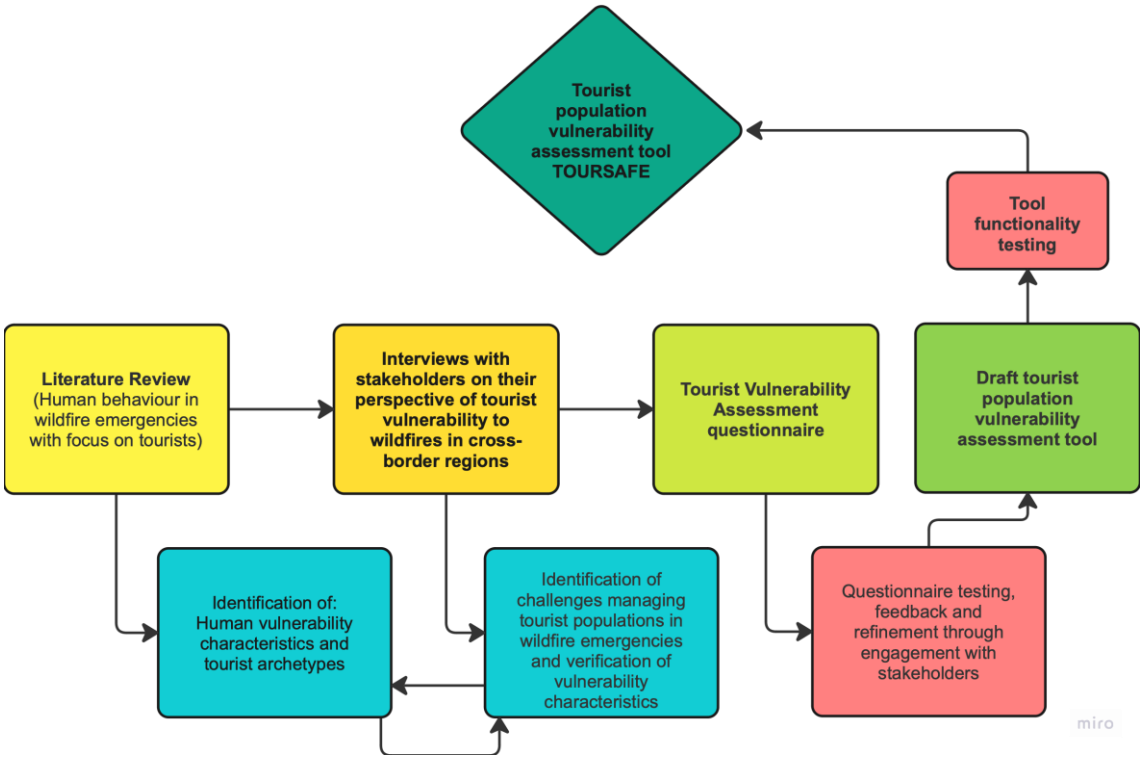

Figure 3 Flowchart of the tourist population vulnerability assessment tool development.

Future research should also involve testing wildfire evacuation models with different population compositions. This means to subsequently analyse evacuation procedures systematically. Such efforts could serve to evaluate the vulnerability of existing tourist communities and assess the vulnerability of communities year-round. Essentially, a practical understanding of the population types, including tourists, in a specific area is valuable for purposes such as fine-tuning simulation tool inputs and evaluating the influence of seasonal population fluctuations on susceptibility to wildfires or other hazards.

Final remarks with regards to the vulnerability assessment tool

The tool should be seen as a first development of this kind. However, the current version of the tool achieves the goal of being easy to use, accessible, and tailored to the challenges that individual users of the tool may face, conveys achievable guiding advice in short-, medium-, and long term, and is flexible for future updates and improvements. As more information becomes available and feedback is generated from the use of the current tool, adjustments can be made accordingly. This tool serves as a guidance only, and its applications should always be informed by experienced disaster risk reduction professionals.

5. Guidelines for good practices for human protection

The guidelines are structured to offer qualitative advice for addressing the issues most encountered in wildfire emergencies, particularly concerning the management of tourist populations in cross-border WUI areas. Each theme presented here offers multiple action tasks that can support emergency managers and authorities in preparedness, mitigation, and response phases of wildfire disaster management.

These guidelines are informed by the literature review (Section 1), qualitative interviews with stakeholders (Section 2), as well as being aligned with general principles from WUI wildfire safety management in communities (US Fire Administration, 2022; Firewise NFPA 2024; Australian Institute for Disaster Resilience, 2024), human behaviour in wildfires (SFPE, 2018), past wildfire incidents, and the fields of psychology, economics and communication.

The guidelines serve as output for the tourist population vulnerability assessment tool (Section 4), presenting users only with relevant elements corresponding to vulnerabilities identified in response to tool questions.

5.1. Wildfire frequency

Tourism during the peak wildfire season can present several challenges, especially when wildfires are frequent. However, even occasional wildfire events can be seen as an opportunity to prepare for potential wildfire risks to people.

Action tasks

- Identify areas where wildfires can occur and ensure proper fire risk mitigation and response strategies for those areas.
  Assessing risk is usually the first step to disaster risk reduction planning. This helps prioritize resources and efforts for targeted mitigation measures.
- To mitigate wildfire risks, it is crucial to ensure that people are aware of the risks. This applies to everyone, even those who might already assume they are aware, such as local residents or returning tourists. This is important because individuals might underestimate the potential impact of wildfires if they have managed to avoid them in the past or have had successful evacuations, a phenomenon known as optimistic bias or the 'cry wolf' effect.
  A key element for wildfire risk mitigation in communities is people's adequate knowledge of wildfire risks and their mitigation practices, as well as knowledge of appropriate protective actions in response to a wildfire.

5.2. Peak wildfire season and tourism

Tourists may be more vulnerable to accidents in wildfire compared to local populations. Thinking about emergency communications, preferred modes of evacuation, capacity to shelter and evacuate people, and any assistance they may need to provide safety for everyone.

Action tasks

- Learn when most tourists visit the municipality and the level of fire danger during that time.
  During peak tourist times, the communication strategy should consider the fire risk context to inform tourists and raise awareness among the disaster risk reduction/civil protection system and local residents.
- Perform training for preparedness and response to wildfires to assist tourists.
  Training, information, and knowledge-building are key aspects of community safety in disaster risk mitigation. Tourists are often not considered part of the 'community' mindset and thus miss out on significant opportunities to contribute to wildfire safety.

5.3. Communication language

Tourists may think that if they cannot understand the information, it is not for them. Even if very few tourists do not understand the emergency communication, it can put them at risk and strain emergency services.

Action tasks

- Identify the languages spoken by tourists and provide necessary emergency information in these languages.
  Instructions, evacuation notices, and safety guidelines should be accessible and understandable to all visitors. Similar to signage in a building, information should either be universally comprehensible or translated into languages that visitors will understand.
- Collaborate with local tourism organizations, hotels, and transportation services to gather information on the communication methods most frequently utilized by tourists during emergencies.
  A collaborative approach fosters synergy among tourism stakeholders, facilitating the sharing of insights and lessons learned to enhance the protection of tourist populations during wildfire emergencies.

5.4. Communication channels

Different segments of population may be used to and aware of different information channels, some will also check several channels to look for more information.

Action tasks

- Identify what channels are being used by tourists and use them to specifically reach out to tourists who may not be familiar with the locally used channels.
  Emergency communication should be consistent. Using the same information channels can reduce misinformation and misunderstanding. For instance, tourists should rely on updates from local authorities rather than international news sources via family and friends.
- Maximize the chances of emergency information being received by using multiple channels.
  Over-reliance on a single communication channel may exclude certain populations and lacks redundancy in case of communication failures.
- Keep the messaging consistent across the channels to not confuse the population.
  Wildfire messaging should be adapted to the channel while consistently providing relevant information. Research has shown that content, style, message length will have influence on action-taking.

5.5. Functionality of communications

In assessing the functionality and effectiveness of communication channels for reaching tourists during emergencies, it becomes evident that each method presents unique advantages and challenges. Thoroughly evaluating each communication channel functionality will allow improving chances that people in need of information at a critical time will be able to receive it. It is also important that people are aware of the protective actions associated with certain communication types that do not have instructions (such as sounds). This is even more relevant where multiple hazards are present and each may require different alerting strategy, which can be confusing to people who are not familiar with the differences in these strategies.

Action tasks

*For the use of **sirens**, consider principles outlined in fire safety guidance regarding fire detection and alarm, in combination with effective use of communication channels.*

- Ensure that sirens are strategically placed in tourist-heavy areas and complement them with other communication methods such as mobile alerts or social media announcements to reach tourists who may not hear the sirens.

- Consider alternative methods such as mobile alerts or public address systems, as sirens alone may not effectively reach tourists, especially in crowded or indoor environments.
- Conduct thorough testing and evaluations to determine the effectiveness of sirens in reaching tourists during emergencies and consider integrating them with other communication channels for improved coverage and clear instructions.

For the use of mobile alerts, consider best practice of emergency alerting in other emergencies, such as earthquakes and weather events.

- Enhance the effectiveness of mobile alerts by ensuring good coverage is available and addressing any potential issues with network congestion or device compatibility.
- Investigate potential barriers to receiving mobile alerts, such as poor network coverage or tourists opting out of emergency notifications and implement measures to overcome these obstacles.
- Monitor the response rates and feedback from tourists regarding mobile alerts during emergency situations and make adjustments as needed to improve their reliability and relevance.

*For the use of **public address systems**, consider principles outlined in fire safety guidance regarding fire detection and alarm, in combination with effective use of communication channels.*

- Optimize public address systems by ensuring clear and multilingual announcements, particularly in tourist-dense areas, and consider integrating them with other communication methods for broader coverage.
- Address issues such as poor audio quality or limited reach of public address systems and explore alternative communication channels that may better suit the needs of tourists during emergencies.
- Evaluate the effectiveness of public address systems in reaching tourists based on feedback and observations during emergency drills or real-life scenarios and implement improvements accordingly.

*For the use of **radio broadcasts**, consider best practice for the use of public information channels in emergency management.*

- Improve the accessibility of radio broadcasts for tourists by providing multilingual content and promoting the availability of radios or radio apps, particularly in areas frequented by tourists.
- Recognize the limitations of radio broadcasts in reaching tourists, especially those who do not have access to radios or do not understand the broadcast language and prioritize alternative communication methods.
- Assess the reach and impact of radio broadcasts on tourists during emergency situations and consider supplementing them with other communication channels to ensure comprehensive coverage.

*For the use of **social media**, consider best practice for the use of social media in emergency management.*

- Enhance the effectiveness of social media communication by regularly updating channels with relevant emergency information and engaging with tourists to address their concerns or questions.
- Address potential issues such as limited access to social media platforms or low engagement rates among tourists and explore alternative communication methods that may better suit their preferences and habits.
- Monitor the engagement and response rates on social media channels during emergencies and adjust the content and timing of posts as needed to maximize their impact on reaching tourists.

*For the use of **emergency notification applications** (downloadable as opposed to network-based), consider best practice of emergency alerting in other emergencies, such as earthquakes and weather events.*

- Improve the functionality and accessibility of emergency notification apps by providing clear instructions for tourists to download and use them and ensure that alerts are timely and relevant to their location.
- Address any technical issues or usability challenges with emergency notification apps and explore alternative solutions that may better serve the needs of tourists during emergencies.
- Gather feedback from tourists about their experience with emergency notification apps and consider implementing enhancements based on their suggestions and preferences.

*For **community meetings**, consider community wildfire risk management advice.*

- Explore ways to make community meetings more inclusive and accessible to tourists, such as providing translated materials or offering virtual participation options. Additionally, focus on disseminating information discussed during community meetings through other communication channels that are more accessible to tourists.
- Recognize the limitations of community meetings in reaching tourists, particularly those who are transient or not involved in local community affairs. Instead, prioritize the development of alternative strategies such as targeted information sessions or workshops specifically tailored for tourists.
- Consider implementing measures to improve outreach and participation, such as promoting community meetings through tourist-facing establishments.

5.6. Communication type

Tailoring communication for diverse tourist groups is essential for effective emergency response.

Action tasks

- Understand people's potential needs in a wildfire emergency.
  Depending on the choice between evacuation and shelter-in-place, tourists may need guidance or support in taking protective action. Accommodating their needs for water, food, shelter for pets, among other things, for evacuation, and providing care, and support for wellbeing during and after wildfire event tailored with principles of human-centered design is important.
- Create child-friendly materials and dedicated assistance centres for families, providing clear evacuation / shelter-in-place guidance.
  Children can be seen to influence adults by bringing their attention to information concerning wildfire preparedness, which could be an effective way to reach wider populations.
- Emphasize personal emergency planning and staying connected for solo travellers.
  Solo travellers may lack support networks to keep them informed. Strategies to keep them connected to emergency information are crucial and depend on the context and available communication channels.
- Ensure communication materials are accessible to individuals depending on their age and functional limitations.
  Some people may be less connected to dynamic information sources, face language barriers, and have different needs. Supporting them specifically at tourist assistance points can facilitate their safety. This could include but not be limited to accessing the internet, purchasing tickets online if travels are cut-short due to wildfire emergencies, booking accommodation online, among other things.
- Increase patrols and monitoring in areas frequented by young tourists during high-risk periods.
  Engaging with young people in areas where they may engage in risky fire-related activities can help identify and intervene early.
- Provide specialized training for tour operators to effectively communicate wildfire risks and information with different tourist groups.
  Tour operators are responsible for large groups, which typically remain together during emergencies. Specific skills of these operators in managing groups should be utilized in directing them and informing them about wildfire emergencies.
- Train staff at visitor centres and tour companies to communicate wildfire safety information effectively.
  Staff at visitor centres have experience communicating with tourists and insight into their activities. This helps anticipate potential communication loss or risks, such as wildfires during high fire days and implications for activities such as hiking, among others.
- Implement clear plans for family and group reunification during evacuations, including designated meeting points.

Groups and families often prefer to stick together during evacuation or shelter-in-place situations. They should be informed of the best organizing strategies for wildfire emergencies.

5.7. Tourist and resident types

The level of knowledge and experience varies across different tourist and local population types (such as first-time tourists, recurring tourists, one-day tourists, seasonal residents, and local residents). It is beneficial to know who is visiting or residing in the municipality to target preparedness and emergency information.

Action tasks

- Provide clear and concise information about wildfire risks and safety measures upon arrival at tourist hubs, hotels, and attractions.
  Reducing cognitive load when presenting information will help tourists find and retain the information they need. For example, using postcards with essential information would be an effective way to disseminate it and ensure tourists keep it throughout their holiday.
- Implement targeted communication campaigns through email newsletters or mobile apps to remind recurrent tourists of safety measures.
  Recurrent, among other types of tourists should have access to the most up-to-date wildfire risk information and can incorporate that in planning their holidays, as opposed to finding all information only on their arrival.
- Encourage recurrent tourists to download emergency notification apps for real-time updates.
  Recurrent tourists can access the most up-to-date wildfire risk information and incorporate it into their holiday planning, rather than relying solely on information obtained upon arrival. Reminding recurrent tourists of their return and the importance of using applications to stay safe and informed may incentivize them to download the applications.
- Designate and train select local residents as tourist liaisons or ambassadors to assist tourists during emergencies.
  Differences in wildfire knowledge are common between local and tourist populations, as tourists do not usually take part in community wildfire risk reduction and wildfire preparedness activities. For example, incentivizing local residents' involvement in educating tourists through opportunities such as when hosting them or providing services would support the dissemination of knowledge.

5.8. Evacuation and shelter-in-place strategy

Regardless of whether the preferred strategy based on wildfire emergency plan is evacuation or shelter-in-place, the aim should be to communicate, and inform tourists

and population about the advantages of following the strategy and risks involved in both compliance and non-compliance with the official advice.

Action tasks

- Coordinate with the wildfire emergency managers cross-border if their strategy for wildfire response is different - they may prefer evacuation over confinement and vice versa.
  Confusion among tourists may arise if two different strategies are employed in close proximity, potentially leading to non-compliance. Coordination of how two strategies may interact, their effects or possible harmonization would potentially minimize non-compliance.
- Consider whether current road and path network is sufficient for potential evacuation.
  Even if evacuation is not the preferred strategy, planning for a wildfire emergency should include consideration of worst-case scenarios for road blockages and mitigation plans. This is especially important when the available roads are few and narrow, but may also be applicable in other contexts.
- People may still want to evacuate if the advice is to shelter-in-place, therefore it would be advisable to inform people about the advantages of the preferred response in order for them to comply.
  Trust in disaster management decisions could be strengthened by explaining the advantages of certain protective actions. This also helps manage emotions such as helplessness, fear, and anxiety that tourists may experience during a wildfire emergency.
- Train touristic infrastructure staff to supervise evacuation efforts in case they are needed.
  Staff management of evacuation is important, particularly in reducing pre-evacuation time at night when staff can assist in waking tourists.
- Ensure provisions of adequate lighting for potential night-time evacuations.
  Evacuation paths should be well lit and clearly marked with illuminated signage, as road signs may not be visible to pedestrians at night.

5.9. Transportation & assembly

Multiple options available to tourists and locals ensures flexibility and efficiency during the evacuation procedure. Providing organised evacuation means sufficiently for the population is vital for their safety. In cases where insufficient resources do not permit access to organised evacuation such as public buses for everyone, people should be informed of the available evacuation options. When wildfire evacuation on foot is considered, it should be as easy as possible for people to achieve.

Action tasks

- Provide clear guidance to tourists and local people in advance on using private vehicles for evacuation, including designated routes, assembly points, and safety considerations.
- Establish safe parking and assembly areas for private vehicles, ensuring sufficient space for organized and efficient evacuation.
- Provide assembly points away from the evacuation routes for cars / away from evacuation traffic.
- Provide more than 1 assembly point and illustrate them in maps available throughout the area indicating the nearest exit.
- Provision of public evacuation transport should be considered in relation to other traffic and road availability.
- It is possible that some tourists and local people may not have ability to evacuate using their private vehicle or will exclusively prefer to use their own vehicle for evacuation. Think about alternative options ahead of time by getting to know which tourists and local residents will need help with evacuation.
- Identify and communicate about alternative evacuation modes, such as public transportation, shuttles, or arranged group transport, to accommodate diverse preferences and situations.
- In planning for on-foot evacuation from wildfires, prioritize evacuation routes that minimize steep inclines and obstacles, ensuring accessibility for all individuals.
- Break down long distances into manageable segments, providing rest areas and checkpoints along the way.
- Tailor evacuation plans to accommodate diverse capabilities, including the elderly, children, and individuals with functional limitations, and regularly test and refine these plans through community drills and exercises.

5.10. Human vulnerability

People can have varying susceptibility to wildfire effects, such as heat and smoke (Purser, 2008). Ensuring well-being of everyone affected by wildfire should be a thorough process, therefore consulting relevant guidelines is advisable.

Action tasks

- Identify and designate shelter spaces equipped with systems that provide cooling, water, among other things that meet people's specific needs in relation to a wildfire emergency.
- Provide items to safeguard people's well-being, which may include but should not be limited to medications, cooling supplies, and respiratory protection gear.

5.11. Reaching remote populations

Certain challenges can be posed if people are residing remotely, so plans for evacuation, shelter, effective communication should aim keep these populations informed and connected.

Action tasks

- Consider access to remotely located individuals and plan for logistics to evacuate or shelter them in case of a wildfire.
- Make sure these individuals have access to means of communication and can receive important information.

5.12. Financially inclusive emergency planning

Understanding the economic status of tourists and local residents in an area facing wildfire risks is crucial for creating inclusive safety plans. People in different income groups may have varying needs and resources during emergencies and it may affect how they make decisions (Katzilieris et al., 2022; Cahyanto et al., 2014; Cohn et al., 2006).

Action tasks

- Create evacuation plans that consider the needs of people with low incomes, ensuring affordable and accessible evacuation options.
  If evacuation is required, people with lower incomes may be the most hesitant to leave as they may not have the resources to stay away, stock up or keep their belonging secure while away. Alleviating the financial burden of evacuation for individuals with lower incomes may serve as a strong incentive for their compliance in emergency wildfire situations.
- Create options for sharing resources and providing assistance to those facing economic challenges.
  While people do not tend to act selfishly during emergencies, research suggests that they may not always be motivated to share their resources with strangers. Therefore, promoting and rewarding such behaviours could influence how people support each other during emergencies.

5.13. Challenges and opportunities

People may face various difficulties during emergencies, such as not knowing where to go for safety, lacking awareness of evacuation procedures, or having language barriers, functional limitations, or logistical issues. Understanding and preparing for these challenges is essential to ensuring the safety of all residents and visitors in the municipality.

This portion of the guidelines targets the most common concerns that authorities may encounter when planning for evacuation. By explicitly highlighting these challenges, there is an opportunity to review existing plans and incorporate elements that directly address them in the most suitable way.

Action tasks

- Distribute informational materials and create digital maps detailing shelter locations and transportation options.
- Conduct community outreach campaigns to raise awareness of available emergency shelters, their locations, and amenities.
- Implement educational initiatives, including workshops and drills, to familiarize residents and tourists with evacuation protocols and routes.
- Utilize multiple communication channels to disseminate clear and concise evacuation instructions, including social media, public announcements, and mobile alerts.
- Provide training and resources to support the use of communication technologies, particularly among vulnerable populations.
- Develop targeted messaging campaigns emphasizing the seriousness of wildfire threats and the importance of preparedness.
- Share real-life stories and testimonials to illustrate the potential consequences of disregarding wildfire risks.
- Expand the reach of emergency information channels by leveraging multiple platforms, including radio broadcasts, emergency notification apps, and community meetings.
- Translate essential emergency information into multiple languages commonly spoken by tourists and locals.
- Train bilingual staff or volunteers to provide language support and interpretation services during emergencies.
- Incorporate messaging on responsible alcohol consumption into wildfire preparedness campaigns.
- Provide alternative transportation options and designated sobering centres to assist individuals who may be impaired during evacuations.
- Develop tailored evacuation plans and resources for individuals with functional limitations, including accessible transportation and shelter accommodations.
- Conduct regular accessibility assessments of evacuation routes and facilities to identify and address barriers.
- Inform tourists and educate the locals about the importance of prioritizing safety over personal belongings during evacuations.
- Establish protocols for streamlined evacuation processes, including pre-designated meeting points.

- Foster a culture of community responsibility and accountability by encouraging tourists and locals to adhere to established protocols for their safety and the safety of others.

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Appendix

I. Human vulnerability assessment questionnaire

Table 5 Operationalisation of the tourist vulnerability assessment questionnaire for the tourist population vulnerability assessment tool.

#	Question	Answer	Score
0	Please, indicate your area of responsibility / jurisdiction	FREE TEXT	N/A
1	How often do wildfires occur in the touristic area under consideration (municipality / touristic sector area)? *(TIP: Very often could be considered as more than 2 large wildfires per season; often could be between once and twice every season; occasional wildfires could be happening one year but some years they would not occur)*	Very often	4
		Often	3
		Occasionally	2
		Rarely or never	1
2	What is the estimated proportion of tourists in the touristic area under consideration during the PEAK WILDFIRE SEASON, e.g. summer? *(TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)*	Most people or everyone	4
		More than a half	3
		Less than a half	2
		Not many	1
		I don't know / not sure	4
3	What is the proportion of population that will understand the emergency communication language(s) that you use? *(TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)*	Most people or everyone	1
		More than a half	2
		Less than a half	3
		Not many	4
		I don't know / not sure	4
4	Are there dedicated communication channels for **tourists**, providing information on fire risk and how to act in emergencies?	Yes	1
		No	9
5	What types of emergency communication channels are utilized in general in the touristic area under consideration?		
	Sirens	Yes	0
		No	1
	Mobile alerts	Yes	0
		No	1
	Public address systems	Yes	0
		No	1
	Radio broadcasts	Yes	0
		No	1

#	Question	Answer	Score
	Social media	Yes	0
		No	1
	Emergency notification apps	Yes	0
		No	1
	Community meetings	Yes	0
		No	1
	Other (please specify)	FREE TEXT	N/A
	None of the above or other	Yes	10
		No	0
6	How would you rate the communication channels you chose to reach tourists in an emergency?		
	Sirens	Useful	1
		Sometimes useful	2
		Not useful at all	3
		Hard to say / Differs depending on the type of tourists	4
	Mobile alerts	Useful	1
		Sometimes useful	2
		Not useful at all	3
		Hard to say / Differs depending on the type of tourists	4
	Public address systems	Useful	1
		Sometimes useful	2
		Not useful at all	3
		Hard to say / Differs depending on the type of tourists	4
	Radio broadcasts	Useful	1
		Sometimes useful	2
		Not useful at all	3
		Hard to say / Differs depending on the type of tourists	4
	Social media	Useful	1
		Sometimes useful	2
		Not useful at all	3
		Hard to say / Differs depending on the type of tourists	4
	Emergency notification apps	Useful	1
		Sometimes useful	2
		Not useful at all	3

#	Question	Answer	Score
		Hard to say / Differs depending on the type of tourists	4
	Community meetings	Useful	1
		Sometimes useful	2
		Not useful at all	3
		Hard to say / Differs depending on the type of tourists	4
	Other (please specify)	Useful	1
		Sometimes useful	2
		Not useful at all	3
		Hard to say / Differs depending on the type of tourists	4
7	Which of the following categories of **tourists** are present in the touristic area under consideration during the peak wildfire season?	Families	2
		Solo travellers	2
		Young individuals	2
		Older individuals	2
		Large groups	2
		I don't know / not sure	10
8A	Can you provide an estimate proportion of the types of **tourists** in the touristic area under consideration? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)		
	First-time tourists	Most people or everyone	4
		More than a half	4
		Less than a half	2
		Not many	1
		I don't know / not sure	4
	Recurrent (returning) tourists	Most people or everyone	1
		More than a half	1
		Less than a half	2
		Not many	1
		I don't know / not sure	4
	One-day tourists	Most people or everyone	4

#	Question	Answer	Score
		More than a half	4
		Less than a half	2
		Not many	1
		I don't know / not sure	4
8B	Can you provide an estimate proportion of **seasonal locals** and **year-round locals** in the touristic area under consideration? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)		
	Local residents	Most people or everyone	1
		More than a half	1
		Less than a half	2
		Not many	1
		I don't know / not sure	4
	Seasonal locals (people who locally own a property but would stay only throughout a peak season)	Most people or everyone	1
		More than a half	1
		Less than a half	2
		Not many	1
		I don't know / not sure	4
9A	What is the preferred protective strategy according to your disaster response plan in response to a wildfire in the touristic area under consideration?	Evacuation	N/A
		Shelter-in-place / confinement	N/A
		It depends on the situation	N/A
9B	What is the **preferred** mode of evacuation in the touristic area under consideration in case a wildfire emergency requires evacuation to be performed?	Private vehicle	N/A
		Public buses	N/A
		On foot	N/A
		Other (such as boats, helicopters or other fire safety services vehicles)	N/A
10A	What proportion of **local residents** in the touristic area under consideration have access to a private vehicle? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)	Most people or everyone	IF Q9 = Private Vehicle THEN score = 1 IF Q9 = Public buses OR On Foot OR Other THEN score = 4

#	Question	Answer	Score
		More than a half	IF Q9 = Private Vehicle THEN score = 2 IF Q9 = Public buses OR On Foot OR Other THEN score = 4
		Less than a half	IF Q9 = Private Vehicle THEN score = 2 IF Q9 = Public buses OR On Foot OR Other THEN score = 4
		Not many	IF Q9 = Private Vehicle THEN score = 4 IF Q9 = Public buses OR On Foot OR Other THEN score = 2
		I don't know / not sure	4
10B			
	What percentage of **tourists** in the touristic area under consideration have access to a private vehicle? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)	Most people or everyone	IF Q9 = Private Vehicle THEN score = 1 (NO ADVICE) IF Q9 = Public buses OR On Foot OR Other THEN score = 4 (ADVICE HERE)
		More than a half	IF Q9 = Private Vehicle THEN score = 2 (ADVICE HERE) IF Q9 = Public buses OR On Foot OR Other THEN score = 4

#	Question	Answer	Score
		Less than a half	IF Q9 = Private Vehicle THEN score = 2 IF Q9 = Public buses OR On Foot OR Other THEN score = 4
		Not many	IF Q9 = Private Vehicle THEN score = 4 IF Q9 = Public buses OR On Foot OR Other THEN score = 2
		I don't know / not sure	4
11	If the preferred mode is public buses or other means, is the capacity for people to be evacuated by public busses, or other means, sufficient?	Sufficient for everyone to get out safely	1
		Sufficient for most people to get out safely	2
		Somewhat sufficient	3
		Not at all sufficient	4
		I don't know / not sure	4
		Does not apply	N/A
12	If the preferred mode is on foot, how easy is it for people to access the shelter / safe place if evacuating on foot?	Easy	1
		Somewhat easy	2
		Not at all easy	3
		I don't know / not sure	4
		Does not apply	N/A
13 A	Which age group of the **local** population is the largest in the touristic area under consideration?	0-18	4
		19-30	2
		31-50	1
		51-65	3
		65+	4
		Varied age groups	4
13 B	Which age group of the **tourist** population is the largest in the touristic area under consideration?	0-18	4
		19-30	2
		31-50	1
		51-65	3
		65+	4
		Varied age groups	4

#	Question	Answer	Score
14	What proportion of people live in rural / areas that are difficult to reach by a vehicle? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)	Most people or everyone	4
		More than a half	3
		Less than a half	2
		Not many	1
		I don't know / not sure	4
15 A	What is the economic status of people who are in the touristic area under consideration who are **locals**?	High income	1
		Upper-middle income	2
		Middle income	3
		Low income	4
		I don't know / not sure	4
15 B	What is the economic status of people who are in the touristic area under consideration who are **tourists**?	High income	1
		Upper-middle income	2
		Middle income	3
		Low income	4
		I don't know / not sure	4
16 A	Which of the following concerns you about **tourists** as a potential challenge during a wildfire evacuation in the touristic area under consideration?		
	Lack of knowledge of emergency shelters	Yes	1
		No	0
	Lack of knowledge of evacuation procedures	Yes	1
		No	0
	Poor perception of danger from wildfires	Yes	1
		No	0
	Limited access to emergency information channels	Yes	1
		No	0
	Limited language capabilities to understand emergency information	Yes	1
		No	0
	Limitations to evacuate or follow emergency procedures (e.g. disorientation) caused by alcohol	Yes	1
		No	0
	Limitations to evacuate or follow emergency procedures caused by disability (e.g. physically difficult to move)	Yes	1
		No	0
	Logistic difficulties that cause evacuation delays (people collecting luggage, or without access to their vehicle)	Yes	1
		No	0
		Yes	1

#	Question	Answer	Score
	Logistic difficulties that cause traffic such as people sticking together if they know each other	No	0
	Disobedience of emergency procedures by tourists	Yes	1
		No	
16 B	Which of the following concerns you about **locals** as a potential challenge during a wildfire evacuation in the touristic area under consideration?		
	Lack of knowledge of emergency shelters	Yes	1
		No	0
	Lack of knowledge of evacuation procedures	Yes	1
		No	0
	Poor perception of danger from wildfires	Yes	1
		No	0
	Limited access to emergency information channels	Yes	1
		No	0
	Limited language capabilities to understand emergency information	Yes	1
		No	0
	Limitations to evacuate or follow emergency procedures (e.g. disorientation) caused by alcohol	Yes	1
		No	0
	Limitations to evacuate or follow emergency procedures caused by disability (e.g. physically difficult to move)	Yes	1
		No	0
	Logistic difficulties that cause evacuation delays (people collecting personal belongings, or without access to their vehicle)	Yes	1
		No	0
	Logistic difficulties that cause traffic such as people sticking together as families	Yes	1
		No	0
	Disobedience of emergency procedures by locals	Yes	1
		No	0

II. Tool testing – case study

As described in the Section 4, the TOURSAFE tool has been tested at a final stage of its development inviting the interested parties participate through the network of the WUITIPS project. One of such participants was a Mayor at a Spanish municipality which acknowledges a potential wildfire risk to tourists and local populations. The testing exercise took place online, where the researcher has gone through the questionnaire in Spanish in real time, while the participant was reflecting on the real-life situation in their municipality as well as giving feedback on the questionnaire clarity, and the relevance of questions and answer options.

Table 6 Case study example as presented during the testing phase; Case study location: Spain. Colour scheme: Grey/white interchangeable: separates questions; Blue: identifies answer options that can be modified by the user; Red: identifies automatic scoring dependent on the answer option, non-modifiable directly.

#	Question	Answer	Score
0	Please, indicate your area of responsibility / jurisdiction	Mayor	
1	How often do wildfires occur in the touristic area under consideration (municipality / touristic sector area)? *(TIP: Very often could be considered as more than 2 large wildfires per season; often could be between once and twice every season; occasional wildfires could be happening one year but some years they would not occur)*	Rarely or never	***1***
2	What is the estimated proportion of tourists in the touristic area under consideration during the PEAK WILDFIRE SEASON, e.g. summer.? *(TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)*	Less than a half	***2***
3	What is the proportion of population that will understand the emergency communication language(s) that you use? *(TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)*	More than a half	***2***
4	Are there dedicated communication channels for **tourists**, providing information on fire risk and how to act in emergencies?	No	***9***
5	What types of emergency communication channels are utilized in general in the touristic area under consideration?		
	Sirens	No	***1***
	Mobile alerts	Yes	***0***
	Public address systems	No	***1***
	Radio broadcasts	No	***1***
	Social media	Yes	***0***
	Emergency notification apps	Yes	***0***
	Community meetings	Yes	***0***
	Other (please specify) (highway signage panels)	No	***1***
	None of the above or other	No	***0***
6	How would you rate the communication channels you chose to reach tourists in an emergency?		
	Sirens		***0***
	Mobile alerts	Hard to say / Differs depending on the type of tourists	***4***
	Public address systems		***0***
	Radio broadcasts		***0***

#	Question	Answer	Score
	Social media	Hard to say / Differs depending on the type of tourists	*4*
	Emergency notification apps	Hard to say / Differs depending on the type of tourists	*4*
	Community meetings	Useful	*1*
	Other (please specify)		*0*
7	Which of the following categories of **tourists** are present in the touristic area under consideration during the peak wildfire season?		
	Families	Yes	*2*
	Solo travelers	Yes	*2*
	Young individuals	Yes	*2*
	Older individuals	Yes	*2*
	Large groups	Yes	*2*
	I don't know / not sure		*0*
8A	Can you provide an estimate proportion of the types of **tourists** in the touristic area under consideration? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)		
	First-time tourists	Less than a half	*2*
	Recurrent (returning) tourists	Most people or everyone	*4*
	One-day tourists	More than a half	*3*
8B	Can you provide an estimate proportion of **seasonal locals** and **year-round locals** in the touristic area under consideration? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)		
	Local residents	Most people or everyone	*1*
	Seasonal locals (people who locally own a property but would stay only throughout a peak season)	More than a half	*1*
9A	What is the preferred protective strategy according to your disaster response plan in response to a wildfire in the touristic area under consideration?	Shelter-in-place / confinement	
9B	What is the **preferred** mode of evacuation in the touristic area under consideration in case a wildfire emergency requires evacuation to be performed?	Private vehicle	

#	Question	Answer	Score
10A	What proportion of **local residents** in the touristic area under consideration have access to a private vehicle? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)	Most people or everyone	*1*
10B	What percentage of **tourists** in the touristic area under consideration have access to a private vehicle? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)	Most people or everyone	*1*
11	If the preferred mode is public buses or other means, is the capacity for people to be evacuated by public busses, or other means, sufficient?	Does not apply	*0*
12	If the preferred mode is on foot, how easy is it for people to access the shelter / safe place if evacuating on foot?	Does not apply	*0*
13A	Which age group of the **local** population is the largest in the touristic area under consideration?	51-65	*3*
13B	Which age group of the **tourist** population is the largest in the touristic area under consideration?	Varied age groups	*4*
14	What proportion of people live in rural / areas that are difficult to reach by a vehicle? (TIP: You can also think in terms of percentages for Most people or everyone = 70-100%; More than a half = 50-70%; Less than a half = 40-50%; Not many = under 40%)	Not many	*1*
15A	What is the economic status of people who are in the touristic area under consideration who are **locals**?	Middle income	*3*
15B	What is the economic status of people who are in the touristic area under consideration who are **tourists**?	Middle income	*3*
16A	Which of the following concerns you about **tourists** as a potential challenge during a wildfire evacuation in the touristic area under consideration?		
	Lack of knowledge of emergency shelters	Yes	*1*
	Lack of knowledge of evacuation procedures	Yes	*1*
	Poor perception of danger from wildfires	Yes	*1*
	Limited access to emergency information channels	No	*0*
	Limited language capabilities to understand emergency information	No	*0*
	Limitations to evacuate or follow emergency procedures (e.g. disorientation) caused by alcohol	No	*0*
	Limitations to evacuate or follow emergency procedures caused by disability (e.g. physically difficult to move)	No	*0*
	Logistic difficulties that cause evacuation delays (people collecting luggage, or without access to their vehicle)	No	*0*

#	Question	Answer	Score
	Logistic difficulties that cause traffic such as people sticking together if they know each other	No	*0*
	Disobedience of emergency procedures by tourists	No	*0*
16B	Which of the following concerns you about **locals** as a potential challenge during a wildfire evacuation in the touristic area under consideration?		
	Lack of knowledge of emergency shelters	No	*0*
	Lack of knowledge of evacuation procedures	No	*0*
	Poor perception of danger from wildfires	No	*0*
	Limited access to emergency information channels	No	*0*
	Limited language capabilities to understand emergency information	No	*0*
	Limitations to evacuate or follow emergency procedures (e.g. disorientation) caused by alcohol	No	*0*
	Limitations to evacuate or follow emergency procedures caused by disability (e.g. physically difficult to move)	No	*0*
	Logistic difficulties that cause evacuation delays (people collecting personal belongings, or without access to their vehicle)	No	*0*
	Logistic difficulties that cause traffic such as people sticking together as families	No	*0*
	Disobedience of emergency procedures by locals	No	*0*

Case study results presented to the user can be seen below.

Scoring results for the different themes represented in the image below as the visualisation of the current trial output.

Figure 4 Trial output for score across the themes of vulnerability as assessed in the tool.

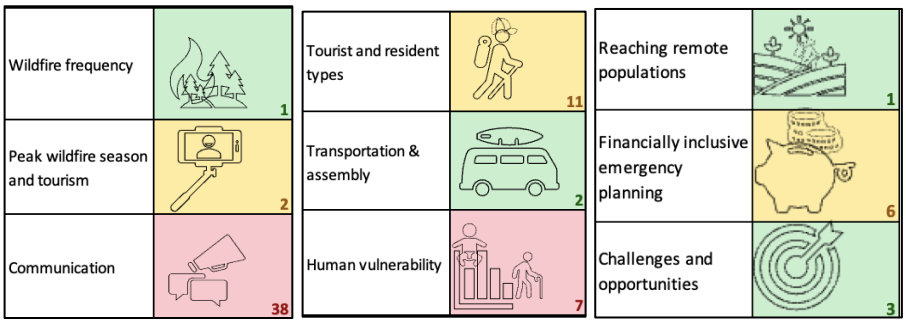

Table 7 Best practice guidelines as presented to the user after the completion of the questionnaire.

Wildfire frequency *Tourism during the peak wildfire season can present several challenges, especially when wildfires are frequent. However, even occasional wildfire events can be seen as an opportunity to prepare for potential wildfire risks to people.*

Action tasks:
You have no specific tasks related to this area.

Peak wildfire season and tourism

Tourists may be more vulnerable to accidents in wildfire compared to local populations. Thinking about emergency communications, preferred modes of evacuation, capacity to shelter and evacuate people, and any assistance they may need to provide safety for everyone.

Action tasks:
• Learn when most tourists visit the municipality and the level of fire danger during that time.
• Organise training where necessary for preparedness and response to wildfires to those who may assist tourists.

Communication language

Tourists may think that if they cannot understand the information, it is not for them. Even if very few tourists do not understand the emergency communication, it can put them at risk and strain emergency services.

Action tasks:
• Identify the languages spoken by tourists and provide necessary emergency information in these languages.

Communication channels

Different segments of population may be used to and aware of different information channels, some will also check several channels to look for more information.

Action tasks:
• Identify what channels are being used by tourists and use them to specifically reach out to tourists who may not be familiar with the locally used channels.
• Maximize the chances of emergency information being heard by using multiple channels.
• Keep the messaging consistent across the channels to not confuse the population.

Functionality of communications

In assessing the functionality and effectiveness of communication channels for reaching tourists during emergencies, it becomes evident that each method presents unique advantages and challenges. Thoroughly evaluating each communication channel functionality will allow improving chances that people in need of information at a critical time will be able to receive it.

Action tasks:
• Monitor the response rates and feedback from tourists regarding mobile alerts during emergency situations, and make adjustments as needed to improve their reliability and relevance.
• Monitor the engagement and response rates on social media channels during emergencies, and adjust the content and timing of posts as needed to maximize their impact on reaching tourists.
• Gather feedback from tourists about their experience with emergency notification apps, and consider implementing enhancements based on their suggestions and preferences.

Communication type

Tailoring communication for diverse tourist groups is essential for effective emergency response.

Action tasks:
• Create child-friendly materials and dedicated assistance centers for families, providing clear evacuation / shelter-in-place guidance.
• Emphasize personal emergency planning and staying connected for solo travelers.
• Increase patrols and monitoring in areas frequented by young tourists during high-risk periods. This can help identify any risky behavior early and provide an opportunity for intervention.
• Ensure communication materials are accessible to individuals depending on their age and functional limitations.
• Provide specialized training for tour operators to effectively communicate wildfire risks and information with different tourist groups.
• Train staff at visitor centers and tour companies to communicate wildfire safety information effectively.

• Implement clear plans for family and group reunification during evacuations, including designated meeting points.
Tourist and resident types *The level of knowledge and experience varies across different tourist and local population types (such as first-time tourists, recurring tourists, one-day tourists, seasonal residents, and local residents). It is beneficial to know who is visiting or residing in the municipality to target preparedness and emergency information.*
Action tasks: • Train staff at visitor centers and tour companies to communicate wildfire safety information effectively. • Provide clear and concise information about wildfire risks and safety measures upon arrival at tourist hubs, hotels, and attractions.
Evacuation and shelter-in-place strategy Regardless of whether the preferred strategy based on wildfire emergency plan is evacuation or shelter-in-place, the aim should be to communicate, and inform tourists and population about the advantages of following the strategy and risks involved in both compliance and non-compliance with the official advice.
Action tasks: • Coordinate with the wildfire emergency managers cross-border if their strategy for wildfire response is different - they may prefer evacuation over confinement and vice versa. • Consider whether current road and path network is sufficient for potential evacuation. People may still want to evacuate if the advice is to shelter-in-place, therefore it would be advisable to inform people about the advantages of the preferred response in order for them to comply. • Train touristic infrastructure staff to supervise evacuation efforts in case they are needed. • Ensure provisions of adequate lighting for potential night-time evacuations.
Transportation & assembly *Multiple options available to tourists and locals ensures flexibility and efficiency during the evacuation procedure. Providing organised evacuation means sufficiently for the population is vital for their safety. In cases where insufficient resources do not permit access to organised evacuation such as public buses for everyone, people should be informed of the available evacuation options. When wildfire evacuation on foot is considered, it should be as easy as possible for people to achieve. Providing organised evacuation means sufficiently for the population is vital for their safety. In cases where insufficient resources do not permit access to organised evacuation for everyone, people should be informed.* *When wildfire evacuation on foot is considered, it should be as inclusive and easy as possible for people to achieve.*
Action tasks: You seem to be doing fine in this area
Human vulnerability *People can have varying susceptibility to wildfire effects, such as heat and smoke. Ensuring well-being of everyone affected by wildfire should be a thorough process, therefore consulting relevant guidelines is advisable.*
Action tasks: • Identify and designate shelter spaces equipped with systems that provide cooling, water, among other things that meet people's specific needs in relation to a wildfire emergency. • Provide items to safeguard people's well-being, which may include but should not be limited to medications, cooling supplies, and respiratory protection gear.
Reaching remote populations *Certain challenges can be posed if people are residing remotely, so plans for evacuation, shelter, effective communication should aim keep these populations informed and connected.*
Action tasks:

You seem to be doing fine in this area
Financially inclusive emergency planning *Understanding the economic status of tourists and local residents in an area facing wildfire risks is crucial for creating inclusive safety plans. People in different income groups may have varying needs and resources during emergencies and it may affect how they make decisions.* **Action tasks:** • Create options for sharing resources and providing assistance to those facing economic challenges.
Challenges and opportunities *People may face various difficulties during emergencies, such as not knowing where to go for safety, lacking awareness of evacuation procedures, or having language barriers, functional limitations, or logistical issues. Understanding and preparing for these challenges is essential to ensuring the safety of all residents and visitors in the municipality.* **Action tasks:** • Distribute informational materials and create digital maps detailing shelter locations and transportation options. • Utilize multiple communication channels to disseminate clear and concise evacuation instructions, including social media, public announcements, and mobile alerts. • Develop targeted messaging campaigns emphasizing the seriousness of wildfire threats and the importance of preparedness. • Share real-life stories and testimonials to illustrate the potential consequences of disregarding wildfire risks.

III. Human vulnerability assessment tool

Vaiciulyte, S., & Ronchi, E. (2024). TOURSAFE: Human Vulnerability Assessment Tool. Zenodo. https://doi.org/10.5281/zenodo.11209158