

## FIRE HAZARD AND SUSCEPTIBILITY TO DESERTIFICATION: A TERRITORIAL APPROACH IN NE PORTUGAL

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### ABSTRACT

Continental Portugal endures an increase in desertification susceptibility, a process accelerated by soil degradation and wildfires. This work aims at discussing outcomes of a research, at territorial scale, on fire hazard relations with soil degradation and desertification susceptibility in NE Portugal, specifically in Bragança District, based on GIS desertification susceptibility fire hazard, land cover and soil degradation maps. High and very high fire hazard prevails in near 2/3 of the territory and around 3/4 are susceptible to desertification, falling in the semi-arid and dry sub-humid climatic domains; about 20% of the former fall in the semi-arid. In around 3/4 of the area with high/very high fire hazard soils depict severe or worse degradation status, and in around 40% they are covered by scrublands, where fuel stock is high and social control is negligible. This negative picture asks for measures towards effective soil protection, a key resource for territorial sustainability.

**Keywords:** Desertification susceptibility, soil degradation, fire hazard, NE Portugal

### Introduction

Recent assessments showed that desertification susceptibility, increased in Continental Portugal when comparing 1960-1990 with 2000-2010 aridity index (PANCD, 2011). In NE Portugal, specifically in the Bragança District, the border of the susceptible belt moved west. For long considered spared from desertification processes due to its geographical position and climatic conditions, the North Portugal region depicts now a considerable extent of susceptible areas, and most of which in the Bragança District.

Besides climatic drivers, desertification is coupled with soil degradation and wildfires are a direct cause for accelerating both processes. A soil degradation map of NE Portugal has been recently presented and points out the wide distribution and extent of the degraded areas in this region (Figueiredo et al., 2014). This should be a matter of concern, especially considering that a significant part of the territory shows an over-exploitation of its soil resources, due to inadequate land use (Figueiredo, 2013). Apart from cartographic approaches, soil degradation is observed in burnt areas and soil experiments were carried out and are ongoing, in order to have a quantitative insight on the problem (Fonseca et al., 2011; Figueiredo et al., 2013).

A map-based approach, at territorial scale, allowed a quantitative insight on fire hazard relations with soil degradation and desertification in NE Portugal and this work aims at discussing the main outcomes of the research.

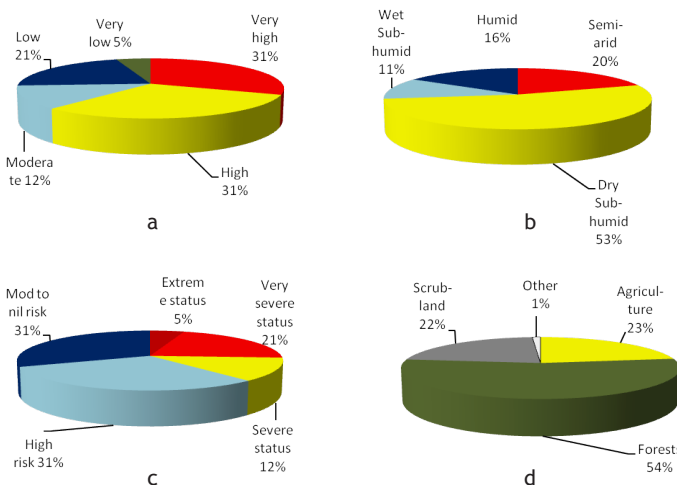
**Available information and data treatment**

The study area corresponds to the Bragança District, an administrative unit that assembles 12 municipalities in the NE corner of Continental Portugal, covering an area of around 6600 km<sup>2</sup>. In the Portuguese Northern Region, this is the area with larger extent of areas affected by high susceptibility to desertification.

For the study area, the data bases were treated with GIS tools included the published maps of desertification susceptibility, 2000-2010 (PANCD, 2011), fire hazard (provided by Bragança Municipality) and land cover, COS2007, level 2 (free access online). The map of soil degradation status and risk, developed by the authors for NE Portugal, was also included in this work (Figueiredo et al., 2014). In each case, information is displayed in classes defined in the respective source. Furthermore, the administrative map allowed a more detailed analysis of these data, at municipality level. Data treatment consisted in basic frequency analysis of categorical information.

**Land degradation in Bragança District: a general picture**

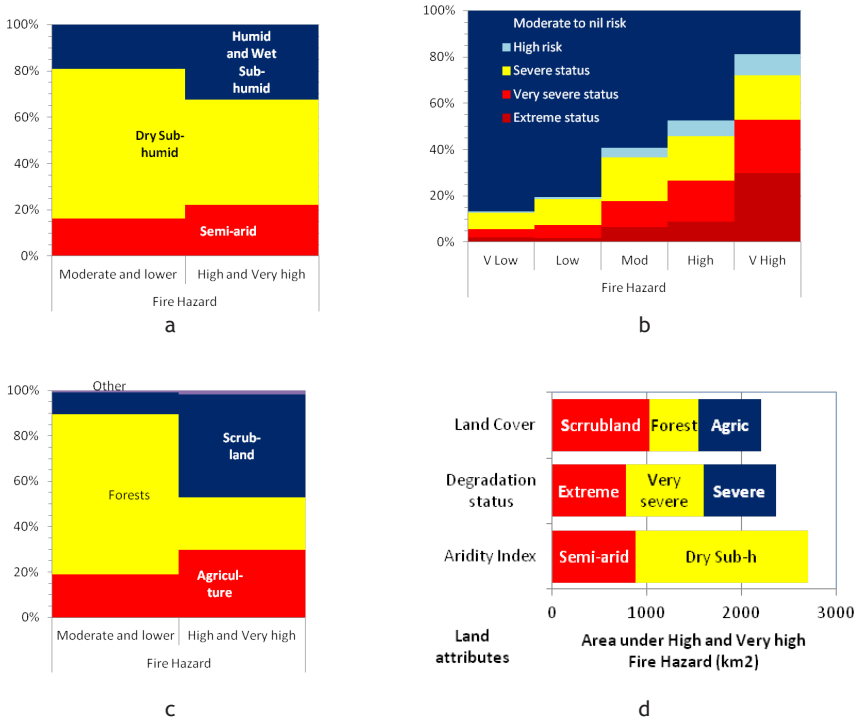
The general picture of Bragança District in what concerns each one of the variables (or land attributes) considered in this study is presented in Figure 1. Fire hazard is high and very high in 62% of the area while around 1/4 corresponds to low and very low fire hazard. Bragança District is susceptible to desertification in as much as 3/4 of the area, for which the dry sub-humid and the semi-arid climatic domains contribute with 53% and 20%, respectively. Only 31% of Bragança District is not or moderately affected by soil degradation, mainly caused by runoff erosion, while a similar area is under high soil degradation risk. Soils in degraded status cover 38% of the area, the extreme class occurring in 5%. Agricultural land, comprising annual crops, permanent crops, and grazing areas, covers about 1/4 of the territory. At the level of detail provided by the available data, land cover categories as forests and scrubland are not precisely discriminated. However, they show the importance of these categories and it can be noted that personal knowledge of the territory and assessments performed elsewhere in NE Portugal indicate more than 30% cover by scrubland (CIMO, 2009).



**Figure 1 - Surface area distribution (%) of Fire Hazard (a), Aridity Index (b), Soil Degradation status and risk (c) and Land Cover (d) classes in the studied territory.**

**Land degradation in Bragança District: coupling threats**

In order to have a better insight on threats to land resources in Bragança District, the attributes analyzed above were coupled with fire hazard and the global results are depicted in Figure 2.



**Figure 2 - Surface area distribution (%) of Aridity Index (a), Soil Degradation status and risk (b) and Land Cover (c), by Fire hazard class, and surface area (km<sup>2</sup>) of classes of those attributes with high and very high Fire hazard (d), in the studied territory.**

High and very high fire hazard may occur in the 3 climatic domains defined by the Aridity Index, Even though semi-arid areas are proportionally more important under high and very high fire hazard, when compared with moderate to lower fire hazard classes, data suggest no clear association between these 2 attributes, meaning that fire hazard is a widespread threat in this territory, not specifically assigned to climatic domains defining desertification susceptibility (Figure 2a). On the contrary, a clear association exists between fire hazard and soil degradation (Figure 2b), meaning an increased threat to land tracts already enduring severe or extreme soil degradation, therefore requiring increased need for soil protection. The clearly higher extent of scrubland areas under high and very high fire hazard, when compared to moderate and lower hazard conditions (35% against 10% of the respective class area), indicates that the potential hazard is more likely to turn real damage in the former than in the latter (Figure 2c). In fact, scrublands, normally associated to remote marginal area or abandoned territory, represent an important fuel stock without the necessary social control to prevent fire occurrence. Figure 2d is intended to explicit the actual extent of the most threatened areas in Bragança District, showing that under high and very high fire hazard near

2700km<sup>2</sup> are also under desertification threat, near 2400km<sup>2</sup> are covered by degraded soils and more than 1000km<sup>2</sup> are scrublands.

### The most threatened areas in Bragança District

Soils at extreme degradation status under very high fire hazard can be taken as examples of the most critical threats to land resources in Bragança District. Considering desertification susceptibility is driven by climatic constraints but it is also coupled with soil degradation processes, those critical conditions have wider consequences if occurring in semi-arid climatic regime and this is the picture represented in Figure 3.

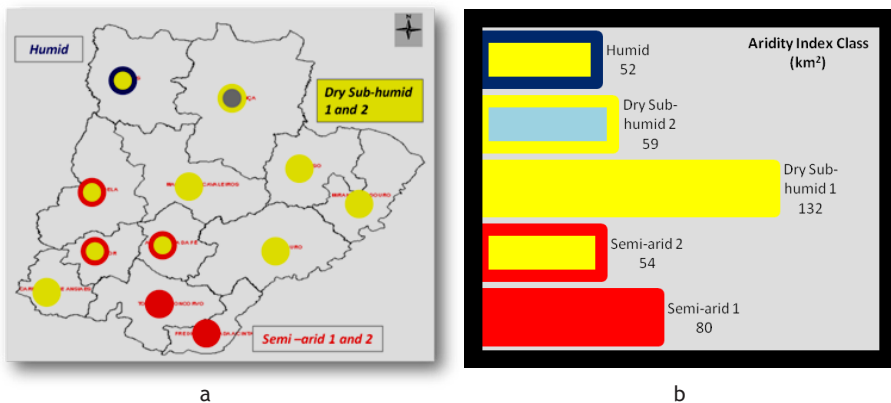


Figure 3 - The most threatened areas in Bragança District: Municipalities' classified by Desertification Susceptibility (a); areas (km<sup>2</sup>) affected by Extreme Soil Degradation under Very High Fire Hazard in each Desertification Susceptibility class (b).

In earlier work (Figueiredo et al., 2014), the authors classified the Municipalities of Bragança District according to their susceptibility, considering the relative importance of the areas assigned to each aridity index class (Figure 3a). Five Municipalities qualify as semi-arid, yet split in two groups according to the relative importance of dry sub-humid areas, and six qualify as dry sub-humid, again split in two groups according to the relative extent of wet sub-humid and humid areas; the remainder Municipality qualifies as humid. Figure 3b shows that from a total of 380 km<sup>2</sup> of very much threatened land, 134 fall in the semi-arid and 191 in the dry sub-humid domains. These could be taken target areas for soil recovery initiatives, and the required efforts on such initiative could modulated according the results depicted.

### Conclusion

Results presented describe a territory under several threats to land resources distributed over wide areas. Fire hazard adds to soil degradation risk as far as land cover is prone to fire (as it is the case of the largely represented scrublands), and the recovery of burnt areas is much constrained in drier conditions where desertification susceptibility is high. Besides change trends in land use, not explored in the paper, but that seemingly add negative elements to the picture drawn, these results ask for a deeper insight on measures able to tackle with and reverse process trends in the long term. In fact, territorial policy instruments and actions urge

in these circumstances, and they should be focused on land use planning and soil management practices towards effective soil protection, a key resource for territorial sustainability.

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