

# **ADVANCES IN FOREST FIRE RESEARCH**

**2022**

**Edited by**

**DOMINGOS XAVIER VIEGAS  
LUÍS MÁRIO RIBEIRO**

## Implementation of "Safe Villages" settlements with surrounding areas of high hazard to wildfire: Outlook from the Algarve Region

Ana Gonçalves\*<sup>1</sup>; Sandra Oliveira<sup>1</sup>; José Luís Zêzere<sup>1</sup>

<sup>1</sup>*Centro de Estudos Geográficos, Instituto de Geografia e Ordenamento do Território, Universidade de Lisboa, Lisboa, Portugal; Laboratório Associado TERRA, {acng, sandra.oliveira1, zezere}@campus.ul.pt*

*\*Corresponding author*

### Keywords

Safe village; Safe people; Hazard; Algarve; Wildfires

### Abstract

Wildfires in Portugal are increasingly putting the population and existing assets at risk. In the aftermath of the fires of 2017, there was a renewed concern to increase the protection of settlements and the self-protection abilities of the population; as such, several initiatives were developed with the aim of increasing the resilience and safety of communities. This study analyzes the implementation of the "Safe Village and Safe People" program, created by the National Emergency and Civil Protection Authority, in the municipalities of the Algarve region, taking into account its spatial distribution and the relationship with hazard levels in the immediate surroundings of settlements (100 m). It also aims to analyze whether this program can be combined with other ongoing initiatives associated with fuel management and landscape transformation in the area surrounding the settlements. For this, a database was created with the location of the Safe Villages already implemented in the Algarve region, with the geographic coordinates defined by a point that intersects the village. This point was then spatially joined with the polygon of the matching built-up area, retrieved from the cartography of Built-up Areas of Portugal, to obtain the boundaries of the villages and delimit the 100 m buffer around. Then, the total hazardous area (of high and very high wildfire hazard) in the 100 m buffer around each Safe Village was retrieved. Finally, the hazardous area around the Safe Villages was analysed in relation to the total hazardous area around all the settlements of the region, to assess the adequacy of "Safe Villages" location with regard to hazard levels for the whole region. Results show that 135 Safe Villages are implemented in 9 municipalities of Algarve. Around 6.6% of the 100 m area surrounding all the settlements in the region presents high and very high hazard. The municipalities of Monchique and Aljezur have the largest hazardous area in the surrounding 100m of all their settlements (61.96% and 20.86%, respectively). When analyzing the implementation of Safe Villages program, the ones implemented in the municipality of Alcoutim cover a greater percentage of surrounding hazardous area (58.08%) in relation to the total. The efficiency of this program and, therefore, the protection of local communities, can be improved by selecting the villages with higher hazardous area around and by combining its implementation with different programs that focus on fuel management that promotes hazard reduction, such as the "Condominium of Villages", created by the Directorate General of the Territory.

### 1. Introduction

In the last decades, wildfires in Portugal have been increasing significantly, either by the high extent of burned area or by the high material damage and human losses they have caused (Bergonse et al., 2021; Gonçalves et al., 2021; Nunes et al., 2016; Oliveira et al., 2020; Vilar et al., 2016). These events put at risk local rural communities as well as urban areas, which increasingly expand into the wildland-urban interface (Tonini et al., 2018). Since the 1980s, these problems have been rising, essentially due to the rural exodus and farmland abandonment, with the subsequent accumulation of fuels in the areas surrounding settlements (areas that were once occupied by agriculture will now be covered by shrubland and/or forest) and the aging population that remains in rural communities (Ferreira-Leite et al., 2013; Nunes et al., 2016). All these factors increase the susceptibility to wildfires in these areas and increase the exposure of people, assets and natural areas (Ager et al., 2013; Gallardo et al., 2016; Vieira et al., 2009). The year 2017 was the most devastating to date in Portugal, with the largest recorded burned area (~ 500 000 ha) and more than hundred fatalities in the June and October fires (Comissão Técnica Independente, 2018; Instituto da Conservação da Natureza e das Florestas, 2017). These events renewed the need to improve the protection of human communities and to increase the coping capacity of the population (Alcasena et al., 2019; Costafreda-Aumedes et al., 2017; Gonçalves et al., 2021;

O'Connor et al., 2016; Oliveira et al., 2020; Palaiologou et al., 2019). Since then, several initiatives have been developed in Portugal to deal with these challenges; one such measure is the Safe Village Safe People program, initiated in 2018 and coordinated by the National Emergency and Civil Protection Authority (ANEPC). This program aims at creating structural measures for the protection of people and assets located in rural villages or in the wildland-urban interface, through the implementation of strategic infrastructures, the identification of critical points and places of shelter and refuge or the creation of evacuation routes. For a settlement to be classified as a "safe village", it must have implemented several measures, among which:

- a) prevention of risky behaviour, by developing awareness actions to reduce the number of ignitions caused by anthropogenic actions;
- b) awareness of the population about wildfire risk levels and self-protection practices they should adopt, by organizing fire drills in coordination with local authorities;
- c) creating evacuation plans for when a fire is approaching the village;
- d) creation of shelter and places of refuge able to protect the population during the passage of the fire, in cases where it is the most viable option (Autoridade Nacional de Proteção Civil, 2018).

By implementing these strategies at the local level, it is intended to increase the self-protection capacity of the population and mitigate the consequences of large wildfires. This is especially important in a context of climate change, where fires will be more frequent and severe (Ager et al., 2014; Birkmann et al., 2013; Dupuy et al., 2020; Marques et al., 2011; Moreira et al., 2010). The objective of this study was to analyze the implementation of the "Safe Village Safe People" program, considering the spatial distribution and the relationship with the level of wildfire hazard in the surrounding area, specifically in the 100m protection area around settlements (defined by Decree Law No. 82/2021, October 13). With this analysis, it is also possible to analyse whether the "Safe Village Safe People" program can be aligned with other initiatives, associated with fuel management and landscape transformation in the surrounding area of villages, such as the " Condominium of Villages" program, coordinated by the Directorate General of Territory (DGT). The implementation of several programs in an integrated manner, which concur to the same objective of wildfire mitigation and communities' protection, can promote a more efficient management of resources and increase the effectiveness of the implemented strategies.

## **2. Methods**

### **2.1. Study area**

The analysis of Safe Villages was carried out for the municipalities of the Algarve region (NUTS III) (figure 1). The Algarve region has an area of 4 996 km<sup>2</sup> and is composed of 16 municipalities. Regarding land use and occupation, 63.02% of the Algarve region corresponds to forest and shrubland and 23.31% to agriculture and pasture. In terms of hazard, 30.65% of the region is at high and very high hazard of fire. According to the provisional results of the 2021 Census, the Algarve has 467,475 inhabitants, showing a positive variation of 3.7% compared to 2011. Monchique is the municipality with the most significant hazard level as 90.74% of its area falls into high or very high hazard while Lagoa records the lowest percentage (1.27%). The municipality of Monchique with the highest percentage of forest and shrubland (91.96%) and the one with the lowest percentage is Faro (17.79%). Over the last decade, Vila do Bispo recorded the highest population growth (+8.7%) while Alcoutim recorded a significant population loss in the same period (-13.5%).

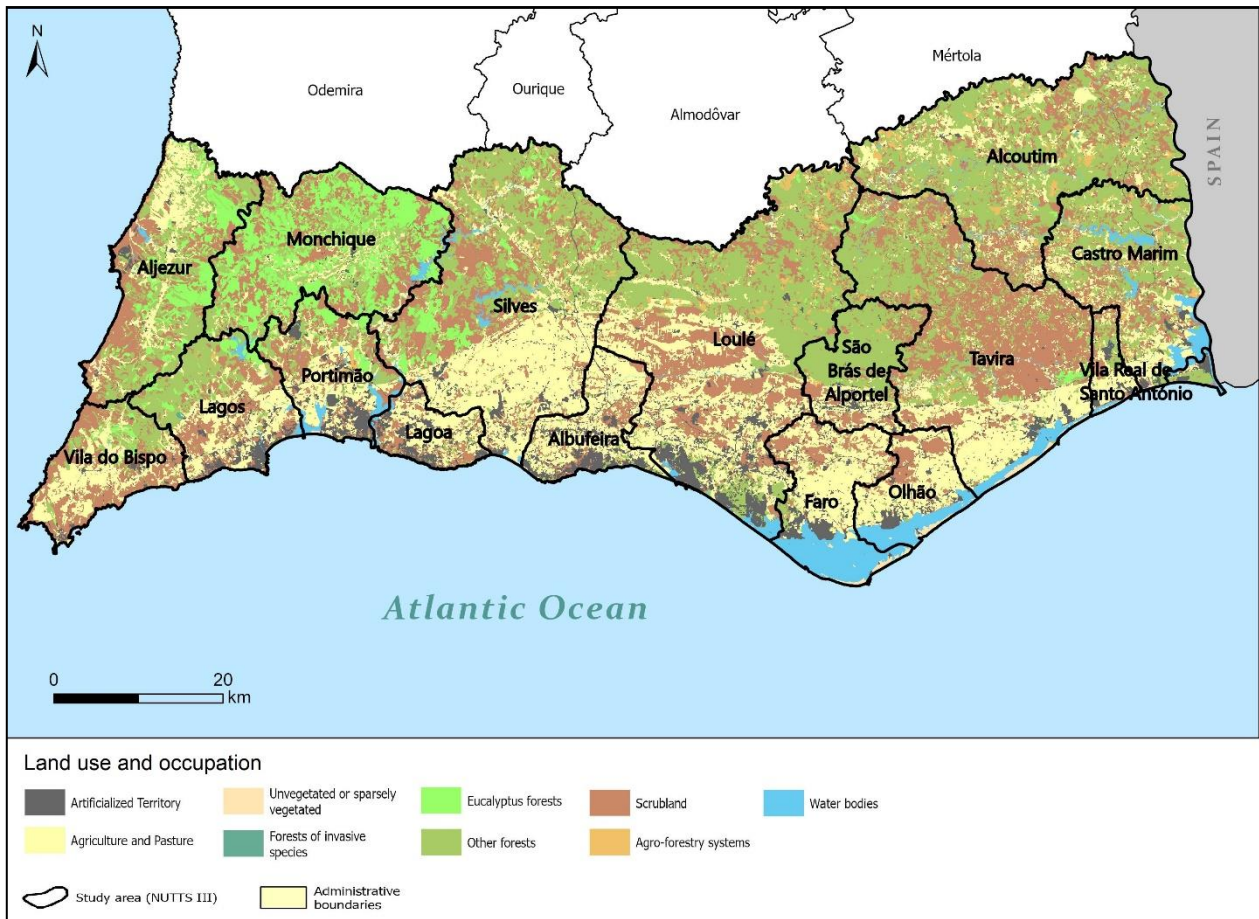


Figura 1 - Geographical setting and hazard level of the study area (Source: ICNF, 2020)

## 2.2. Data collection and processing

For this analysis, a database was first built with the location of the safe villages already implemented in the Algarve region. For this task, the geographic coordinates of a point that intersects the settlements designated as safe villages were retrieved from the website of the program "Safe Villages"<sup>6</sup>. To obtain the boundaries of the settlements, the built areas made available by the DGT were taken, mapped from the artificialized classes of the 2018 Land Use and Occupation (COS2018) combined with the geographic base of classic residential buildings of the National Statistics Institute (INE) (2011). Although a settlement is generally defined as a group of 10 or more residential buildings (Instituto Nacional de Estatística, 2001), this database of built-up areas includes several typologies: type 1 concentrated settlement (settlements with 10 or more residential buildings); type 2 dispersed settlement (isolated houses or places with less than 10 residential buildings); type 3 non-residential areas. For this analysis, all non-residential areas (type 3) and all isolated houses defined as type 2 were excluded, keeping the dispersed settlement that corresponds to at least 2 residential buildings. This option is connected to the application of fuel management areas (FGC) of 100 m around a settlement, since in the cases of isolated houses the FGC defined by law are of 50m. The definition of the FGC for the protection of settlements around built areas was accomplished by creating a 100 m buffer in the surroundings, using *ArcGIS tools*. Then, the area of high and very high hazard existing in these surrounding buffers was calculated, being considered the most critical or priority area. The hazard layer corresponds to the structural assessment of wildfire hazard levels for 2020-2030, based on probability from historical burned area and susceptibility resulting from landcover and topography (Oliveira et al., 2020) and it was obtained from the Institute for Nature Conservation and Forests (ICNF). The following step was to calculate the proportion of critical area (high and very high hazard) in the

<sup>6</sup><https://aldeiasseguras.pt/aldeias-seguras/>

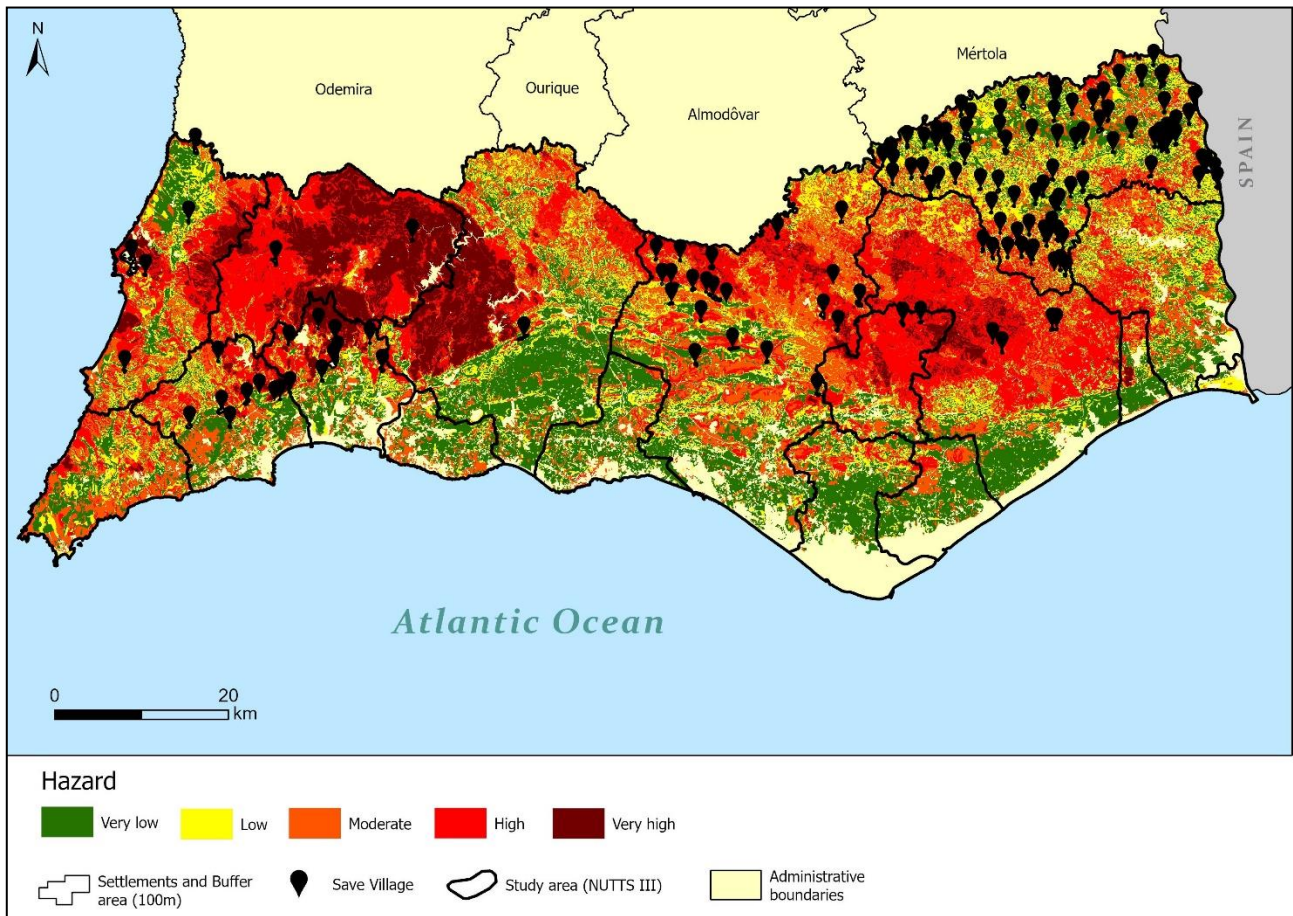


buffer zones around the safe villages, in relation to the critical area within all buffer zones in the settlements of the municipality.

### 3. Results and Discussion

In Algarve the high and very high hazard levels cover 6.6% of the 100 m buffers around the built-up areas of the region, which are composed of 8060 individual polygons. In these polygons, 25% have high or very high hazard area in the surrounding 100 m buffer. In these settlements with hazardous surrounding area, 22% have more than 50% of critical area in their buffer.

Up to 2021, 135 safe villages were implemented (figure 2), in 9 municipalities (table 1). These villages (SV), cover 6.7% of the critical area around the settlements where hazardous levels are found.



**Figure 2 - Location of Safe Villages and wildfire hazard levels in the Algarve region**

Overall, Monchique has the highest percentage of critical area in the surrounding 100m of its settlements (61.9%), followed by far by Aljezur (20.9%) (figure 3). However, the municipality of Alcoutim and Aljezur (figure 3a) are the ones where the SV implemented cover a higher percentage of critical area around (58.1% and 32.7%, respectively). The SV in Monchique cover 2.2% of the hazardous area around its settlements. These results suggest that the implementation of SV is done in view of conditions other than the hazard levels around the settlements. Alcoutim, for example, shows a low amount of critical area surrounding the settlements (<1%), but it is the municipality with more SV, whose implementation has covered nearly 60% of the critical area. It should also be noted that the 100m buffer here considered may not suffice to protect a settlement in case of large fires, nor match the size of the wildland-urban interface that should be considered in wildfire management strategies (Sirca et al., 2017).

Table 1 - Percentage of critical areas in implemented Safe Villages

Municipalities	% high and very high hazard in the FGC of SV (with total FGC of settlements)	% high and very high hazard in total FGC of settlements	Number of Safe Villages	% of Safe Villages
Albufeira	0	1.98	0	0
Alcoutim	58.08	0.86	84	62.22
Aljezur	32.69	20.86	5	3.70
Castro Marim	0	2.21	0	0
Faro	0	4.18	0	0
Lagoa	0	1.50	0	0
Lagos	4.16	3.59	7	5.19
Loulé	12	4.12	20	14.81
Monchique	2.28	61.96	2	1.48
Olhão	0	0.52	0	0
Portimão	3.29	5.47	8	5.93
São Brás de Alportel	11.32	13.57	2	1.48
Silves	5	3.28	1	0.74
Tavira	2.09	13.27	6	4.44
Vila do Bispo	0	6.92	0	0
Vila Real de Santo António	0	1.17	0	0

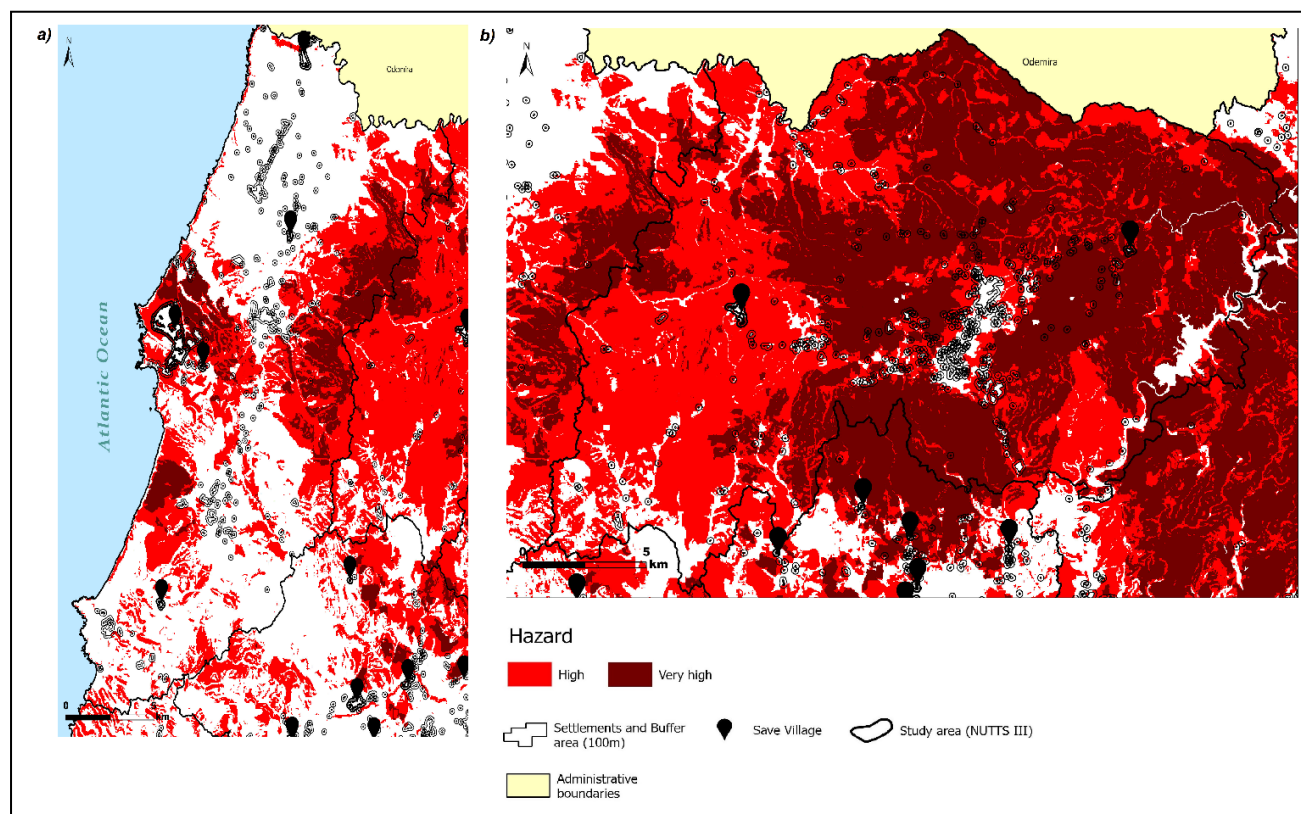


Figura 3 - Safe Villages and critical areas in the municipality of Aljezur (a) and Monchique (b)

To accelerate the implementation of protection measures around human settlements, the connection and integrated application of different but complementary initiatives can be helpful. One example is the

"Condominium of Villages", a program created by the DGT in 2020 that is directed towards fuel management around settlements. Its main purpose is to support actions aimed at changing landcover-landuse and promoting fuel management around built areas, to improve the resilience of vulnerable villages, particularly those located in parishes with at least 40% of critical area in their territory.

The articulation of measures will enable a better definition of priorities, namely in the the location of safe villages, but also a better implementation of fuel management around the village. Although this interconnection is important, at this moment the implementation of the "safe village" program does not depend only on the physical factors of the territory, but also on the involvement of the resident population, namely the existence of a volunteer to be a Safety Officer in the settlement. This officer must also have knowledge of the geographic and social context and of existing structures at the local level. If we consider demographic aging and rural exodus, especially in the inner part of the country, it is challenging to designate a Security Officer, since many villages only have elderly residents, who do not have the required profile to assume this role.

#### **4. Conclusions**

In the ideal scenario, all settlements should be Safe Villages. The creation of different initiatives in Portugal should increasingly allow an interconnection in the implementation of measures that contribute to the protection of people and assets. That said, a main objective must be a better articulation between entities and local communities, for the application of this type of programs. This becomes even more pertinent in a context of climate change, which can increase the frequency and magnitude of wildfire events, but also in a context of sociodemographic changes that increase the vulnerability of territories, thus making it necessary to have a better definition of mitigation and prevention strategies for wildfires.

#### **5. Acknowledgments**

Ana Gonçalves was supported by FCT in the scope of her PhD dissertation "*The influence of land use transition and socio-demographic dynamics in the evolution of fire risk in Portugal*". [2020.07651.BD]. Sandra Oliveira was funded through FCT, I.P., under the programme of 'Stimulus of Scientific Employment—Individual Support' within the contract '2020.03873.CEECIND'.

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