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Susceptibility and perception of landslide risk in the municipality of Coimbra

Master's Dissertation

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Acknowledgements

I dedicate this dissertation to my parents, whose steadfast support and boundless love have been my guiding lights not only through my academic journey but also throughout my life. I am grateful for everything I am today and all that I aspire to become. I cherish the eternal bond we share.

To my dear brothers, constant companions in life, who have always been a beacon to guide me through life. To my beloved sister, whose absence was deeply felt during my time in Coimbra, my affection for you has no bounds. I hold each of you close to my heart.

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Abstract

The municipality of Coimbra is a region with peculiar geological and geomorphological characteristics, where landslides often cause significant impacts. In addition, the disorderly urban sprawl in areas of greater susceptibility, coupled with a poor land use planning strategy, has resulted in an increase in the occurrence of these disasters in urban areas.

This master's dissertation studies landslides whilst considering not only the geo-physical and climatic aspects related to them, but also the sociological component regarding the Coimbra's population perception of landslide risk. Susceptibility mapping is key when dealing with natural hazards. Thus, a landslide documentary database was developed and then analysed along with the geological, geo-physical, and meteorological elements of the study area.

After this phase, the next step was to study Coimbra's population perception of landslide risk. It was at this stage that a structured questionnaire was carried out to understand the way in which individuals perceive risk and how they deal with it daily. Data gathered through this process was treated and analysed to find correlations between variables included in the questionnaire.

Landslide susceptibility was assessed, demonstrating a significant impact from both land-use and slope characteristics. Greater susceptibility values were observed in the eastern portion of the study area in contrast to the western region. This discrepancy primarily stemmed from the prominent consideration of slope and the spatial arrangement of historical events used as the foundation for susceptibility evaluation.

Although not fully representative, insights from the questionnaire sample yielded noteworthy findings. Notably, a positive correlation between age and risk perception emerged, as did variations in risk perception based on experience with natural hazards.

Keywords: Susceptibility; Coimbra; Predisposing Factors; Natural hazards; Structured questionnaire.

Resumo

O município de Coimbra é uma região com características geológicas e geomorfológicas particulares, onde os movimentos de vertente vão causando impactos significativos cada vez mais assinaláveis. A expansão urbana, muitas vezes desordenada, em áreas de maior suscetibilidade, aliada a uma pobre estratégia de ordenamento do uso do solo, tem resultado num aumento da ocorrência de desastres relacionados com estes processos também em espaços urbanos.

Esta dissertação de mestrado propõe-se a estudar os movimentos de vertente atendendo não só aos aspetos geofísicos e climáticos relacionados com os movimentos de vertente, mas também à componente sociológica e de perceção de risco da população de Coimbra face ao fenómeno em questão, e ainda à evolução urbana que se tem verificado no concelho e de que forma estes aspetos confluem. Importa, portanto, identificar zonas onde o risco é mais elevado com a criação de uma base de dados documental e com a análise dos elementos geológicos, geofísicos e meteorológicos da área de estudo.

Após esta fase, segue-se o estudo da perceção de risco de movimento de vertente na população de Coimbra. Nesta fase, foram conduzidos inquéritos estruturados numa tentativa de perceber a forma com que os indivíduos percecionam o Risco e como lidam, no seu quotidiano, com ele.

A suscetibilidade a deslizamentos de terras foi avaliada, demonstrando um impacto significativo tanto do uso do solo como das características do declive. Foram observados valores de suscetibilidade mais elevados na parte oriental da área de estudo, em contraste com a região ocidental. Esta discrepância deveu-se principalmente à consideração proeminente do declive e à disposição espacial dos eventos utilizados como base para a avaliação da suscetibilidade.

Apesar de não ser representativa, a análise da amostra do questionário produziu resultados importantes. Nomeadamente, surgiu uma correlação positiva entre a idade e a perceção do risco, bem como variações na perceção do risco com base na experiência com perigos naturais.

Palavras-Chave: Suscetibilidade; Coimbra; Fatores de predisposição Perigos naturais; Questionário estruturado

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Introduction

Overview and objectives

The focus of this dissertation is to define and investigate areas prone to landslides and to measure/ascertain the Coimbra's population perception of landslide risk. Thus, the dissertation contains a first phase focused on the geo-physical and morphological characterization of the region (municipality) of Coimbra (through land surveys and field trips meant for cartographic validation) and a second phase based on conducting surveys (via questionnaire) to understand how the risk is being perceived and how it affects the daily life of Coimbra's population.

The municipality of Coimbra is located along the central region of Portugal, in the district of Coimbra and is bordered by the municipalities of Cantanhede, Mealhada, Penacova, Vila Nova de Poiares, Miranda do Corvo, Condeixa-a-Nova and Montemor-o-Velho (Figure 1). According to the 2021 Census (data published by the National Institute of Statistics), the

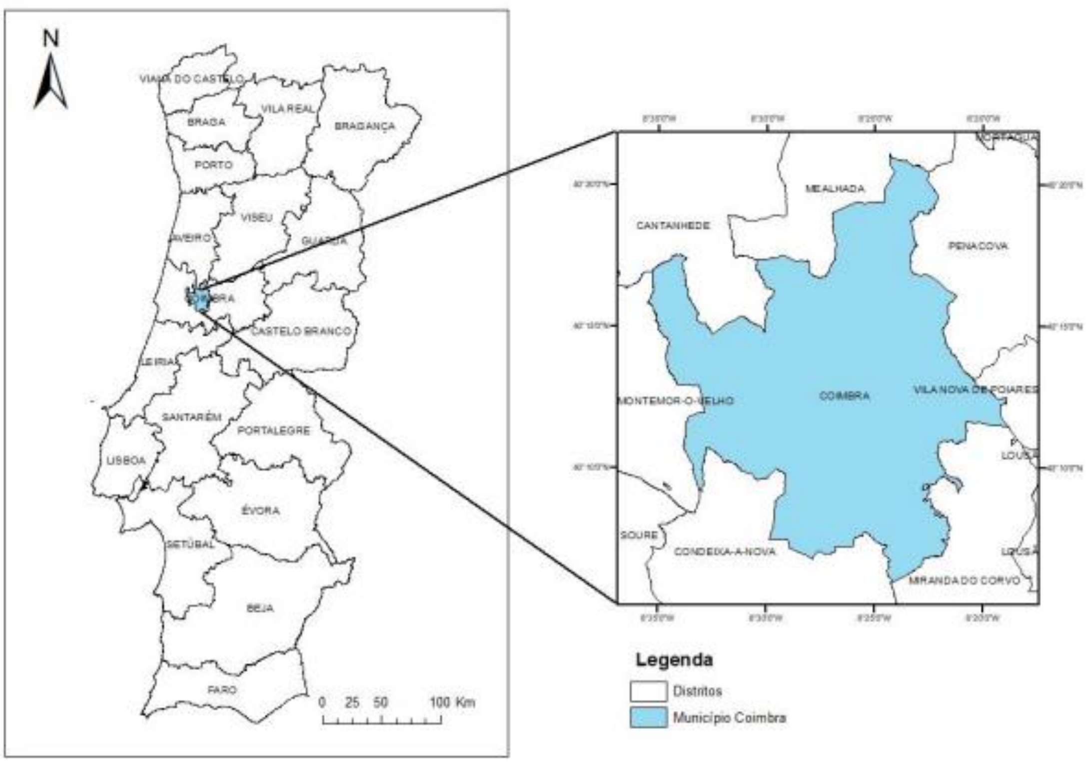


Figure 1: Location of the study area in Portugal

municipality totals an area of 319.4 km2 and a population of 140,796 inhabitants spread over 18 distinct parishes.

The choice of the subject matter and of the objectives derive from a personal interest in studying the topic, but also in the desire to produce a study that may represent a tool to better understand the problem in question. Moreover, the issue at hand is tightly connected to a history of landslide occurrences in Coimbra and the relatively frequent way in which these types of events have manifested themselves over the years. Thus, it is common for situations such as the ones shown in Figures 2 and 3 to arise. In the first, scars of a previous landslide and the accumulation of organic matter next to the dwellings are easily identified. In the second, a road (Estrada da Beira) that is regularly blocked by the deposition of moved material is presented. These are just two examples of the characteristic landslides in Coimbra.

Figure 2: Landslide in Alto da Guarda Inglesa (2020);
Source: Diário de Coimbra (2023)

Figure 3: Accumulation of deposited material on Estrada da Beira (2018); Source: TSF (2023)

Research Questions

The definition of research questions helped to guide the current study. Moreover, the questions posed below express the interest in studying the geo-physical and sociological components associated with the risk of occurrence of these phenomena. Five research questions were defined (the first three related to susceptibility and the remaining to risk perception):

1. → How is landslide susceptibility distributed in Coimbra?

2. → Which of the variables included in the analysis are most important when calculating landslide susceptibility in Coimbra?

3. → Is the landslide risk perception high on the population of the selected parishes of Coimbra?

4. → Do people who reside in the areas with higher susceptibility to landslides have a higher risk perception?

5. → Do previous experiences with landslides influence risk perception?

This dissertation is divided into five main chapters. In the first, theoretical foundations related to landslides, typologies and predisposing factors are presented. A geological, climatic, and socio-economic characterisation of the study area is also provided. Some studies carried out on the subject are also presented.

In the second chapter, similarly to the previous chapter, theoretical foundations involving risk perception and risk communication are presented, along with some international studies focused on exploring risk perceptions related to landslides. These first two chapters are dedicated to reviewing the important bibliography for this study.

The third chapter focuses on describing the methodologies adopted to try and find answers to the questions mentioned above. Firstly, the procedures used to analyse the susceptibility of the study area are explained, and secondly, the procedure for analysing risk perception is detailed.

Both the fourth and fifth chapters present the results derived from the application of the methodologies, where some conclusions are also drawn. The fourth chapter is dedicated to the susceptibility component and the fifth to the risk perception component.

At the end of the document, some final considerations are made that address the research questions and any constraints and difficulties encountered during the dissertation.

Chapter I – Landslides and Characterization of the Study Area

1.1. Landslides

According to Cruden and Varnes (1996), a landslide denotes the displacement of a mass of rock, debris, or earth down a slope, driven by the force of gravity. Landslides manifest in both sub-aerial and subaqueous environments and are triggered by various phenomena such as heavy or extended rainfall, seismic events, swift snow melting, volcanic disturbances, and various human activities. The movement of landslides can take the form of flowing, sliding, toppling, or falling, and frequently, a single landslide showcases a blend of two or more of these motion types either concurrently or over the course of its development.

The landslides that develop on natural and artificial slopes are a clear manifestation of the instability of such slopes. These movements of mass can be placed into categories depending on the characteristics of the relief, lithology, vegetation, cohesion of the materials and the climatic aspects of the region under analysis (Rebelo, 2001). The scale of these phenomena varies between occurrences, from the fall of small blocks with volumes of around one cubic decimetre to deep landslides involving millions of cubic meters of geological material and from small-sized landslides such as surface landslides to large debris flows. These occurrences engender different social, economic, and environmental impacts (Pellegrina & Cunha, 2019).

On a global scale, landslides cause heavy economic and human losses every year. Therefore, landslide study is paramount to reduce and manage risk. High landslide mortality is mainly found in mountainous areas with high population density, especially in developing countries. Countries with high landslide mortality risk include China, India, Nepal, Pakistan, Italy, and Brazil (Wentao et al. 2015).

1.2. Types of Landslides

In the literature produced on landslides, several forms of classification emerge (Carson & Kirkby ,1972; Hutchinson, 1988; Varnes, 1978; WP/WLI, 1993; Dikau et al., 1996; Cruden & Varnes, 1996). Such variety highlights the various needs of researchers and is crucial in Applied Geomorphology, since the recognition of the acting mechanism is the first step of any attempt to control or reduce manifestations of instability (Hansen, 1984). Terzaghi, states that "a phenomenon involving such a quantity of combinations between materials and disturbing agents opens unlimited horizons to the classification enthusiast (Terzaghi, 1950)

According to the European classification used by Dikau et al. (1996) which is based upon the proposals of Varnes (1978) and WP/WLI (1993), the type of mechanism is considered as the main factor of discrimination (between landslides) whilst the material affected is considered a secondary factor (Table 1).

Type	Rock	Debris	Soil
Fall	Rock fall	Debris fall	Soil fall
Topple	Rock topple	Debris topple	Soil topple
Slide (rotational)	Single (slump) Multiple Successive	Single Multiple Successive	Single Multiple Successive
Slide (translational) Non-rotational Planar	 Block slide Rock slide	 Block slide Debris slide	 Slab slide Mudslide
Lateral spreading	Rock spread	Debris spread (no case reported in Europe)	Soil spread
Flow	Sackung (rock flow/sagging)	Debris flow	Soilflow
Complex (with runout or change of behaviour downslope, note that nearly all forms develop complex behaviour)	E.g. rock avalanche	E.g. flow slide	E.g. slump-earthflow

Table 1: Classification of landslides used in the TESLEC project based on Casale et al. 1994 Source: Dikau et al. 1996)

1.2.1. Falls

Falls (Figure 4) are abrupt movements of mass (such as rocks and boulders) that become detached from steep slopes or cliffs. Separation occurs along discontinuities such as fractures, joints, and bedding planes, and movement can take place as free-fall, bouncing, and rolling. Falls are also strongly influenced by gravity, mechanical weathering, and the presence of interstitial water (WP/WLI, 1993). It is an abrupt landslide, characterized by high-speed rates, especially during the free-fall period of the displacement (Varnes, 1978).

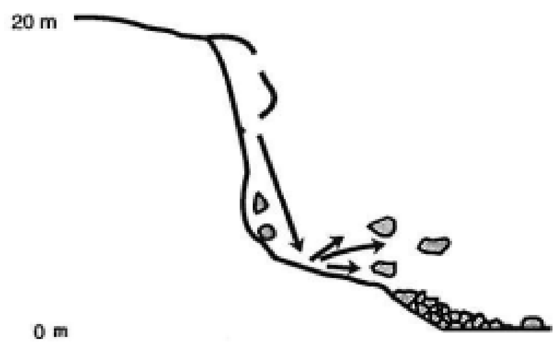


Figure 4: Fall Illustration; Source: *(Cooper, 2007)*.

1.2.2. Topples

Topples (Figure 5) occur when there is a rotation in a mass of soil or rock, from a point or axis situated below the centre of gravity of the affected mass (WP/WLI, 1993). Additionally, these are movements controlled by the influence of the force of gravity, lateral force applied by adjacent units, lateral force exerted by the water present in cracks and crevasses in the rock. They are regularly related to rock masses with discontinuities inclined in the opposite direction of the slope.

Topple failures develop slowly and may or may not evolve into a fall or slide, depending on the geometry of the affected mass and the extent and orientation of the stratification planes and/or cracks (Zêzere, 2005).

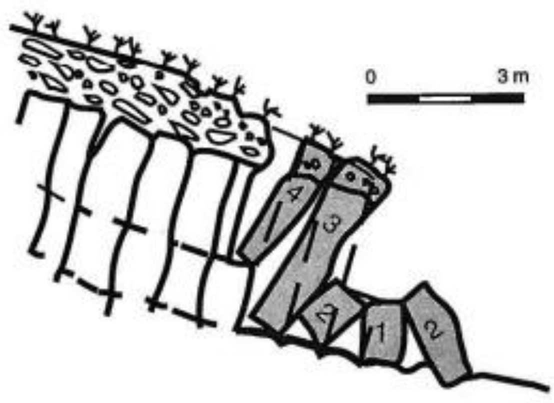


Figure 5: Topple Illustration; Source: *(Cooper, 2007)*.

1.2.3. Slides

Slides (Figure 6) are movements of soil or rock that occur dominantly along rupture planes or relatively narrow zones, subject to intense tangential deformation (WP/WLI, 1993). The mass displaced during movement has very variable degrees of deformation and remains in contact with the unaffected underlying material (Zêzere, 2005). They are activated when the resisting forces of the terrain are overcome by the tangential stress to which the materials are subjected on the slope (Zêzere, 2000). Furthermore, this type of landslide can be further divided into two typologies: rotational and translational slides.

Figure 6: Slide Illustration; Source: (Cooper, 2007).

1.2.3.4. Rotational Slides (Slumps)

Rotational slides are marked by a concave surface of rupture and the sliding movement is roughly rotational on an axis that is parallel to the ground surface and transverse across the slide (Varnes, 1978).

1.2.3.5. Translational Slides

When a translational slide takes place, the mass moves along a roughly planar surface with little rotation or backward tilting (Varnes, 1978). It can be divided into three different subtypes of slide depending on the material of which the slope consists of.

1.2.4. Lateral Spread

Lateral Spread (Figure 7) is the lateral displacement of cohesive masses of soil or rock, combined with a general subsidence in the underlying soft material, subject to liquefaction or outflow (WP/WLI, 1993). Furthermore, they are marked by the absence of well-defined base ruptures (Zêzere, 2005).

Figure 7: Lateral Spread Illustration; Source: (Cooper, 2007).

1.2.5. Flows

Flows (Figure 8) are spatially continuous movements where the tangential stress surfaces are ephemeral and poorly preserved. Furthermore, stresses are distributed throughout the affected mass, being responsible for a large internal deformation of the materials involved. The distribution of velocities in the affected mass resembles that of a viscous fluid (WP/WLI, 1993).

Figure 8: Flow Illustration; Source: *(Cooper, 2007)*.

1.3. Predisposing Factors and Triggering Mechanisms

Defining the cause of a particular landslide is a very complex task, as there are several factors involved, some of which may be responsible for reducing the stability of a certain slope, while others may be responsible for triggering the landslide. Generally, the final factor is a triggering mechanism that sets in motion a mass that was at the breaking point (Zêzere, 2005).

According to Glade and Crozier (2005) there are three types of factors: predisposing, preparatory and triggering factors. Predisposing factors include all the factors which are inherent to the terrain. They hold control over the stability of slopes and determine the spatial variation of landslide susceptibility of the territory being studied. Even when characterized as static factors, they are subject to change, albeit in the long term (Zêsere, 2005). Examples of this type of factor are geological characteristics (e.g., lithology), morphological characteristics (e.g., slope and curvature) and land use (Varnes, 1984).

Preparatory factors are dynamic and reduce slope stability, but do not trigger landslides. Prolonged episodes of low rainfall intensity can cause water to accumulate on the slopes (depending on the permeability of the material and surface and underground runoff) therefore reducing their cohesiveness without necessarily causing landslide.

The triggering factors are the immediate cause of the landslide (i.e. they trigger the movement). Such factors include physical processes (e.g. precipitation, earthquakes, volcanic eruptions) and certain anthropogenic activities (e.g. excavations, infrastructure installation). According to Zêzere (2005) these factors determine the temporal landslide rhythm. In this study, special emphasis is placed on landslides took place during periods of intense and/or prolonged precipitation.

Precipitation is the main physical process responsible for triggering landslides in Portugal (Zêzere et al., 2015). Albeit the relationship between landslides and precipitation is indirect. The infiltration of the water that falls upon a slope, increases the pressure applied to the soil causing a decrease in the shear resistance of the slope in question (Glade and Crozier, 2005).

Due to the orographic effect, the highest altitudes generally correspond to the largest amounts of precipitation (Louro, 2004). Louro (2004) also highlighted that the geographic disposition also interferes in the amount of precipitation that is registered, due to the humid air masses with ocean-continent trajectories.

1.4. Characterization of the Study Area.

1.4.1. Geological context

In Coimbra, the geological and geomorphological characteristics of the municipality promote multiple episodes of instability in slopes (Cunha et al. 2017; Cunha, et al. 1997; Rebelo, 1985). Additionally, it is a region of significant geomorphological and climatic susceptibility, where movements of instability in slopes triggered mainly by precipitation take place. Other processes related to water erosion, movements of subsidence and collapse of karst features stand out as well.

Moreover, well-demarcated physical contrasts emerge. The clash between the metasedimentary units of the Hesperic Massif, (Pre-Cambrian and Palaeozoic formations prior to 280±10 Ma), and the sedimentary units of the Western Cenozoic Massif (approximately 5000 m of sediments with 225±5 Ma of age) (Soares and Gomes, 1997 cited by Tavares and Cunha, 2008) are an example of such contrast (Figure 9). The west section comprises a greater demographic and economic/business dynamism (Alves & Cunha, 2019).

Coimbra's geographical position favours the existence of diversified soil types and a contrasting morphology, with steep slopes (sometimes exceeding 30º) (Cunha and Dimuccio, 2002), especially in the eastern sector of the study area, as can be seen in the slope distribution map shown in Figure 10. The altitude values vary, in an easterly direction, from 140 metres in the Tovim area (eastern sector of Coimbra's urban concentration) and 350 metres in the Dianteiro area (Ferreira, 2018).

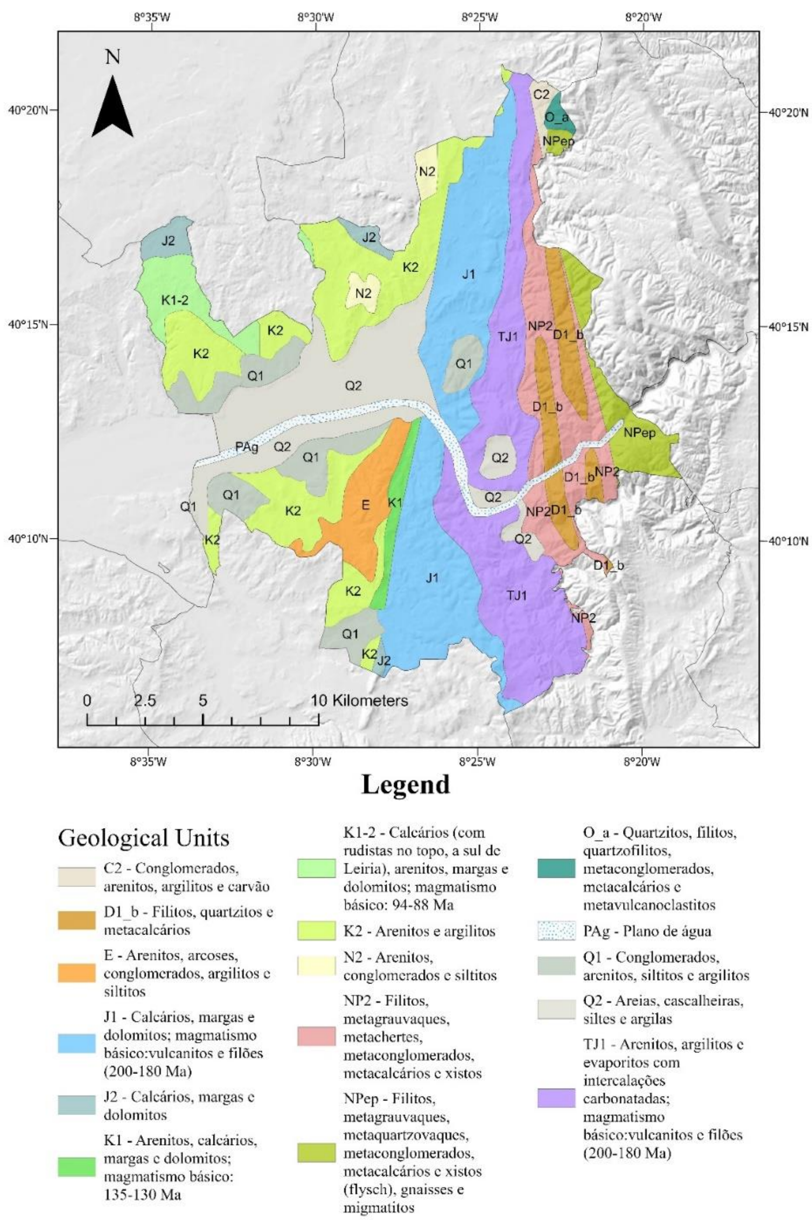


Figure 9: Geological Map of Coimbra (2016); Data used was produced by Laboratório Nacional de Energia e Geologia, I.P. Original figure caption in Portuguese.

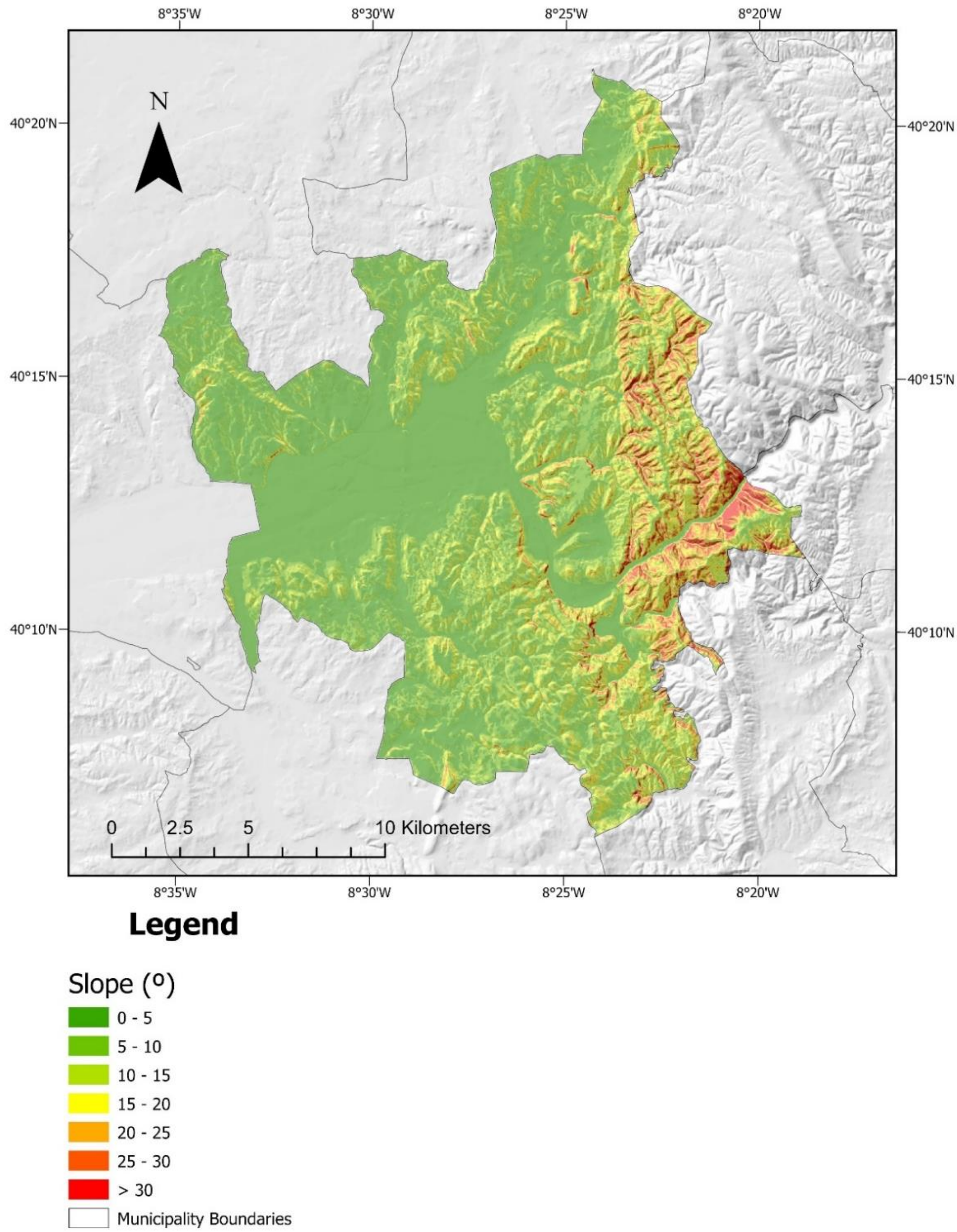


Figure 10: Slope Distribution in the Municipality of Coimbra (2020); Data used was produced by *Direção Geral do Território*

1.4.2. Climate

The climate of Coimbra is Mediterranean, with temperatures that vary between 5ºC and 15ºC (sometimes close to 0ºC) in the winter. Whereas during summer, the mean temperatures mostly fluctuate between 16 and 29ºC, reaching 40ºC on some occasions (Cunha and Pellegrina, 2019).

In the database created by Cunha and Pellegrina (2019), a greater number of occurrences is observed during the months of higher precipitation (from October to February and sometimes even reaching March). Figure 11, presented by the authors (using data provided by the Geophysical Institute of the University of Coimbra and the Portuguese Institute of Sea and Atmosphere), shows the average monthly precipitation between 2000 and 2021 and the climate mean values between 1981 and 2010 in millimetres.

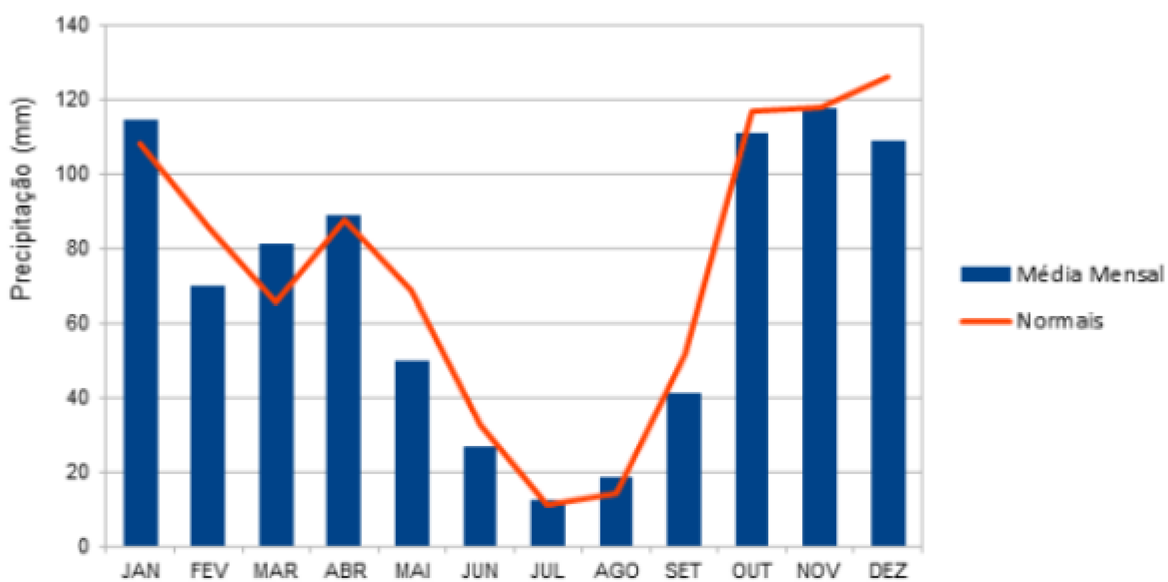


Figure 11: Monthly Mean total precipitation (2000-2012) and Climate mean values (1981-2010) in Coimbra; Pellegrina and Cunha, 2019 (Data provided by IGUC and IPMA). Original figure caption in Portuguese.

In the aforementioned study, it was found that most of the accounted landslides were located in the eastern half of the municipality of Coimbra, where there are higher areas with steeper slopes. These slopes are often associated with a relatively fragile lithology, because of the intrinsic characteristics of shales or the presence of many fractures and some outcrops of superficial deposits, as well as recent changes in land occupation and the increasing opening of accessibility routes, built without the appropriate geotechnical care (Cunha and Pellegrina, 2019).

In another study, by Tavares and Cunha (2008), a deterministic method was used, where some factors related to slope instability were recognized, namely, the geological/geotechnical characteristics of the lithic units, slope, fracture density, tectono-structural interpretation, and land use. Each one of these factors had a relative importance attributed to them, the slope being the one with the greatest emphasis. Then, a susceptibility map was produced for the municipality of Coimbra with four classes: Stable, Low, Moderate and High Susceptibility (Figure 12). In this case, as the slope was key, it was expected that the susceptibility map presented some similarity (and even a certain overlap) with the slope map of the region, although other aspects had been considered.

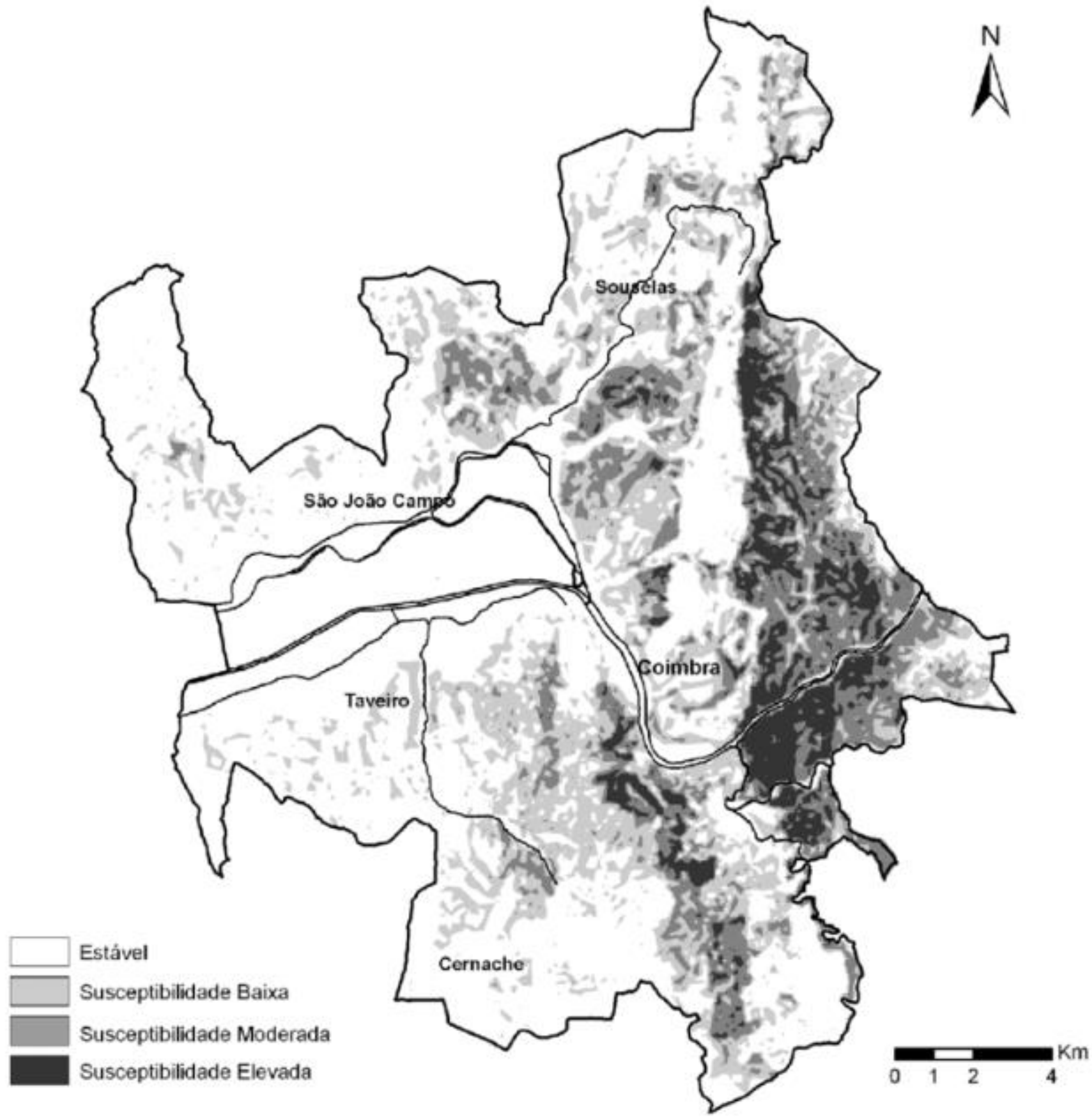


Figure 12: Landslide susceptibility in Coimbra; Source: Tavares and Cunha (2008). Original figure caption in Portuguese.

According to data from the hydro-geomorphological database, Disaster (2012), there were 9 reported landslides on the slopes of the municipality of Coimbra between 1865 and 2010 responsible for 144 evacuees and 23 displaced people (only landslides which caused fatalities, injuries, evacuation, displacement or left people missing were recorded). Coimbra totalled 3.2% of all slope movements on slopes with negative impacts recorded in mainland Portugal, occupying, therefore, the 4th place in the national ranking (Cunha and Pellegrina, 2019). As such, it is important to continue studying this matter to create tools to support the decision of the authorities regarding the implementation of risk reduction measures.

1.4.3. Sociodemographic Aspects

According to data produced by the National Statistics Institute for the 2021 census, the municipality of Coimbra has a population of 75,365 females (53.5%) and 65,451 males (46.5%), for a total of 140,816 inhabitants (-0.2% compared to 2011). Figure 13 shows the distribution of residents by sex and age group. The 50-59 age group (and adjacent age groups) stands out, comprising 11,154 women and 9,377 men.

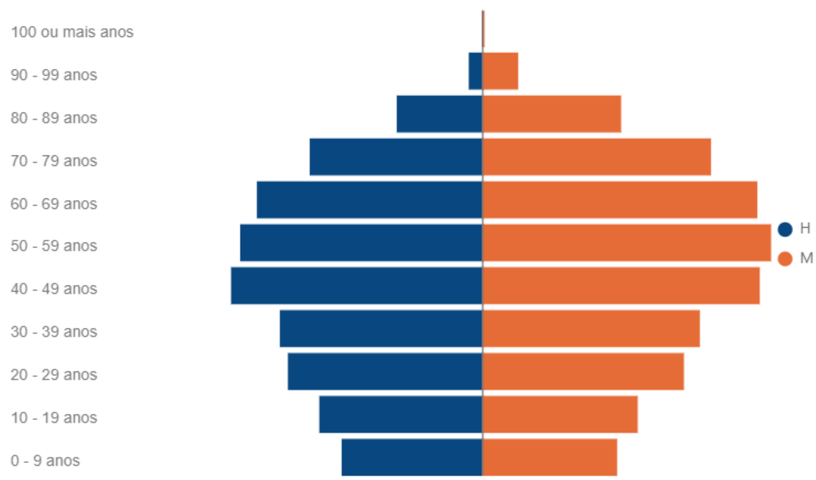


Figure 13: Coimbra resident population by age and gender. INE (Censos 2021).

Compared to the data from the 2011 census, the municipality saw a decrease of -8% in the number of people under the age of 15. On the other hand, the number of elderly people (>65 years old) increased significantly in this period. As a result, there was an increase in the ageing index, from 161.4 to 215.1 people per 100 young people (individuals under the age of 15). These figures show that the municipality is undoubtedly keeping pace with national trends in the ageing of its population.

Most of the working population (63,440 individuals) living in the municipality of Coimbra is employed in the tertiary sector (53,968 individuals), followed by the secondary sector (8,992) and finally the primary sector with only 480 individuals. When comparing these figures to those recorded in 1960, a very significant variation is noticed. In 1960, the tertiary sector accounted for 45% of the municipality's activity, while in 2021 this value was 85% due to the installation of new commercial activities related to the increase in the urban area that took place after 1960. During 1961 and 1980, 11,841 new buildings were raised (Figure 14), this period was the one, in Coimbra history, where most of the buildings were built.

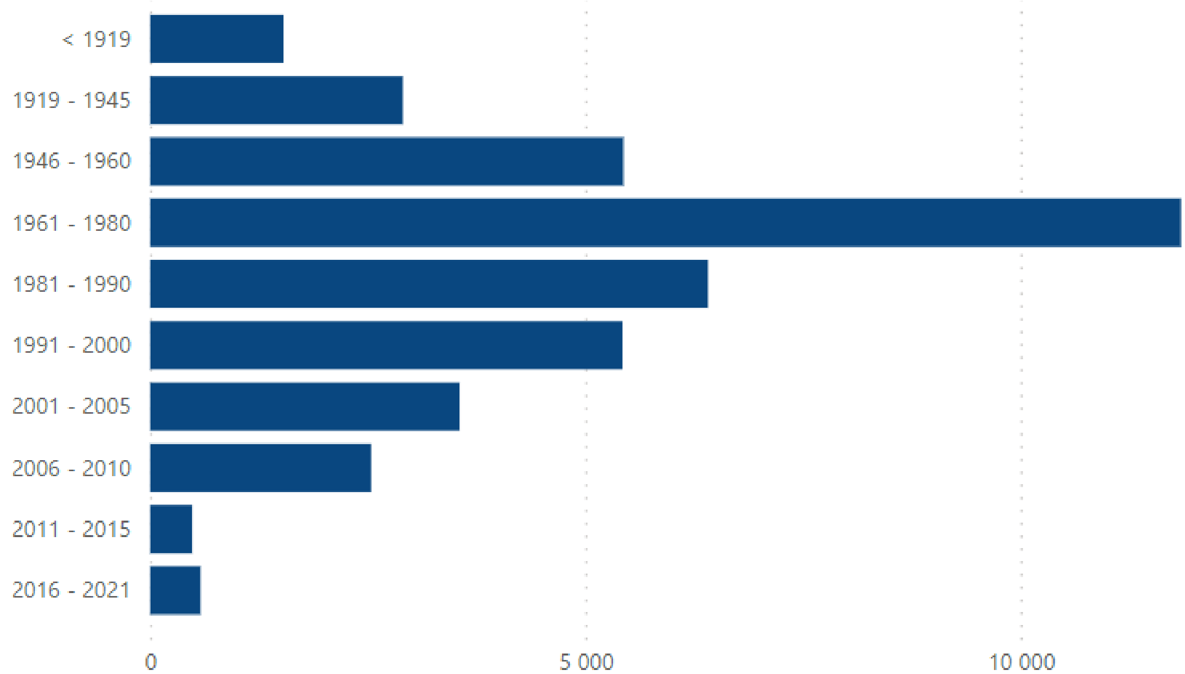


Figure 14: Number of buildings constructed by year range, Source: INE (Censos 2021).

In terms of education levels, a large portion of the population of Coimbra has completed higher education (31.1%). There is also a large portion with a 12th grade degree (22.1%). In addition, 15.4% of the population have completed the 9th grade, 6.5% have completed the 6th grade and 17% have only completed the 4th grade.

Coimbra is a region characterised by its university community, which, although not a permanent resident of the municipality, has a major influence on the city's dynamics. Examples of such are the various festivals associated with academic events that take place throughout the year, such as the “Latada”, “Cortejo” and “Queima das Fitas”. According to the University of Coimbra, the student community consisted of 28,182 people in December of 2022.

Chapter II: Understanding Risk Perception and its Connection to Landslides

2.1. Fundamental Concepts

Perception is an active psychological process by which stimuli are selected and organised within a conceptual model of the situation. In other words, we would say that the individual does not just register the observed aspects in relation to the system to which he is a part, but assigns meanings and values to them (Carochinho, 2011).

Risk perception is the subjective assessment of the likelihood of a certain type of accident happening and how concerned one is about the consequences. In other words, risk perception always requires assessments of probability and consequences of a given phenomenon.

In this context, risk perception refers to the way non-experts think about risk. It includes a set of beliefs and values that give meaning to a threatening event (Pidgeon et al., 2008). It refers to a set of beliefs, attitudes, evaluations, and feelings of people about dangerous situations and the risks associated with them (Carochinho, 2011).

The concept of risk awareness involves a complex process of gathering, filtering and interpreting information related to the uncertain outcomes of events, activities, or technologies. These signals can come from personal encounters (e.g., experiencing an earthquake) or indirect sources (e.g., receiving information on disasters). It is important to note that risks cannot be "perceived" in the same way as concrete phenomena that humans can directly perceive with their senses (such as their vision or hearing). Instead, individuals rely on internalized mental models and various psychological mechanisms such as cognitive heuristics and risk perceptions developed through social and cultural learning.

Daily risk assessment should be a dynamic and continuous process, constantly influenced and amplified, modified, enhanced, or weakened by media coverage, peer influence and other communication processes. The perception of risk is often beyond the individual and is a social and cultural construct which reflects values, symbols, history, and ideology (Weinstein, 1989). It stems from the specificity and variability of human social relations. John Adams (1995) stated that "the starting point of any risk theory must be that everyone voluntarily takes risks" (Sjöberg et al. 2004).

Individuals, as part of a society, tend to be particularly impervious to the idea of living under disaster risk conditions. Most people think that they are exposed to a lower risk than the average individual. This unreal optimism is based on the information available and on a reasoning that suggests that the danger is not a real threat, even if it affects people within their social circle (Alcantara-Ayala and Moreno, 2016).

2.2. The Emotional Aspect of Risk Perception: The "Affect Heuristic"

Paul Slovic et al. (2000) introduced the concept of the "affect heuristic," a cognitive mechanism through which individuals utilize their positive and negative emotions to shape their assessments of the potential risks and advantages associated with an activity. This concept states that information becomes significant when it causes an emotional or affective reaction. According to the authors, "affect" in this case refers to the specific quality of "goodness" or "badness" that is felt as an emotional state, whether consciously or unconsciously, and determines a stimulus' positive or negative attribute.

Their research highlights that affective reactions occur swiftly and spontaneously, pointing to how quickly people's sense the feelings associated with the stimulus word ''treasure'' or the word "hate". Additionally, the authors observed that if individuals have a positive inclination towards an activity, their evaluations tend to depict the risks as minimal and the benefits as substantial. Conversely, when in a negative disposition, they are more likely to appraise the situation with high risks and scarce benefits. The authors characterize this reliance on emotional responses as "the affect heuristic". This concept is based on a myriad of conclusions that had been verified by different authors. Fischhoff et al. (1978), determined that the way risks are perceived and how society reacts to them are closely related to the level of dread evoked by a potential hazard. This connection is demonstrated by the notion that activities linked to cancer are perceived as possessing greater risk and requiring more stern measures compared to actions associated with less fear-inducing types of ailments, harm, and hazards, such as accidents.

Another notable discovery from the same study is the existence of a negative correlation between evaluations of risk and benefit. This phenomenon often manifests as heightened perceived benefits coinciding with diminished perceived risks, and conversely, heightened perceived risks aligning with reduced perceived benefits. This pattern is evident in instances such as smoking, alcoholic beverages, and food additives, which tend to be perceived as posing substantial risks and minimal benefits. In contrast, vaccines and medicine are often deemed to offer significant benefits with relatively minor risks as exemplified by the author. This persists even when the nature of gains or advantages from an activity stands distinctly and qualitatively apart from the nature of the risks involved.

The fact that this inverse relationship takes shape within people's mental constructs is suggested by the observation that, in the real world, risk and benefits generally tend to be positively correlated, if at all. Activities yielding substantial benefits might encompass either high or low risks, whereas activities offering minimal benefits are unlikely to pose substantial risks.

Slovic et al. (2005) point to two disadvantages of the “affect heuristic” and experiential thinking. One stems from the intentional manipulation of our emotional responses by individuals aiming to influence our actions. For instance, celebrities often endorse specific products to create a positive association. The second limitation arises from the inherent constraints of the experiential system and the presence of stimuli in our surroundings that cannot be accurately represented through emotions. The authors use the irrationality of decisions to smoke cigarettes provides as a dramatic example of this process.

According to Paul Slovic (2010), one of the most important theoretical frameworks to emerge out of the study of risk perception is that of the 'social amplification of risk.' integrating discoveries from media and communication research, from the psychometric and cultural risk perception research, and from studies of organizational responses to risk. Slovic defines social amplification to be particularly useful for studying risk-induced stigma and its effects on policy application.

Slovic et al. (2005) introduce the important concept of numeracy (since a significant portion of risk information is presented to people in the form of statistics and probabilities), showing that individuals who differ in their ability to understand numbers often fail to comprehend risk information adequately. Those who design health risk communications need to consider what can be done to help less-numerate people make better health care decisions.

But even more basic than understanding risk numbers is understanding the consequences being quantified by the numbers. Risk perception has been shown to be a layered process starting with superficial knowledge (e.g. smoking is harmful) and progressing (sometimes) to deeper levels of understanding (e.g. what forms of harm are caused by smoking and how does it feel to experience them?). A significant portion of risk-related information is presented through statistics and probabilities. Slovic et al. (2000) introduce the crucial notion of numeracy, revealing that individuals with lesser levels of mathematical comprehension often struggle to fully understand risk information. When designing communications about health risks, it becomes imperative to consider strategies that assist individuals with limited numerical understanding in making informed health care decisions.

However, more fundamental than merely comprehending risk figures is comprehending the implications encapsulated within those statistics. The process of perceiving risk is multifaceted, beginning with basic awareness and potentially evolving into deeper layers of comprehension (Slovic, 2010).

Weinstein et al. (2004) (cited by Slovic, 2010) demonstrate that while individuals may acknowledge that smoking can carry negative health effect, they lack even a foundational comprehension of the extent and seriousness of these harmful effects. The author presented using graphic images showcasing smoking-related diseases as an example of method aimed at increasing knowledge and producing adverse emotional responses toward smoking.

2.3. Risk Governance

According to the IRGC Risk Framework (2017), Governance encompasses the activities, procedures, customs, and organizations through which authority is exercised and collective decisions are formulated and executed. Risk governance can be described as the processes of recognizing, assessing, managing, evaluating, and communicating risks in the context of diverse values and distributed authority. As such, it should include all stakeholders, considering their rules, conventions, and processes. Consequently, it focuses on how risk information is gathered, analysed, and disseminated along with how risk management decisions are implemented and communicated.

The IRGC (2017) Framework is presented through Figure 15. It comprises four main phases: pre-assessment (identification and framing; setting the boundaries of the risk or system), appraisal (assessing the technical and perceived causes and consequences of the risk), characterisation and evaluation (judging risk and the need to manage it.), management (deciding on and implementing risk management options) and three cross-cutting elements (communicating, engaging with stakeholders, considering the context)

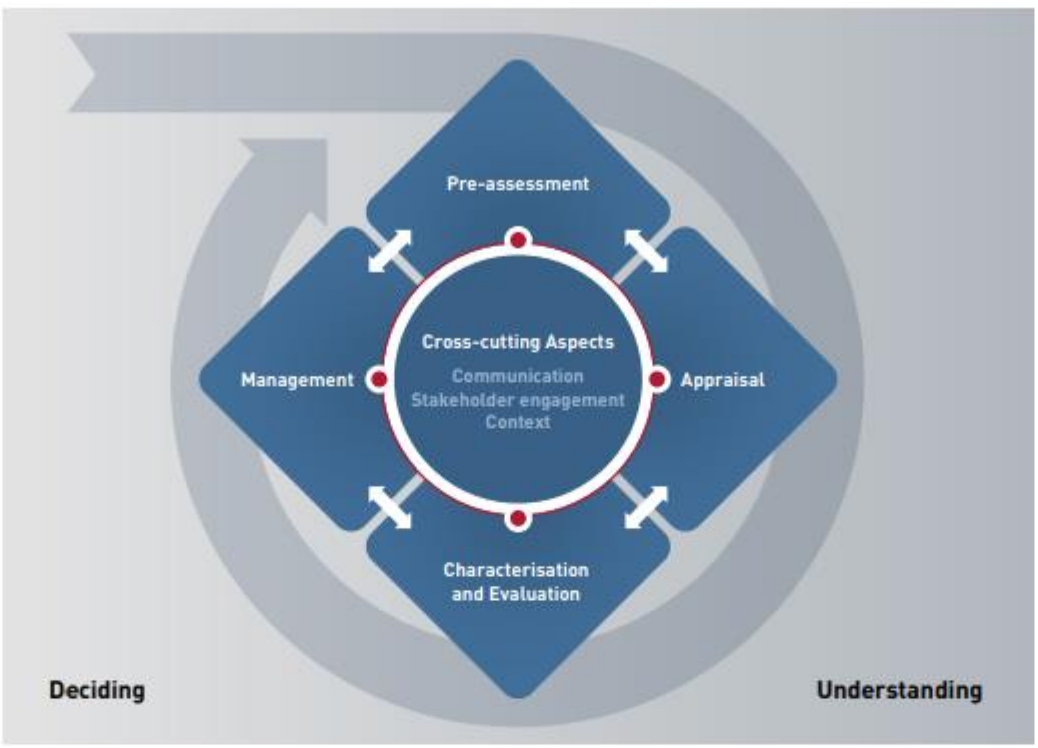


Figure 15: IRGC Risk Framework; Source: IRGC (2017).

2.3.1. Risk communication

According to the IRGC (2017) Risk communication is the process of exchanging or sharing risk-related data, information, and knowledge between and among different groups such as scientists, regulators, industry, consumers, or the general public. It is of the utmost importance for effective risk governance. First, it enables risk assessors and risk managers to develop a common understanding of their tasks and responsibilities (internal communication). Second, it empowers stakeholders and civil society to understand the risk and the rationale for risk management (external communication). It allows stakeholders to make informed contributions to risk governance, recognises their role in the risk governance process and gives them a voice by creating a deliberate two-way process, effective and early communication is the key to creating long term trust in risk management, when risks are perceived complex, uncertain or ambiguous.

Risk communication should be bilateral and should consider the opinions and experiences of vulnerable individuals (affected or not by a certain event). Understanding their views and perceptions is paramount to act upon risk. Hence the intrinsic importance of conducting studies aimed at a not only the physical aspect of understanding risk, but also at the sociological aspect (Calvello et al. 2016).

When information on Risk is being communicated, there are a few questions (Table 2) that should be taken into consideration by those conveying such information (IGRC, 2017)

Table 2: Risk Communication questions proposed by the IGRC Risk Framework; Source: IRGC (2017).

Questions
"How can the communication process be organised and facilitated between and among regulators, risk assessors and other in-house experts (internal communication)?"
"How can communication be facilitated between risk takers, risk affected parties, other stakeholders, the media and risk managers (external communication)?"
"How can communication be organised so that two-way information is effective, enlightening and timely?"
"What is known about the risk and the hazard, by whom, and how can it be conveyed to the interested stakeholders and the public?"
"Does the communication take into account how the risk is perceived by the stakeholders?"

“Are there ambiguities and controversies about the risk within the public sphere?”
“What is the degree of confidence in the risk managers responsible for generating or disseminating information, and for organising a dialogue?”
“How to deal with confidential and sensitive information?”
“What are the demands, needs and purposes for information and communication among the different stakeholder groups, including members of the general public?”
“Are the concerns of stakeholders and the public being clearly articulated and are decision-makers listening?”
“How is information interpreted by those who receive it?”
“What has been and can be the role of the media, both traditional and social?”

2.4. The International Endeavours on Landslide Risk Perception.

There have been extensive endeavours focused on investigating the way individuals perceive risks associated with natural hazards and the processes involved in weighing these risks against potential benefits, thereby offering alternative approaches to hazard management (Slovic et al. 1974). Recently, considerable attention has also been given to exploring the role of risk perception in disaster risk management.

Moreover, the rich history of disaster events linked to natural hazards has prompted studies on the perception of volcanic activity (Barberi et al. 2008; Gaillard, 2008; Bachri et al. 2015), earthquakes (Armas, 2006; Lindell et al. 2009), hurricanes (Lindell and Hwang 2008; Trumbo et al. 2016), floods (Grothmann and Reusswig, 2006; Whitmarsh, 2008), and other types of natural hazards. However, there is still a noticeable gap in research concerning landslide risk perception in Portugal.

These latest developments in risk perception research are founded on a growing interest in investigating the contrasts between experts' supposedly "objective" risk evaluations and the intuitive judgments of the public (referred to as risk perception). This observation has become a significant driving force behind the exploration of people's risk perception and the factors that influence it. Unveiling the intricacies of risk perception and its determinants holds paramount importance as it paves the way for enhancing risk communication strategies and formulating more effective mitigation policies (Ho et al. 2008).

In 2004, The National Science and Technology Center for Disaster Reduction (NCDR) carried out a questionnaire encompassing risk rating, risk perception, and demographic background aspects (A total of 2,163 households were sampled and the age of the population ranged from 20 to 70 years).

For risk rating, participants were asked to assess the level of risk associated with six common hazardous events in Taiwan, namely earthquakes, floods, landslides, fire, environmental pollution, and contagious diseases. A four-point scale was employed for this evaluation, with 1 point indicating "almost no risk" and 4 points representing "very high risk."

The risk perception section comprised seven questions, specifically focused on the characteristics of natural disasters, such as floods or landslides. Participants responded to all questions using a four-point scale enabling the scoring of the risk perception for each question. Additionally, the demographic background category gathered information on gender, family monthly income, education level and past experiences with disasters to compare those variables with the risk perception scores.

Through this method, the authors concluded that individuals who directly experienced the hazards manifested a more heightened risk perception compared to other groups. On the other hand, the indirectly affected group demonstrated a lower risk perception, yet still higher than that of the public.

Furthermore, the authors concluded that there are more personal mitigation actions that one can take in the case of a flood than in the case of a landslide. However, a noteworthy discovery in this study is that the perceived sense of controllability was negatively correlated with the perceived impact among landslide victims, whereas this correlation was not observed among flood victims. To explain this, a concern-specific hypothesis was developed. For flood victims, the main concern is centred around financial loss, which is not easy to completely reduce through the available mitigation actions. However, the main concern of the landslide victims is human casualties, which can be effectively avoided by timely evacuation measures.

From this perspective, the sense of controllability will remain high only if the type of disaster impact that concerns people can be effectively prevented through their actions. Coimbra is too an area where both floods and landslides and prominent.

The perception of landslide risk one develops, influences decisions directed at reducing the impact of these phenomena. Such decisions should be based on extensive geological analysis and mapping of the most susceptible regions. The latter concept translates the probability of a territory to be affected by a natural or technological phenomenon in view of its magnitude, severity, and in the case of our study, through the analysis of the geo-physical aspects of Coimbra (Tavares and Cunha, 2008). In addition, appropriate forms of communication are fundamental to the success of risk management systems (Calvello et al. 2016).

Hernández-Moreno and Alcantara-Ayala (2016) carried out a survey in Santo Andrés (Mexico) aimed at analysing landslide risk awareness and knowledge based on people's common understanding and perception of landslides associated with previous events. A total of 600 participants, all aged 18 years or above, were included in the final sample.

The questionnaire had 62 questions categorised into several sections related to risk perception, namely: experience (previous direct or indirect experience with landslide disaster events); landslide risk awareness (main causes of landslides); exposure (levels of landslide risk perception of exposure, based on location and nature of dwellings); preparedness (preventive measures to be undertaken to cope with landslide disaster events); responsibility (perceived accountability of actors in case of a landslide disaster); response (evaluation of the response of different actors after a landslide disaster); and trust (level of people's confidence to be informed about disaster preparedness and response by different social actors).

The participants attributed heavy rains as the primary natural factor contributing to landslides. As for anthropogenic causes, most respondents, considered building houses on slopes as the most significant contributor to landslides.

Remarkably, a significant proportion of the respondents identified a ban on housing construction in high-risk areas as the most important measure to prioritize among various mitigation measures. In both regions, landslide instrumentation and monitoring were rated the worst of all prevention measures despite being classified as high and medium priority. Houses built on the edge of a slope were perceived as being the most exposed. Additionally, in both neighbourhoods, most participants believe that houses located at the city centre are the least exposed to landslides.

Concerning perceived accountability, interviewees were asked to which extent they considered different community actors responsible for taking actions in case of landslide disasters. The respondents elected the Mexican Army as the most accountable institution. Interviewees were also queried about the disaster response of various stakeholders.

The authors' findings concur with previous research on risk perception awareness, which have suggested that quite often interviewees are not very much concerned with natural hazards and lack disaster risk preparedness (with most not adopting any kind of mitigation measure). According to Hernández-Moreno and Alcántara-Ayala (2016), "public awareness and knowledge require solid foundations of the processes and factors involved in the construction of disaster risk, not only on what to do during and after a disaster takes place". This notion reinforces the need for efficient information communication.

2.5. A Large-Scale Risk Perception Study in Portugal

In Portugal, a risk perception study of a similar nature was conducted by Tavares et al. (2011). With a survey designed to study a total of 28 hazards (natural and technological). A a total of 1200 individuals were. The assessment of respondents' perception on the possibility of being affected by a set of 28 natural, technological, and mixed processes and events was analysed based on two scales of analysis: one more proximal to the respondents and considered to characterise the municipality of residence; and the other more distal characterising the national space.

When analysing the perceptions using the most relevant descriptive variables as a reference (statistical analysis of the differences between the means of the scales, using gender, age, level of education, social class, type of housing area and NUTS II as independent variables and applying the ANOVA sample test), the authors found that, both at the level of the municipality of residence and at the national level, the education and age of the respondents, as well as their geographical location (North, South, Greater Lisbon) appear to explain almost all the differences in responses. Regional differences stand out clearly, as respondents from Greater Lisbon have a much higher perception of risk than respondents from the South and especially the North. Among the various hazards, drought stands out as the one that has an exclusively regional explanation - related to the typology of areas and geographical location - since the remaining variables, purely sociographic, do not contribute to its variation.

The data presented on the perception of risk in mainland Portugal brings forth the fact that as the evaluation scale become larger, the dependence on general knowledge and access to information sources for risk perception also grows. This dependency is tightly linked to factors such as education level, social class, and the geographical location of residence, particularly in coastal and urban areas.

In terms of institutional trust, respondents recognise the National Institute of Meteorology (IPMA) as an important agent in publishing trustworthy warnings and alerts. However, answers indicate a lower trust in the civil protection services (communication wise), although they scored positive in the trust indices. These services have lower public recognition indicators in terms of communication strategy and warning and alert particularly when related to emergency scenarios. There was also a low recognition of communication from government/central administration, as opposed to health professionals, academics, and scientists.

The authors also concluded that there was a high level of trust in the response given by civil protection institutions and emergency and rescue organisations in emergency scenarios. This high degree of trust in civil protection institutions in Portugal stems from an institutional context and a consensus-based risk regulation regime, which is characterised by the general public's acceptance of this regulatory model and broad trust in regulators.

Landslides placed seventeenth in risk perception ranking with a 2.75 score (on a 5-point Likert scale). The processes/hazards that obtained higher values were road accidents and forest fires. Moreover, landslides scored low in risk perception in all the NUTS II regions as shown in Figure 16. Lisbon and Tagus Valley regions scored higher than the other regions, regardless of the lower probability evidenced in the guiding documents on landslide risk in Portugal.

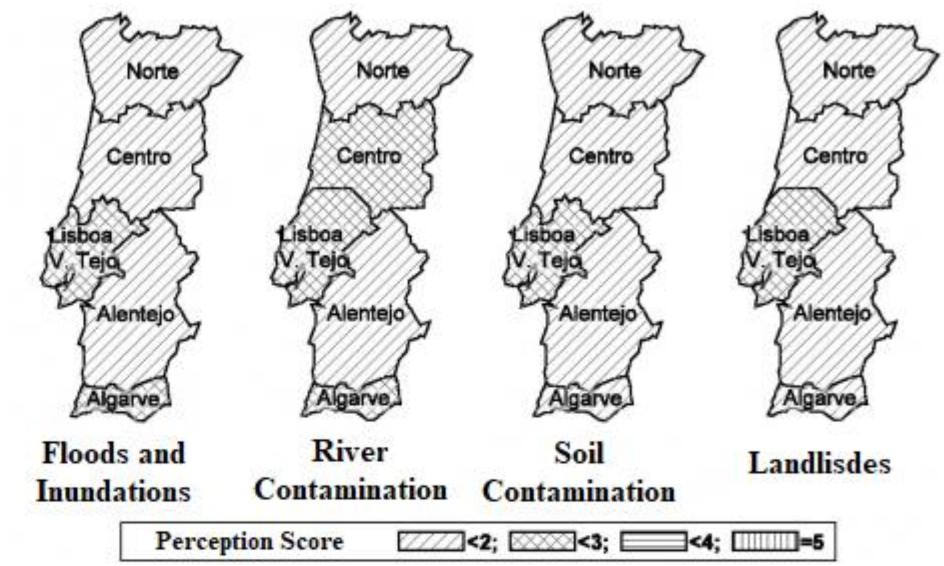


Figure 16: Risk perception scores; Source: Tavares et al. 2011.

Chapter III: Methodology

3.1 Methodological Principles

3.1.1. Landslide Susceptibility Evaluation

To assess susceptibility to landslides, a range of methods and techniques can be applied to evaluate the distribution of instability. In this sense, the development of a susceptibility map would provide the answer to the first starting question (How is landslide susceptibility distributed in Coimbra?).

The main purpose of landslide susceptibility maps is to rank the different regions of territory according to the probability of landslide (Corominas et al., 2014), regardless of the type of methods used and overlooking the temporal recurrence of the phenomenon. This spatial probability does not exactly represent the probability of a landslide, but rather the potential for a given area to become unstable, depending on a set of predisposing factors (Corominas & Moya, 2008).

Conceptually, the assessment of susceptibility to slope movements is supported by a set of universally accepted assumptions that follow the following presuppositions (Varnes, 1984 Dikau, 1996):

- Landslides possess a distinct morphological character, facilitating their identification, classification, and cartographic representation.
- The occurrence of slope movements is controlled by mechanical and physical laws, whose variables can be reproduced empirically, statistically or deterministically, through a set of factors that can be used in predictive modelling.
- The inventory of landslides, although not containing all the slope movements that have occurred in the area subject to study, represents a statistically representative sample of their spatial distribution and the factors that have conditioned their occurrence.
- The circumstances that have historically triggered landslide events can be discerned, whether through direct observation or indirect inference.
- The predisposing factors used to assess susceptibility are globally representative of the conditions that typify the occurrence of slope movements.

- By applying the Principle of Uniformitarianism, we can extrapolate the occurrence of landslides spatially, enabling the hierarchical classification of regions based on their susceptibility.

3.1.2. Susceptibility Analysis Methods

Figure 17 shows a classification and grouping scheme for the various methods used to assess susceptibility to landslide, according to the proposals put forward by Soeters & Van Westen (1996) and Aleotti and Chowdhury (1999). According to this classification, the methods are separated into qualitative methods (e.g. landslide susceptibility mapping based on geomorphological mapping supported by fieldwork and photointerpretation; multi-criteria analysis) and quantitative methods based on statistical/probabilistic approaches and static or dynamic deterministic approaches.

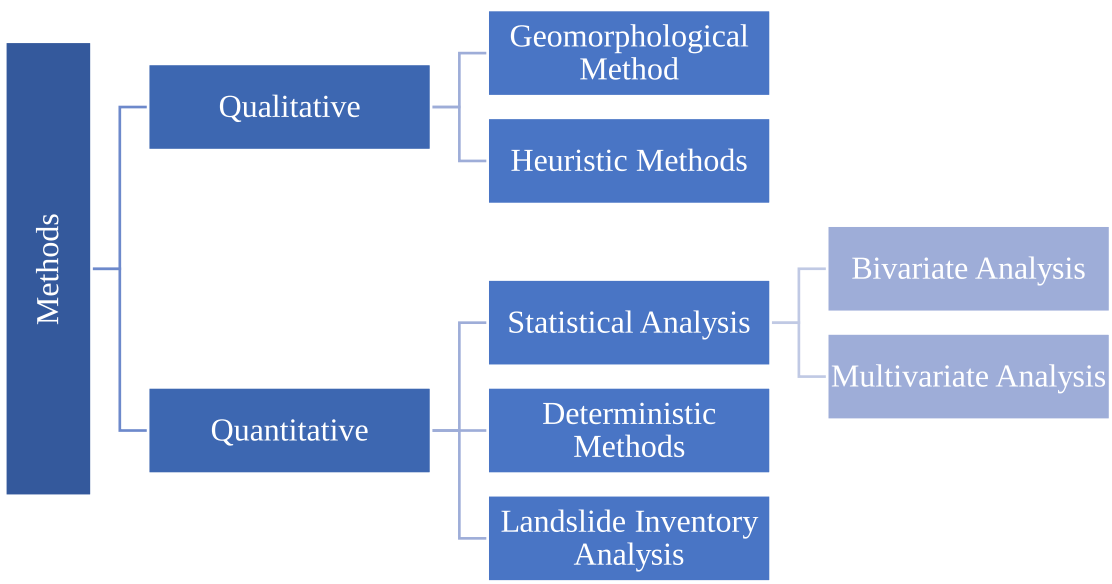


Figure 17: Susceptibility analysis methods; (Adapted from Soeters & Van Westen, 1996; Aleotti and Chowdhury, 1999)

3.1.2.1. Geomorphological Method

The geomorphological method is a direct susceptibility assessment method whose results are qualitative, and which essentially depend on the investigator's experience in recognising and assessing the instability of current slopes and potential areas of future instability. According to Aleotti and Chowdhury (1999), this is the simplest (with no clear indication of procedures) and quickest method. In this case, the susceptibility mapping is a product of the subjective analysis of the slopes contained within the area subject to study the geomorphological characteristics the area in question. It is a method that quickly produces results and is adapted to the study area, but it is highly dependent on the judgement of the analyser, which makes comparisons to other studies difficult and sometimes totally unreliable.

3.1.2.2. Heuristic Method

Aleotti and Chowdhury (1999) characterise heuristic methods as indirect methods that produce semi-quantitative results, which assume that all the causes and factors of instability in a certain study area are known and whose reliability, similarly to geomorphological methods, is dependent on the degree of knowledge and understanding the researcher carries. Moreover, the instability factors are classified, hierarchised and weighted (the factors have weights subjectively assigned to them), considering their expected importance on the occurrence of landslides. Based on this information, subjective criteria are established to define possible areas of instability and proceed with the susceptibility mapping and zoning. The final susceptibility map is based on the sum of the weights given to factors during the process of analysing the study area.

3.1.2.3. Landslide Inventory Analysis

The analysis of landslide inventories aims to predict the occurrence of instability events directly through the distribution of past occurrences. Through this, landslide density maps are created containing the respective percentage of occupied area or the number of landslides in any given study area (Guzzetti, 2005).

This method of assessing susceptibility is indirect and produces quantitative results (Soeters and van Westen, 1996). According to Guzzetti (2005), if properly normalised, landslide density maps can provide adequate estimates for susceptibility mapping. However, uncertainties and errors can arise that are directly related to the inventories and their spatial representativeness. Furthermore, this method does not consider the relationships between landslides and predisposition factors.

3.1.2.4. Deterministic Methods (Safety Factor)

Deterministic (geotechnical) methods are based on understanding the physical laws that control the stability of slopes, such as the conservation of mass, energy, and force balance (Guzzetti, 2005). When the physical properties of the various slopes are identified, they are then quantified and added to specific mathematical models, making it possible to calculate the Safety Factor. This Factor is based on a geotechnical model, the reliability of which is improved by using detailed information on the geometry of the slope and on the shear strength parameters (cohesion and angle of internal friction) and on the pore water pressure (Aleotti and Chowdhury, 1999) and also, according to Soeters and van Westen (1996), by obtaining information on the thickness of the soil and on the depth and geometry of the potential rupture plane. These methods require detailed information on the geometry of the slope and the physical, mechanical, and hydrological properties of the materials and present some difficulty in being applied to large areas, forcing the use of mean values.

3.1.2.5. Statistical Methods

Statistical models are used to assess susceptibility to landslides to describe the functional relationship between predisposing factors and the distribution of past and present occurrences (Carrara, 1983).

According to Aleotti and Chowdhury (1999), statistical methods can be further divided depending on the relationship between predisposition factors (independent variables) and the distribution of slope movements (dependent variable), into: Bivariate statistical methods (e.g. Informative Value Method, Weights of Evidence, fuzzy logic systems), where the relationship is established individually between each predisposition factor and the distribution of the events i.e. the weight value of each class is determined directly on the basis of the corresponding density of slope movements; Multivariate statistical methods (e.g. discriminant analysis, multiple regression, logistic regression), in which the weighting is based on the relative importance of the various predisposition factors in relation to the occurrence of slope, combining the independent variables under unique conditions, considering the interactions between them.

3.2. Employed Methodology

In the current study, a multivariate statistical method with the following predisposing factors was conducted: elevation, slope, exposure, geological units, profile curvature, planform curvature, drainage density, distance to water streams and land use. Georeferenced data (in shapefile format) on hydrology and hypsometry (contour lines and datum points) were input to create a digital terrain model of the municipality of Coimbra in the ArcGIS tool, using the Spatial Analyst functionalities. This digital model made it possible to derive most of the predisposition factors used throughout the study, namely elevation, slope, aspect, longitudinal profile, transversal profile, drainage density and distance to watercourses. Land use and geological units were extracted from the website of the National Geographic Information System (NGIS) and the National Energy and Geology Laboratory (NEGL) respectively. Maps were also created for each of the variables as a way of assessing and getting to know the study area.

3.2.1. Gathering and Data Analysis

The inventory that was utilized in the susceptibility analysis carried out in this study is an extended version of the database that was created by Pellegrina (2015) between January 2000 and March 2013 for events that occurred during periods of precipitation. In this study, new data was included in the previous database, from April 2013 to February ,2023 while applying a similar methodology.

A selection of the periods with the highest recorded rainfall values. Such values were subject to analysis using data provided by the Geophysical and Astronomical Observatory of the University of Coimbra (OGAUC). The Excel tables provided contained daily rainfall records gathered between 2013 and 2022. However, the tables for the years 2018 and 2019 had to be rearranged, as the data was presented by the hour and some of the values were duplicated. The tables present the daily accumulated rainfall values (from 09:00 to 09:00) for the period under study in Coimbra, where consecutive days accumulating at least 10 mm of rain were selected.

The next step was to search for any news related to landslides in the local newspapers. This search was carried out in the Diário de Coimbra newspapers provided by the Coimbra

Municipal Historical Archive, with the days pre-selected by the sequence of rainy days from the OGAUC rainfall data. Moreover, the online platforms of the newspapers As Beiras and Noticias de Coimbra were utilized in the search. Paper articles were photographed, and images of the online pages were saved for all the events that were included in the database (Figure 18 and 19). Part of the occurrences were georeferenced in ArcGIS using the information provided by the news articles and their location on the orthophoto maps provided by the Google Maps tool.

To examine the database, Excel was used, and occurrences were stored along with the date, location, type and description of the damage and resources allocated, for example, to clean up displaced material unblocking a certain road.

Diário de Coimbra

Publicidade 239 499 999

Mau tempo corta estradas e provoca deslizamento de terras e inundações

Alerta Um pouco por todo o distrito, a chuva não deu tréguas no fim-de-semana da Páscoa. As previsões para os próximos dias não permitem pensar em melhorias

Esplanada continua completamente alagada

Derrocada condiciona trânsito na Ladeira do Baptista

João Henriques

Mau tempo e períodos de chuva. É este o cenário para os próximos dias. Uma previsão que não deixa antever melhorias no que diz respeito à situação hidrológica na bacia do Rio Mondego, que, ontem, se mantinha estável, por volta dos 900 metros cúbicos por segundo [(m3/s)]». Contudo, as variações dos caudais dos efluentes do Rio Ceira, a montante de Coimbra, levaram a Protecção Civil a avisar para a possibilidade de «um aumento do caudal do Rio Mondego até aos 1200 m3/s». visão do aumento da precipitação», lia-se no documento assinado por Paulo Palrilha.

A subida das águas originou o alagamento e consequente corte de estradas no distrito de Coimbra, sobretudo no Baixo Mondego. A estrada do campo entre Pereira e Formoselha, no mos dias, provocou deslizamento de terras em diversos pontos do distrito, provocando, por exemplo, o corte da Estrada Nacional 544, entre Arganil e Mont'Alto, e da Estrada Regional 235 ao quilómetro 0.8, em Penacova, no Largo Dona Amélia.

Também no centro da cidade

Figure 18: Printed landslide news; Source: Diário de Coimbra (2013).

Figure 19: Online landslide news; Source: Jornal as Beiras (2020)

3.2.2. Susceptibility Assessment

The susceptibility map was created using the Weighted Overlay function in ArcGIS in which each variable had to be assigned a percentage influence. The predisposition factors were converted from vector to raster format and reclassified into quintiles (five classes which share the same area covered) so as to discriminate the data, except for land use and geological units (reclassified into six classes) since these variables are not composed of numerical values. The typification for each factor is described in the next chapter.

3.2.3. Principal Component Analysis

Percentages were also assigned to each of the classes based on the proportion of landslides that were spatially contained within each class. The percentage of influence for each factor was determined using the IBM SPSS data processing tool by applying a principal component analysis to the percentage values assigned to each class of all the variables. This data was added into the application and then analysed using Factor Analysis.

The principal component analysis made it possible to choose, using the total variance table, two components that explained most of the variation in the data entered. This method was also used to calculate the component matrix which has a scale ranging from minus one to one and shows the variables with the most influence on each component. Due to their explanatory and discriminatory value, two susceptibility maps were created, one for each component.

Finally, the two maps were joined with a new application of the Weighted Overlay function to obtain the final susceptibility map. The results derived from the principal component analysis are displayed in the next chapter.

3.2.4. Risk Perception Questionnaire

To find the answer to question number four and five, a questionnaire (Appendix I) was developed with questions based on various studies on the perception of natural risks (mainly related to landslides) (Bustillos et al. 2017, Calvello et al. 2016, Tavares et al. 2011, Ming-Chou et al. 2008, Lin et al. 2008). In addition, the questionnaire was divided into four sections: Respondent Characterisation (10 questions), Emergency Plans (3 questions), Risk Perception (22 questions) and Institutional Trust (8 questions). The questionnaire was written in Portuguese.

The questionnaire was conducted in three parishes in Coimbra, namely the Union of the Parishes of Eiras and São Paulo de Frades, Santo António dos Olivais and Ceira. Ease of access to the parishes was the main factor in choosing them as the target area of the questionnaire.

Before the questionnaire was applied, a pre-test phase was carried out during which the questionnaire was presented to 10 people (half men and half women) in order to identify errors or any kind of ambiguity that could lead to confusion. Some details related to scientific language were identified and altered so that they could be easily understood by the respondents. A good example of this was the concept of "*movimento de vertente*" (the proper scientific term related to landslides in Portuguese) which was changed to "*deslizamento*" or "*derrocada*" (as these are widely more common in the Portuguese language).

The questionnaire was conducted in two contexts, one in person and the other using the online tool Google Forms. In person, the questionnaire was conducted on paper with the help of the student presenting the questions and marking the answers. At this stage, the streets and houses subject to the questionnaire were chosen at random. The online version of the questionnaire had no difference in the questions compared to the printed version. Moreover, the online questionnaire was publicised on Facebook pages related to the previously chosen parishes.

In both phases, the participants were presented with the objectives of the study, and it was assured that all the information they provided was confidential, anonymous, and solely for research purposes. In addition, help was offered should any doubt come to surface.

3.2.4.1. Data Analysis

After conducting the questionnaire, the data collected were codified with IBM SPSS tool using statistical descriptors, such as the mean, mode, median, standard deviation, minimum and maximum values (especially for the respondent characterisation questions and the questions concerning risk perception). A Pearson correlation matrix was also created with the values gathered on respondent characterization (age, qualification, duration of residence and parish of residence.

In addition to the descriptive statistics, various tests were carried out to identify whether there were statistically significant differences between the means (obtained through the risk perception Likert-scale questions) of certain groups of participants organised by: parish of residence, education level, gender and whether they knew someone who had been seriously affected by a natural hazard. To test whether there were significant differences between these last two variables and their answers to the risk perception questions, the independent samples t-test was used. This type of test is used to compare the means of two independent samples, and in this case, female and male answers were compared. If the test reveals a significance level of 0.05, we assume that the variances are homogeneous and choose to use the values from the t-test of equal variances assumed. In both cases, if the values are less than 0.05, we can consider that there are significant differences between the male and female groups. Additionally, the anova-one-way test was used to test the other variables. This type of test is used to compare means between groups with three or more samples. If the test reveals a significance level of less than 0.05, it is considered that there are statistically significant differences between the groups. If this is confirmed, it is necessary to carry out the post-hoc test to identify which groups carry such differences (Kim, 2017).

Chapter IV – Results on The Susceptibility Analysis

4.1. Landslide Database

A total of 52 landslide occurrences were added to the inventory developed by Pellegrina (2015), for a total of 189 identified events, (one occurrence related to the subsidence of a road was removed since it was unrelated with the landslide phenomenon). Out of these 52 events, 23 were mapped adding up to 110 landslides georeferenced in the study area as shown in Figure 20. 83 of the mapped movements (approximately 75% of the total mapped movements) were classified as slides and the remaining 27 as falls. Most of the recorded events took place in the eastern half of the municipality (Figure 20), which is the most mountainous region with the steepest slopes. Apart from the slopes of the Ceira and Mondego rivers valleys, most of the landslides were caused by construction works responsible for the destabilisation of slopes, especially road works (Cunha and Pellegrina, 2019).

The damaged caused by most of the landslides resulted in road closures and traffic restrictions, especially on Estrada da Beira, where 18 landslides were recorded (some were a result of landslide reactivations). Most incidents were recorded were in: Ceira (21 incidents), Union of Parishes of Santa Clara and Castelo Viegas (19 incidents), Santo António dos Olivais (18 incidents) and Union of Parishes of Coimbra (Sé Nova, Santa Cruz, Almedina e São Bartolomeu) (17 incidents).

Timewise, the winter of 2000/2001 clearly stands out, as it was the season with the highest number of landslide occurrences out of the entire period studied (January 2000 to February 2023) with 42 mapped occurrences. It was the wettest winter in recent years, with floods and a lot of damage in Coimbra (Pellegrina and Cunha, 2019).

Figure 21 shows the annual distribution of recorded occurrences. 2000 was the year with the most occurrences (32) while no events were recorded for 2004, 2005, 2008 and 2022. The annual mean is 4.78 occurrences, and the monthly mean is 0.41 occurrences.

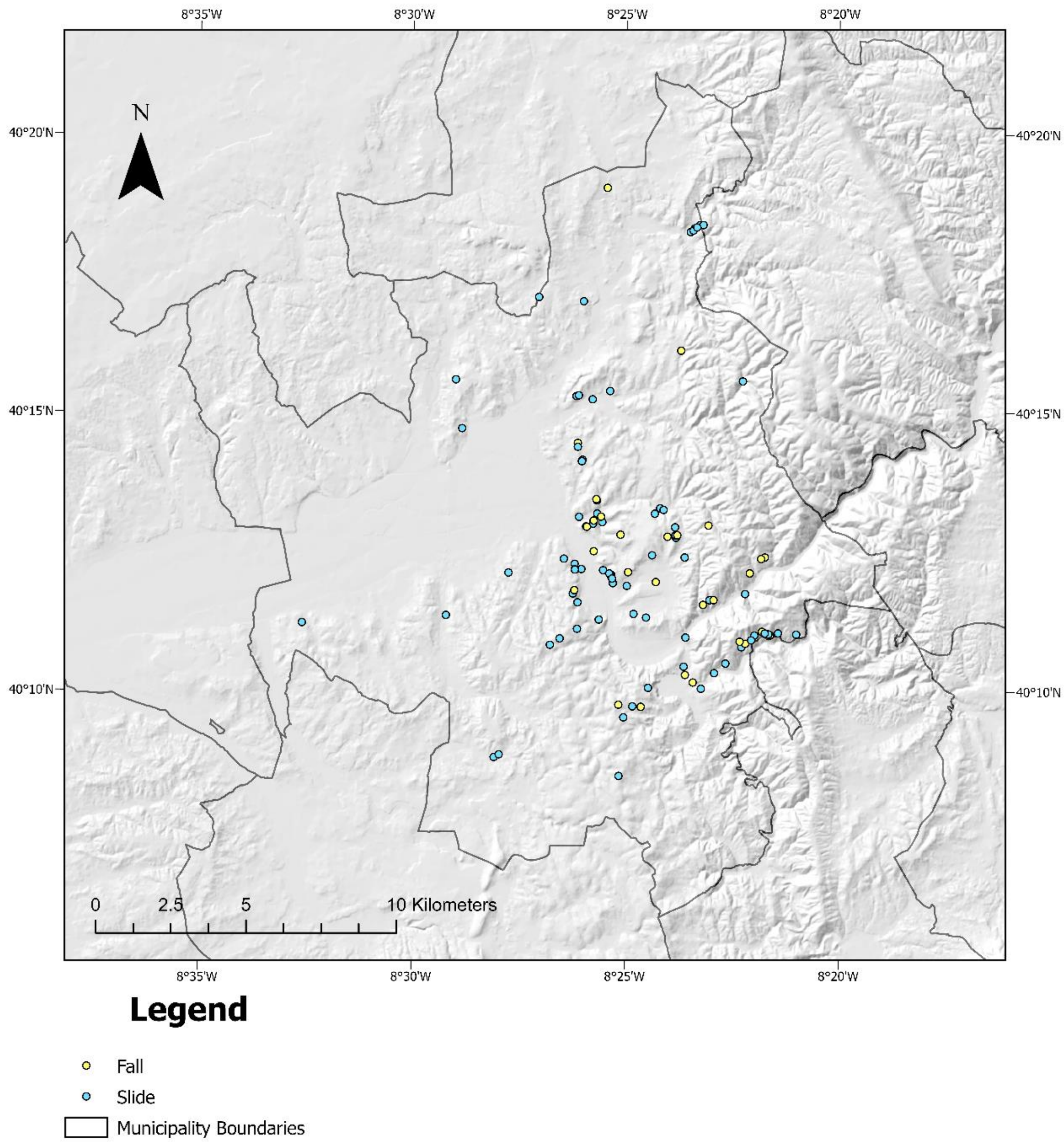


Figure 20: Mapped landslide distribution by type of occurrence.

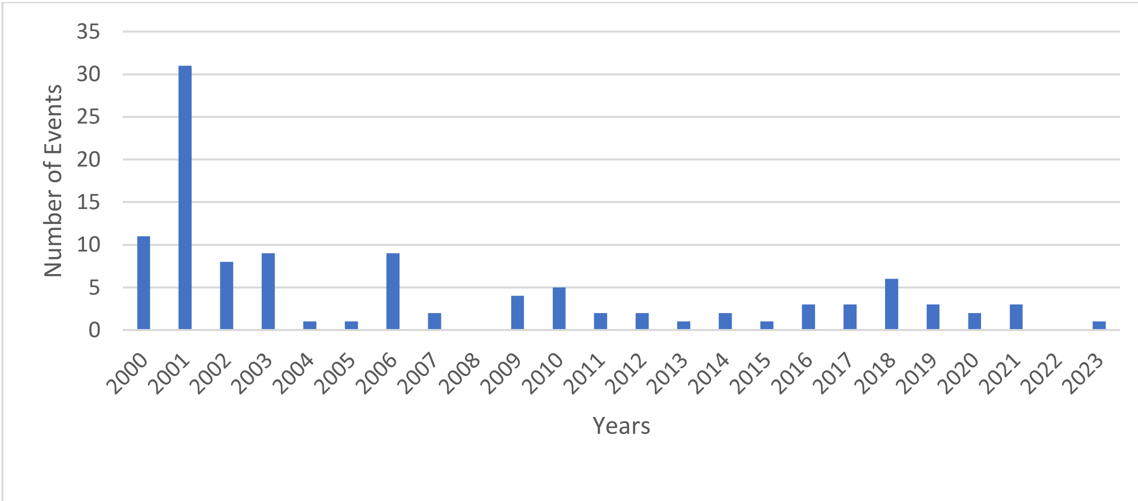
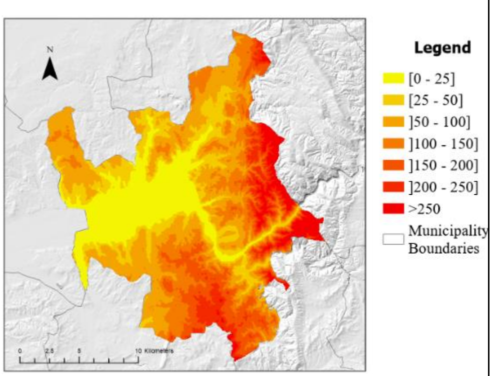
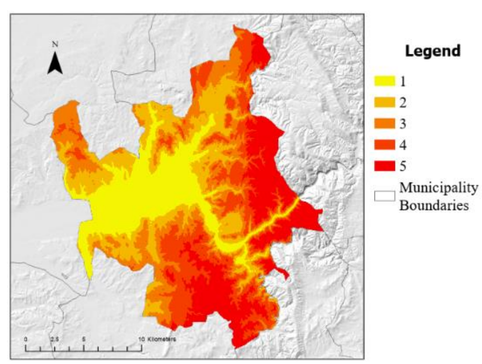


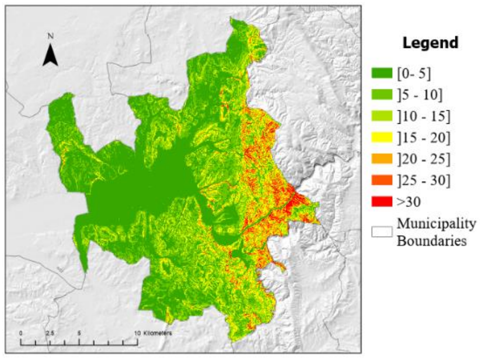
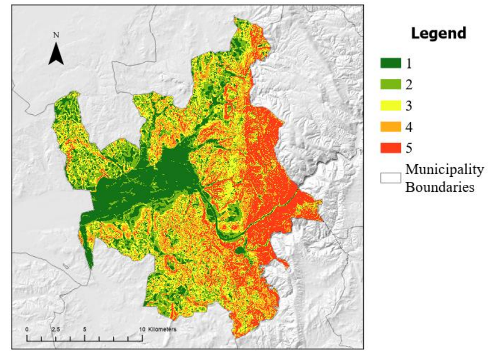
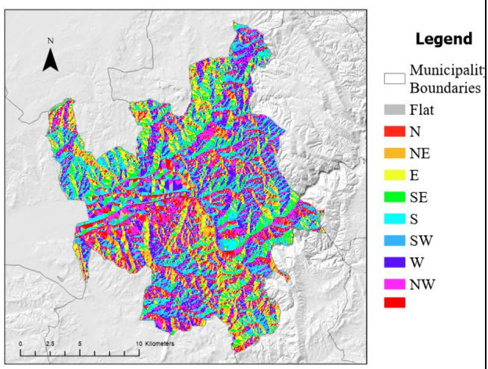
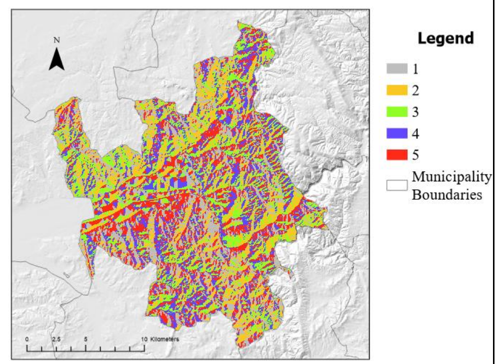
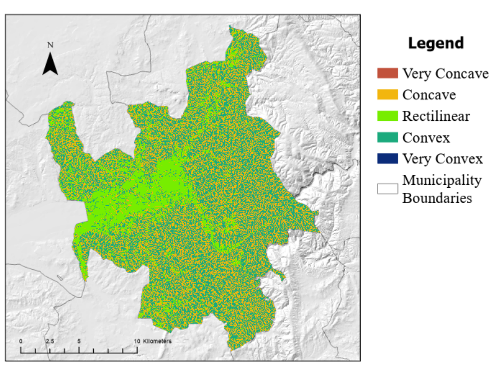
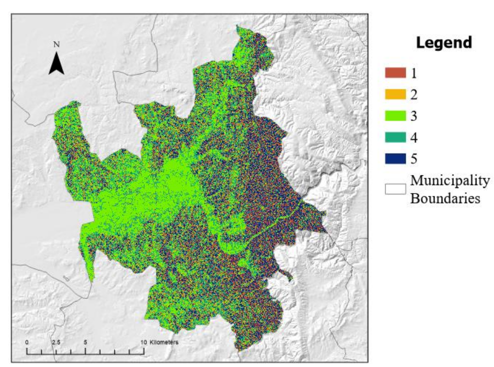
Figure 21: Annual distribution of the recorded landslide events from 2000 (January) to 2023 (February).

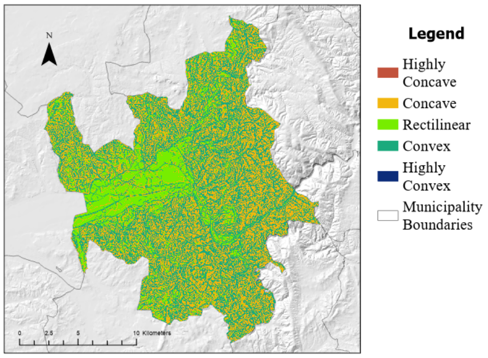
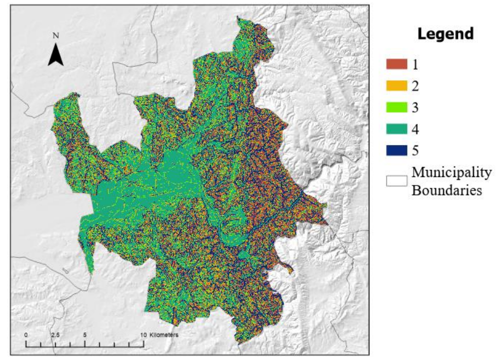
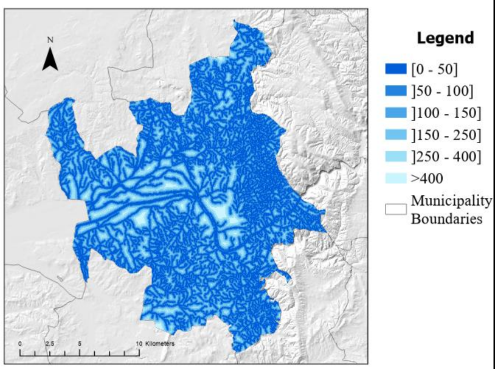
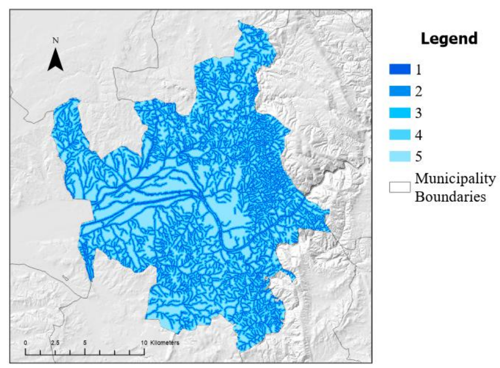
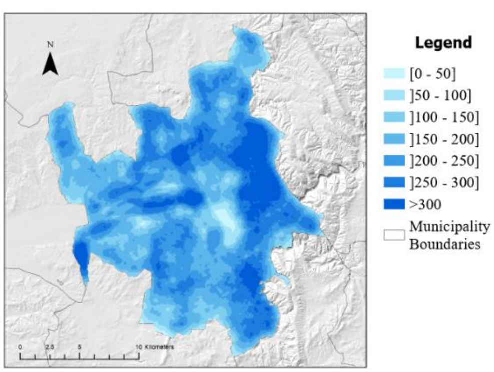
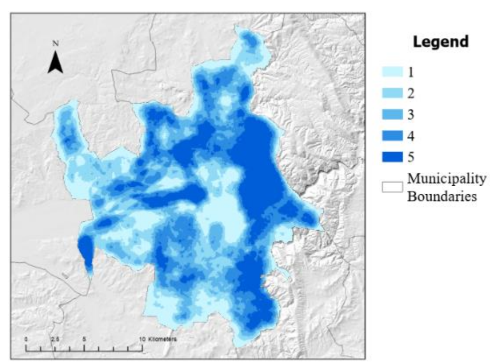
4.2. Predisposing Factors Used in the Modulation of Susceptibility

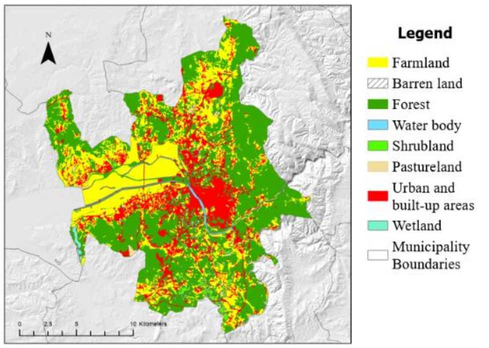
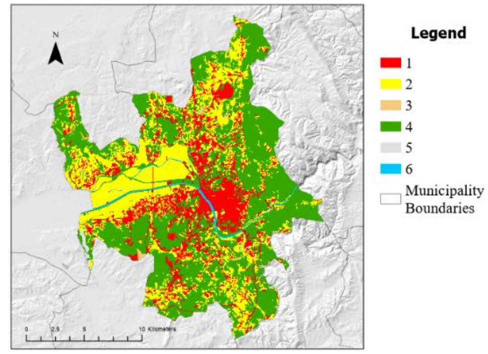
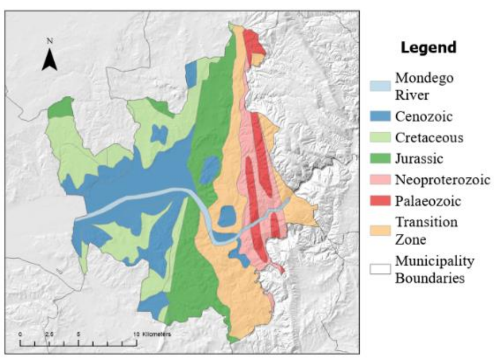
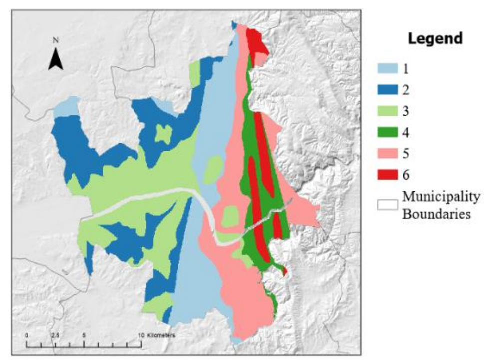
Table 3 shows all the maps created for each predisposing factors, as well as their reclassified classes presented spatially and their respective IDs.

Table 3: Maps created for each predisposing factor, reclassification IDs and spatial representation.

<table>
<tr><th>Predisposing Factors</th><th>Reclassification and ID</th><th>Spatial representation of the reclassified factor</th></tr>
<tr><td>Elevation (m)

</td><td>1 = [0 ;29]
2 =]29;67]
3 =]67;102]
4 =]102;162]
5 = >162</td><td>Reclassified Elevation

</td></tr>
</table>

<table>
<tr>
<td>Slope (º)

</td>
<td>1 = [0;1.4]
2 =]1.4;4.4]
3 =]4.4; 8]
4 =]8; 13.7]
5 = >13.7</td>
<td>Reclassified Slope

</td>
</tr>
<tr>
<td>Aspect (º)

</td>
<td>1 = [-1; 81]
2 =]81; 163]
3 =]163; 236]
4 =]236; 294]
5 = >294</td>
<td>Reclassified Aspect

</td>
</tr>
<tr>
<td>Profile Curvature

</td>
<td>1 = [-4.25; -0.12]
2 =]-0.12; 0.057]
3 =] -0.057; -0.06]
4 =] -0.06; – 0.16]
5 = > 0.16</td>
<td>Reclassified Profile Curvature

</td>
</tr>
</table>

<table>
<tr>
<td>Planform Curvature Transversal
</td>
<td>[-3.9; -0.16] = 1
2 =] -0.16; -0.04]
3 =] -0.04; -0.014]
4 =] -0.014; – 0.14
5 = >0.14</td>
<td>Reclassified Planform Curvature
</td>
</tr>
<tr>
<td>Distance to Streams (m)
</td>
<td>1 = [0; 22]
2 =]22; 47]
3 =]48; 82]
4 =]82; 140]
5 = >140</td>
<td>Reclassified Distance to Streams
</td>
</tr>
<tr>
<td>Drainage Density
</td>
<td>1 = [0; 154]
2 =]154; 192]
3 =]192; 229]
4 =]229; 270]
5 = >270</td>
<td>Reclassified Drainage Density
</td>
</tr>
</table>

<table>
<tr>
<td>Land Use

</td>
<td>1 = Urban and built-up areas
2 = Farmland
3 = Pastureland
4 = Forest and shrubland
5 = Barren land and wetland
6 = Waterbody</td>
<td>Reclassified Land Use

</td>
</tr>
<tr>
<td>Geological Units

</td>
<td>1= Jurassic
2= Cretaceous
3= Cenozoic
4 = Neoproterozoic
5 =Transition Zone
6 = Paleozoic</td>
<td>Reclassified Geological Units

</td>
</tr>
</table>

The elevation map was initially classified into seven classes: [0;25]m,]25;50] m,]50;100] m,]100;150] m,]150;200] m,]200;250] m, >250 m. The elevation map shown in Table 3, displays that the highest values are located in the eastern sector of the study area, where the slopes are also steeper. The most prominent class is the third (]50;100] m) occupying 28.3% of the study area. The last two classes (]200;250] m and >250 m) are the least significant, with 6.4% and 4.8% of occupation respectively. The remaining classes have similar percentages of occupation in the study area. The minimum value recorded was 3.72 metres and the maximum was 498 metres. Furthermore, the mean elevation value is 98.9 metres. The reclassification transformed these values into the following quantiles: [0;29] m,]29;67] m,]67;102] m,]102;162] m, >162 m.

Similarly, to what happened with elevation, slope values were initially categorized into seven classes: [0;5] º,]5;10] º,]10;15] º,]15;20] º,]20;25] º,]25;30] º, > 30 º. In this case, as the classes increase in slope, the area they occupy decreases. Thus, the first class ([0;5] º) occupies most of the study area (43.8%). The second and third classes ([5;10] º and]10;15] º) occupy 24.9% and 14.5% of the study area respectively. The minimum and maximum slope values are 0º and 48.7º respectively and the average is 7.98º. The reclassification of this variable resulted in the following classes: [0;1.4] º,]1.4;4.4] º,]4.4;8] º =]8;13.7] º, >13. 7 º.

After calculating the aspect, nine classes were assigned, eight of which correspond to the cardinal points (N, S, E and W), collateral points (NO, NE, SE and SO) and slopes which faced no specific direction were assigned a “Flat” value. The Aspect map in Table 3 shows that the different classes (calculated in degrees) are evenly distributed. The class with the greatest percentage of occupation is W with 16% of the study area being covered. On the other hand, the class with the least expression is NE with 10.4%. The reclassification of this variable resulted in the following classes: [-1;81] º,]81;163] º,]163;236] º,]236;294] º,]294;360] º.

Profile Curvature describes the level of convexity or concavity of the slopes. The values assigned generally range from -4 to 4. The closer to four the value is, the more convex the slope is (the same logic applies inversely to concavity). When the values are very close to 0, the slope is straight (rectilinear). In this case, the measurement is made longitudinally (downhill, along the surface of the slope). In addition, this variable was categorised into five classes: highly concave (< -3), concave (]-0.01; -3.0]), rectilinear (]-0.01;0.01]), convex (]0.01;3]) and highly convex (> 3). Most of the slopes in the study area have a convex (44.14%) and concave (36.69%) profile curvature, although these values are close to 0 (mean value is 0.02), which means that concavity and convexity are not very significant. The minimum and maximum values are -4.25 and 3.73 respectively. The reclassification of this variable resulted in the following classes: [-4.25; -0.12],]-0.12;0.057],]-0.057; -0.06],]-0.06;0.16], > 0.16

Planform Curvature was categorised in the same way as the previous variable. However, in this case the measurement is made on a transversal plane of the slope. The spatial distribution of the class is also very similar to that of Profile Curvature, i.e. the convex (42,8%) and concave (40%) classes stand out, with values also close to 0 (0,02 average) as seen before. In this case, the minimum and maximum values are -3,89 and 3,84 respectively. The reclassification of this variable resulted in the following classes: [-3.9; -0.16],]-0.16;-0.04],]-0.04;-0.014],]-0.014;0.14], 5 = >0.14.

In these last two variables, the values classified as "rectilinear" are often present in areas of lower slope and elevation because the slopes are less prominent. On the other hand, in the steeper areas where the valleys are located, there is a predominance of convexity in the ridge lines and concavity in the areas closest to the water streamlines.

The "distance to streams" factor was divided into six classes: [0;50] m,]50 – 100] m,]150;250]m,]250;400]m and >400m. The first class ([0;50] m) stands out the most with 40.3% (Since a large part of the study area is close to some kind of water stream). As the distance to the stream increases, classes become less prominent. The last class (> 400 m) occupies the least percentage of the study area with only 0.8%. The maximum and minimum values are 813 m (near the area where the Town Hall is located) and 0 m respectively, and the mean value is 89.37m. The reclassification of this factor resulted in the following classes [0;154],]154;192]]192;229],]229;270], >270.

Drainage density was stratified into seven classes: [0;50],]50;100],]100;150],]150;200],]200;250],]250;300] and >300. The classes that stand out the most are the fourth (]150;200]) and fifth (]200;250]) classes occupying 26.1% and 27.1% of study area respectively. The minimum and maximum values for this variable are 0 and 446.6 respectively and the average is 211.65. The highest values are in the eastern area of Santo António dos Olivais and Union of Parishes of Eiras and São Paulo de Frades. The reclassification left this variable with the following classes: [0; 154],]154; 192],]192;229],]229;270], >270.

Regarding land use, the simplest classification (COS18n1_L) was used resulting in the following classes: "Farmland", "Forest", "Barren land", "Shrubland", "Pastureland", "Urban and built-up areas", "Wetlands" and "Waterbody". Almost half of the study area is occupied by forests (47.91%). Withing this class, 87,8% are eucalyptus forests. Furthermore, Farmland and Urban and built-up areas obtained 29,79% and 17,93% of occupation of the study area, respectively. When reclassifying the Land Use variable, the number of classes was reduced to six by combining the “Forest” with “Shrubland” and “Barren lands” with “Wetlands” classes.

This resulted in the following classes: “Urban and built-up areas”, “Farmland”, “Pastureland”, “Forest and shrubland”, “Barren land and wetland”, “Waterbody”.

The “geological units” variable originally had 16 classes (describing the lithology of the study area) when it was added into the ArcGIS tool. This high number of classes was reduced to six through the geological age of each unit, namely: “Cenozoic” (conglomerates, sandstones and siltstones), “Cretaceous” (mainly sandstones and claystones), “Jurassic” (consisting of limestones, marls and dolomites) , “Neoproterozoic” (phyllites, metagraucites and shales), Palaeozoic (phyllites, quartzites and metacalcites) and “Transition Zone” (includes the zones that mix the end of one period and the beginning of another)(sandstones, claystones and shales). The reclassification of these classes only assigned a numerical value to each one.

4.3. Principal Component Analysis and Weight Assignment

The weights that each class obtained were derived from identifying the proportion of landslide that each class encompassed. For instance, if 50% of the movements occur within the "Forest" class, then that class gets a weight of 0.5 which is converted to 50 when inserted into the ArcGIS model. Table 4 shows the proportion of landslides for each class included for all the predisposing factors and the respective percentages. The percentages used were converted into whole numbers so that they could be inserted into the ArcGIS model.

Table 4: Proportion (%) of landslide events for every variable and its classes.

Classes	Slope	Elevation	Aspect	Profile Curvature	Planform Curvature	D. Streams	D. Density	Land Use	Geo. Units
1	2%	11%	13%	19%	26%	17%	36%	47%	30%
2	19%	27%	26%	15%	13%	15%	16%	16%	5%
3	23%	22%	19%	12%	7%	20%	16%	0%	7%
4	19%	29%	24%	26%	26%	24%	16%	37%	17%
5	37%	11%	18%	29%	29%	25%	16%	0%	29%
6	-	-	-	-	-	-	-	0%	12%

Regarding slope, it's worth noting that the class with the highest prevalence of landslides is the fifth (> 13.7º) with 38% of occupation, while the first class (0 - 1.4º) had the lowest percentage of occupation (2%).

The first class (0 - 154) of the drainage density stands out from the rest containing 36% of the landslides, while the rest remain constant at 16%.

Regarding land use, almost half of the landslides (47%) were recorded within the first class ("Urban and built-up areas"). This value can be explained by the nature of the database, which is based on reported events that generally occur in urban environments, hence their newsworthiness. Additionally, landslides are also prominent in class 4 ("Forest and shrubland") with 37% of area being occupied. Part of this percentage can be explained by the predominance of forested land in the study area.

Table 5 presents the total variance explained. There are two components that describe 80.724% of the total variance of the data. The remaining components do not have much explanatory or descriptive value for the data and therefore were not used.

Table 5: Total variance explained.

Component	Inicial Values		
	Total	% of Variance	Cumulative %
1	4,180	46,443	46,443
2	3,085	34,281	80,724
3	1,373	15,256	95,980
4	0,362	4,020	100,000
5	4,521E-16	5,024E-15	100,000
6	2,916E-16	3,240E-15	100,000
7	-8,285E-17	-9,205E-16	100,000

As described in the previous chapter, weights were assigned to the predisposing factors using principal component analysis. Table 6 shows the values transformed into percentages (from the component matrix obtained through principal component analysis) for the two most important components. These percentage weights serve as an answer to the second starting question (Which of the used variables are most important when calculation landslide susceptibility in Coimbra?).

Table 6: Weights (%) assigned to each variable depending on the component.

Variables	Components	
	1	2
Slope	7%	18%
Elevation	2%	9%
Aspect	2%	11%
Profile Curvature	14%	16%
Planform Curvature	16%	13%
Distance to Streams	12%	17%
Drainage Density	15%	3%
Land Use	14%	4%
Geological Units	18%	11%

For both components, several parameters appear with similar relevance. In component 1, elevation and aspect are devalued, obtaining only 2% weight percentage each, while the other variables obtained around 15% influence (except for slope, which received only 7%). On the other hand, in component 2, land-use and drainage density are the variables that lose relevance (with 3% and 4% influence, respectively). In addition, the remaining variables have influence values that vary between 11% and 18% (apart from elevation, which was assigned 9% of influence).

4.3.1. Correlations between Variables

A Pearson's correlation matrix (Table 7) was calculated through the PCA. It contains the type of relationship (if any) between the variables. The variables Land Use, Geological Units and Aspect were excluded because they represent nominal units unlike the other predisposing factors. It should be noted that these values vary between -1 and 1. Positive values describe a positive linear correlation (in which the values of the classes vary similarly and in the same direction) depending on the proximity of the values to 1. When this occurs, they present a totally direct correlation in which the values for each class vary linearly for both variables. The same happens inversely for negative values, specifically those closer to -1. Values close to 0 represent variables that have little or no correlation between them.

Table 7: Pearson correlation matrix.

Variables	Slope	Elevation	Profile curvature	Planform curvature	Distance to streams	Drainage density
Slope	1	-0.004	0.420	0.052	0.605	-0.825
Elevation	-	1	-0.290	-0.48	-0.158	-0.549
Profile curvature	-	-	1	0.913	0.737	-0.086
Planform curvature	-	-	-	1	0.326	0.541
Distance to streams	-	-	-	-	1	-0.374
Drainage density	-	-	-	-	-	1

As already mentioned, the values subjected to analysis refer to the proportion of landslides for each class. For this reason, the correlation matrix translates the relations between variables through the proportions that each one obtained.

Table 7 highlights the strong positive correlation (0.913) between the profile curvature variable, explained by the proportions, observable in the Table 4. Profile curvature is still positively correlated (0.737) to "distance to streams". Moreover, since the proportions of occurrences are higher in the first classes of drainage density contrast with the higher proportions in the last classes, hence the value of -0.825 which represents a strong negative correlation. Additionally, there is a moderate positive correlation (0.605) between slope and distance to streams, since the proportions tend to increase in the last classes for both variables. According to the matrix of correlations, some variables have no significant correlation between them, namely, especially in the correlations between slope and elevation (-0.004), slope and planform curvature (0.052), profile curvature and drainage density (-0.086). The remaining values do not highlight particularly significant correlations.

4.4. Landslide Susceptibility Maps

Figure 22 corresponds to the first susceptibility map developed from the weights of the first component. The values of the susceptibility rating range from 9 to 33 (all values involved in the Weighted Overlay method are converted to integers by default). The weights for each class were applied through a scale ranging from 1 to 100 and the sum of these values equalled 100. The value assigned to each class of a given variable is multiplied by the weight that this variable previously received. For example, a weight of 45 is multiplied by 0.18 if the proportion of landslides verified for the variable in question is 18%, resulting in an 8.1 rating (8 by default) and this value is then added to the calculated values for the remaining variables. The cells that obtained the value 9 scored the lowest susceptibility rating from each predisposition factor while the ones that scored 33 represent areas with the highest value obtainable through this methodology in this study area. Susceptibility was organized into five quantiles: “Very low”, “Low”, “Moderate”, “High” and “Very high”.

The first susceptibility map is clearly influenced by the most important variable for component 1, geological units. Such influence is observable through the "Very High" susceptibility red stains in the eastern and central section of the municipality of Coimbra. Furthermore, the land use variable also had a great influence on the distribution of susceptibility values due to the "Urban and built-up areas" class which obtained a high weight in the employed model (47%) and to the class "Forest and shrubland" that occupies most of the study area and also obtained a significant weight (37%). Finally, the drainage density variable is also highlighted, considering that most of the landslides occurred in the first class of the drainage density (0 – 154) variable, precisely where the most susceptible spots appear.

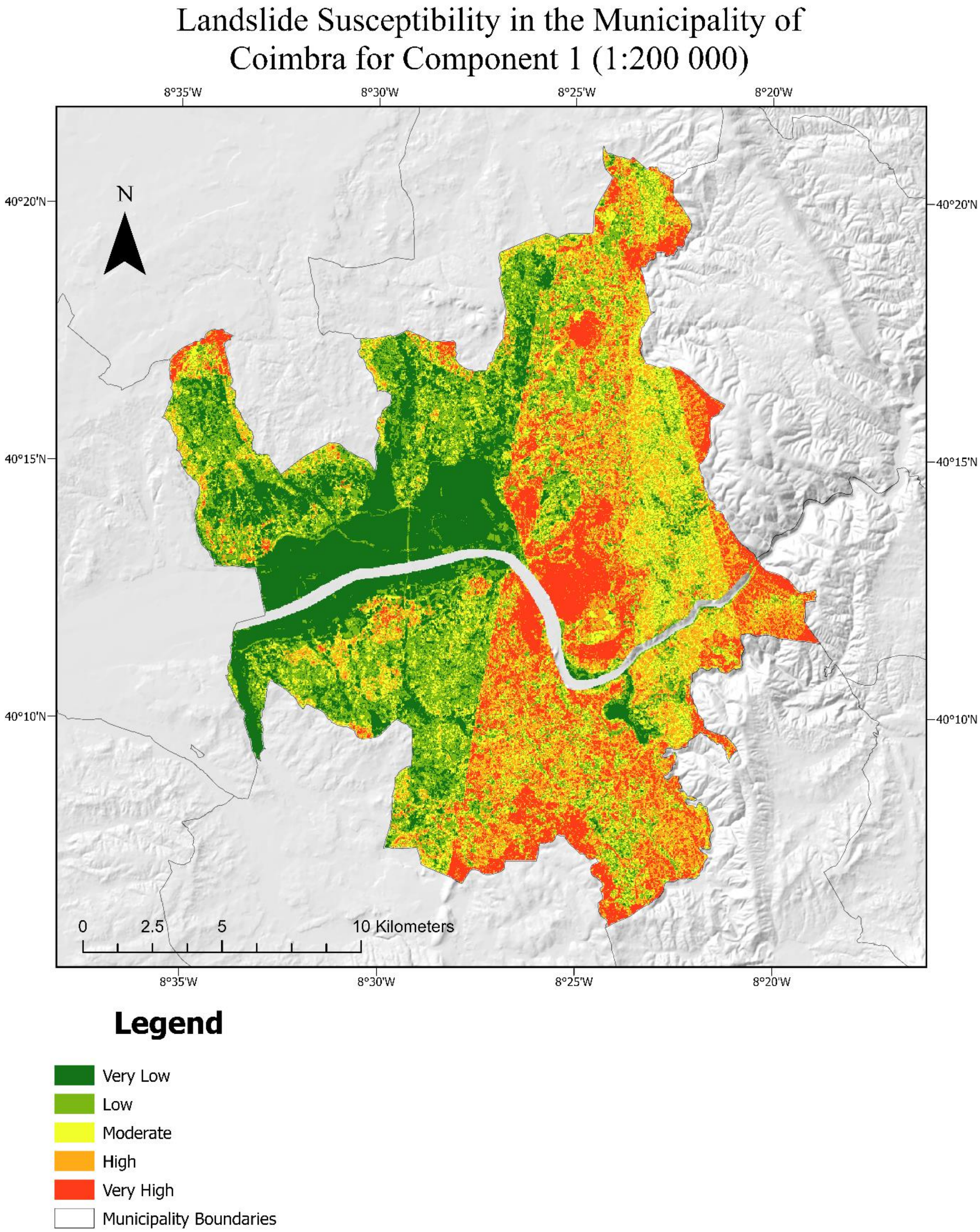


Figure 22: Landslide susceptibility map based on component 1.

The second susceptibility map (Figure 23) was developed through the same procedure used for the previous map, except for the natural changes in the assigned weights for each predisposing factor obtained for component 2. Moreover, the number and nomenclature of the classes is the same. However, since the susceptibility values for this card vary between 9 and 30, it was not possible to create five equidistant classes. The data were then arranged in quantiles of 5. In this case, the variables Slope and Distance to streams were the ones that most influenced the distribution of susceptibility since higher values of susceptibility coincide with the zones of greater slope (class a higher weight, 37%). The variable of geological units also has a significant influence on the distribution of susceptibility, especially in the dashed that crosses the chart on an almost north-south axis.

In both maps, the highest susceptibilities are in the eastern region. However, in the first, "Very High" susceptibility occupies is concentrated in certain areas in both the centre and south of Coimbra. In the current map, this class is distributed more homogeneously in the right section of the studied territory. Lower susceptibility values are more frequently seen in the northwest quadrant of the study area, in the region near the west part of the Mondego River.

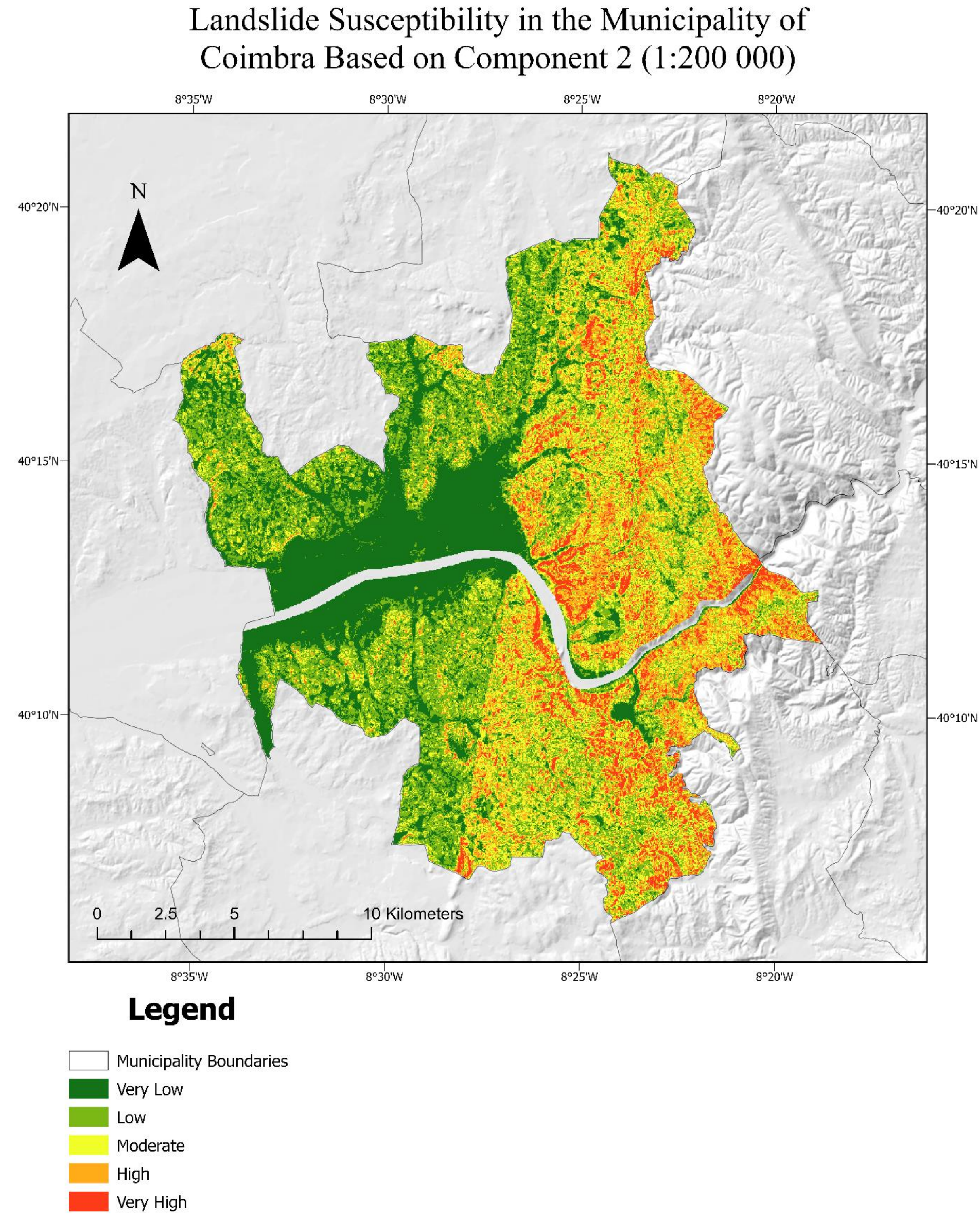


Figure 23: Landslide susceptibility map based on component 2.

4.4.1 Final Landslide Susceptibility Map

The final landslide susceptibility map was created by joining of the two maps presented earlier. The percentage weight assigned to each map was calculated from the values of explained variance that each component obtained during the PCA. More precisely, the first component obtained a weight of 58% (46,433/80,724 * 100) and the second obtained a value of 42% (34,281/80,724 * 100). These two were rounded off to the nearest whole number. In addition, the map comprised susceptibility values that range from 9 to 32 and was classified using the same logic as the previous map, in five quantiles.

Through the observation of the susceptibility map presented in Figure 24, it is easily realized that the class of greatest susceptibility has main prominence in the urban area located in the centre of Coimbra, but also in the regions of higher slope and in the geological units where the slope movements were recorded (“Jurassic” and “Transition Zones”). The large red stain in the centre is intrinsically related to the process of creating the database that only took into account the reported landslides, which usually take in an urban environment (47% of the total occurrences), especially those that cause some form of damage (e.g. cutting a road or damaging a house).

The final map stems from the blending of the two previous maps and thus contains traits of both. There are zones of “Very High” susceptibility in the urban area located in the centre of the study area (as seen in the first map), while higher susceptibility values cover the steeper slopes (as seen in the second map).

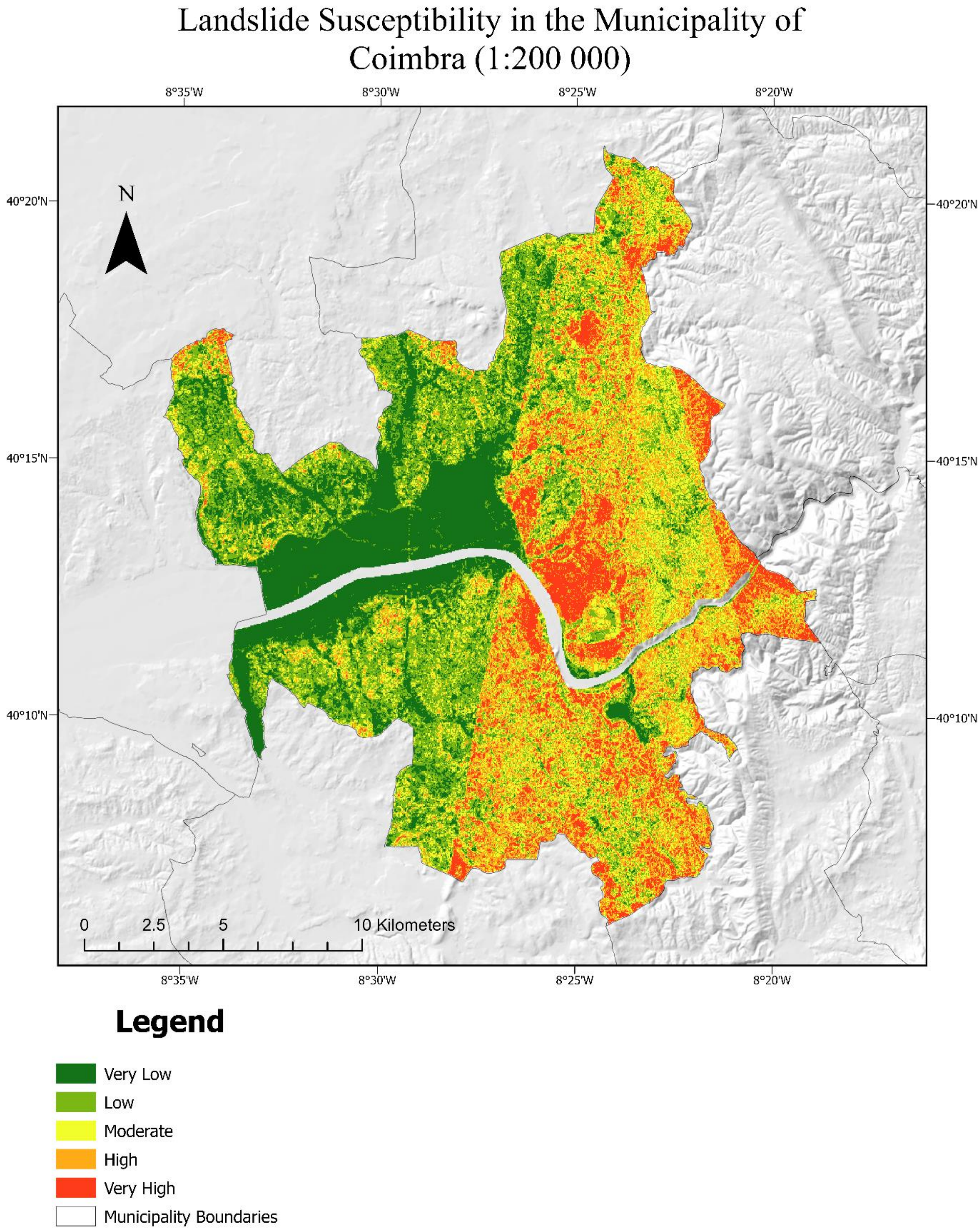


Figure 24: Final landslide susceptibility map.

Table 8 shows the number of landslides for each susceptibility class as well as their respective percentages. As classes increase in susceptibility level, occurrences also increase. Therefore, the susceptibility class where the highest number of occurrences are located is the “Very High” susceptibility class with 35.45% of landslide events followed by the “High” class with 26.36% which together make up more than half of the mapped landslide inventory (61.81%). In addition, only one event was recorded in the lowest susceptibility class (“Very Low”). Figure 25 spatially presents the mapped landslide occurrences over the susceptibility distribution.

Table 8: Number of landslides per class of susceptibility and respective percentages.

Susceptibility Classes	Ocurrences	Percentage	Cumulative %
Very Low	1	0.91%	0.91%
Low	18	16.36%	17.27%
Moderate	23	20.91.%	38.18%
High	29	26.36%	64.54%
Very High	39	35.45%	1
Total	110	1	-

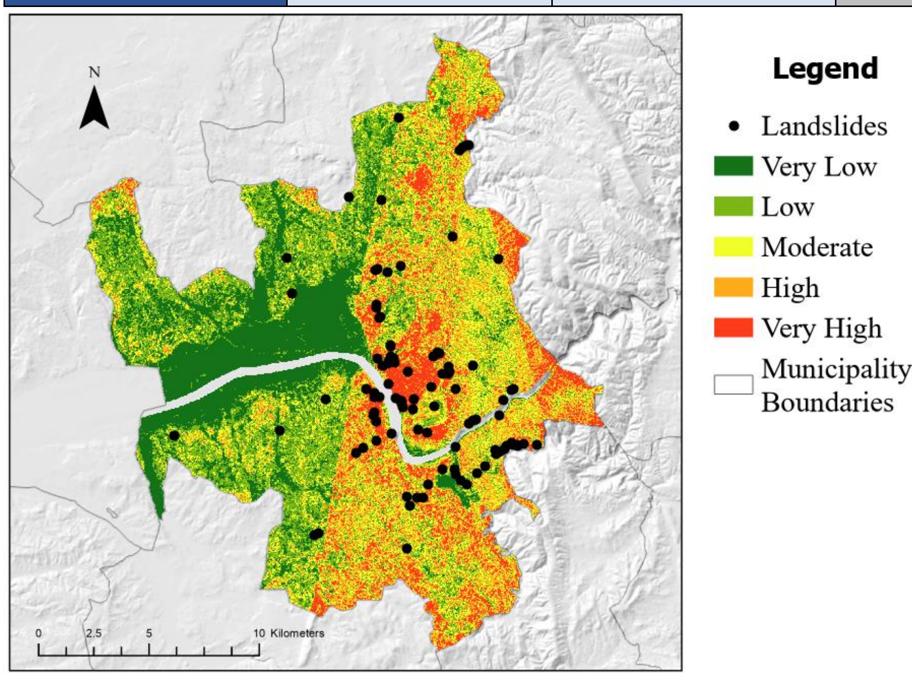


Figure 25: Final susceptibility map and mapped landslide events.

When considering the three parishes selected as subject to questionnaire in the final susceptibility map (Figure 26), Santo António dos Olivais is clearly the one with the highest count of cells with “Very High” susceptibility level, followed by the Union of Parishes of Eiras and São Paulo de Frades, and lastly by Ceira. This analysis is important when trying to understand if the questionnaire participants have higher or lower risk perception depending on their parish of residence.

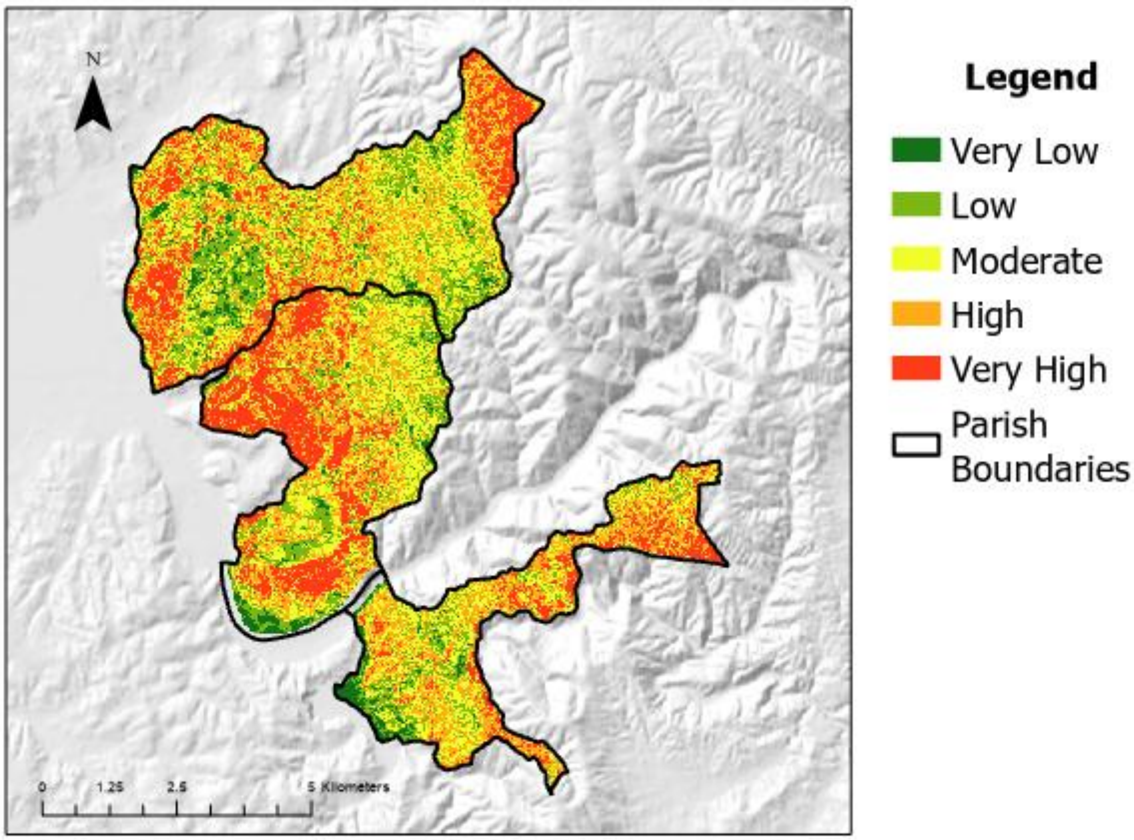


Figure 26: Portion of the final susceptibility map containing only the values of the selected parishes.

Chapter 5: Results on the Landslide Risk Perception Questionnaire

5.1. Respondent Characterization

The final sample to study landslide risk perception consists of 49 participants, of which 29 (59.20%) are female and 20 (40.8%) male. Out of the 49, 12 were online respondents, of which nine were female and three male. It is important to note that this sample is only exploratory and is not representative of the population of Coimbra. Therefore, all the conclusions drawn concern only the sample subject to the questionnaire.

Regarding age, Figure 27 describes the distribution of the ages by gender. Three age groups were designated: 18 – 25 years of age, 26 – 65 years of age and >65 years of age. The first group holds most of the participants (55.1%) and consists of 10 men and 17 women. The second group makes up 36.7% of the sample and is composed of seven men and 11 women. Finally, the last group (>65) is composed of only 4 respondents, 3 men and 1 woman. In addition, the sample has a mean age value of 35.6 and a standard deviation of 19.3, a mode and median of 19 and 23 respectively. The youngest respondent is 18 years old and the oldest is 79.

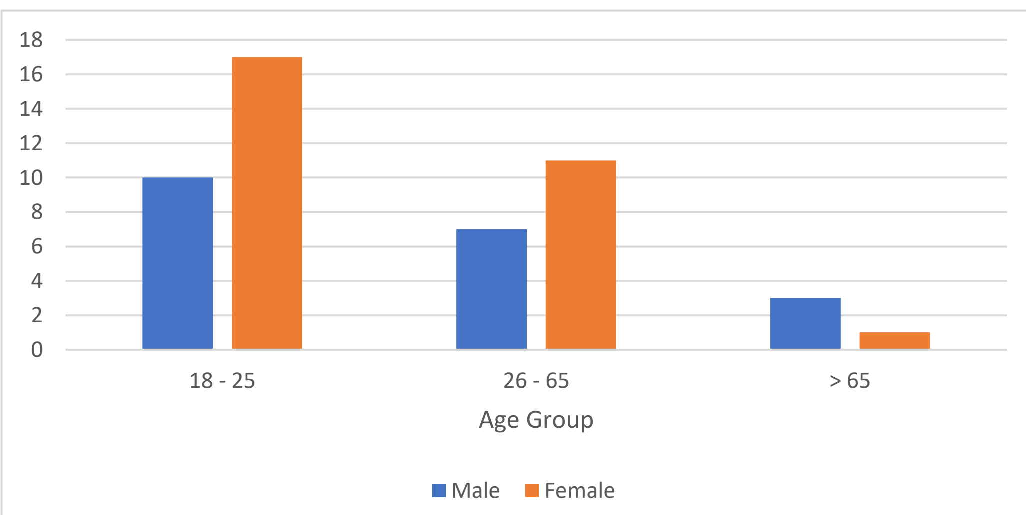


Figure 27: Distribution of participants by age and gender.

Regarding the education level, 25 participants (51%) obtained a bachelor's degree as shown in Figure 28. In Addition, 18 participants (36.7%) have 12 years of school education. Moreover, three participants have 9 years of school education, two have a master's degree and one has a doctorate degree.

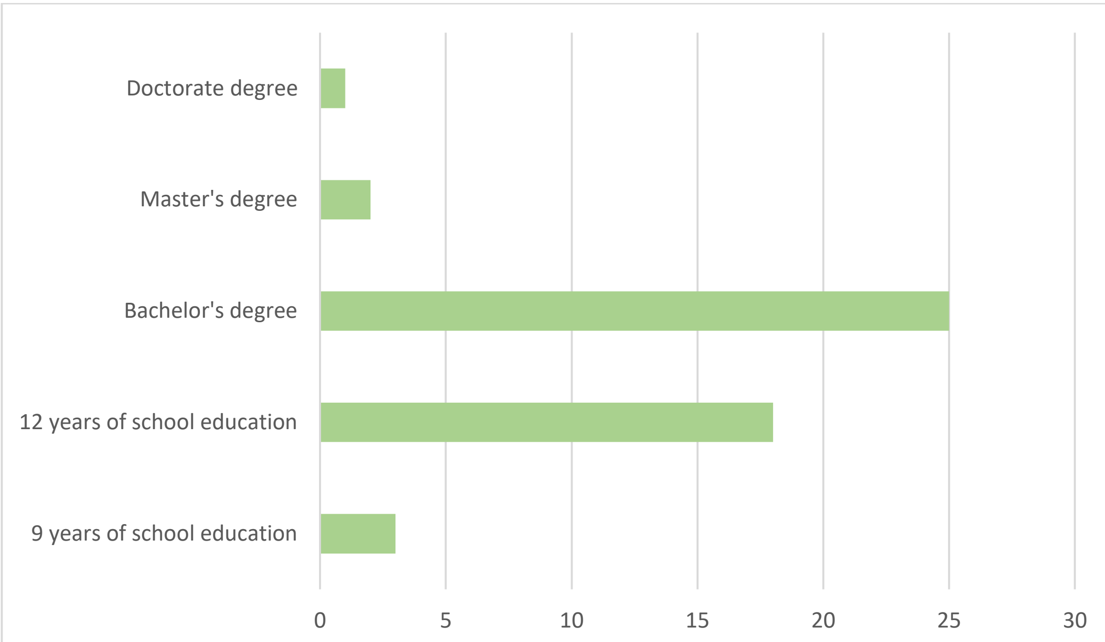


Figure 28: Number of participants by instruction level.

Regarding the area of residence, the sample contains 25 participants who live in the parish of Santo António dos Olivais, 17 reside in the Union of the parishes of Eiras and São Paulo de Frades and the remaining 7 in the parish of Ceira. In addition, the mean value for years of residence in the municipality of Coimbra is 26.3 with a standard deviation of 22.65. The mode and median for years of residence are 1 and 21.5 respectively. The lowest number of years of residence recorded was 1 and the highest was 76. It is important to mention that answers indicated which less than one year of residence were excluded answers (5 out of 46 answers).

A great portion of the sample (24 participants) is composed of students, while 13 participants (27.1%) are employed. In contrast, 3 participants (6.3%) are unemployed. Moreover, 5 participants (10.4%) are retired, and another 3 participants (6.3%) are employed and students at the same time. All participants who are employed work in the tertiary sector.

5.2. Emergency Plans

In this section of the questionnaire, respondents were asked about their level of knowledge ("Very low", "Low", "Medium", "High" and "Very high") on each of Coimbra's municipal emergency plans. A major group of respondents answered that their level of knowledge of the plans was "Very low" (the mean percentage of response for this answer was equal to 19.75% for every plan) or "Low" (mean percentage of response equal to 11,5% for every plan), which means that more than half of the sample that answered this question (45 answers in total) has a lower than “Medium” level of knowledge. This fact is reflected in the next question, in which participants were asked about their degree of agreement with the statement "I would like to receive more information about Emergency Plans (5-point Likert scale). 22 participants answered "4" and another 22 "5".

5.3. Risk Perception

To assess the respondents' risk perception, a number of questions were asked relating to past experiences and the level of concern about the occurrence of natural hazards.

In the question "Have you ever been in any way affected by a landslide", 44 respondents answered they had not been affected while 3 participants answered contrarily. In this latter group, 2 participants answered they had only been affected once and 1 respondent 2-3 times. These three respondents answer that "It cut off an access road that regularly traverse" when asked how they had been affected.

A large majority of participants (91.5 %) admitted having never taken any measures to reduce the damage or the likelihood of being affected by a flood or a landslide. However, in the next question, 24 participants (52.2 per cent) said they had already avoided going to a place that they considered to be at high risk of being affected by a natural hazard.

Respondents were then asked to determine the likelihood of their home being hit by a landslide, on a Likert scale ranging from 1 (no likelihood) to 10 (for sure). Most participants answered "1" (16 participants), followed by "3" (8 participants) and "2" (7 participants) as can be seen in Figure 29. In this case, the mean value is 3.13 with a standard deviation of 2.32, the mode is equal to 1 and the median is equal to 2.5. With these statistical values, one can conclude that the sample considers the occurrence of a landslide damaging their home to be unlikely and, to this extent, the perception of risk is low.

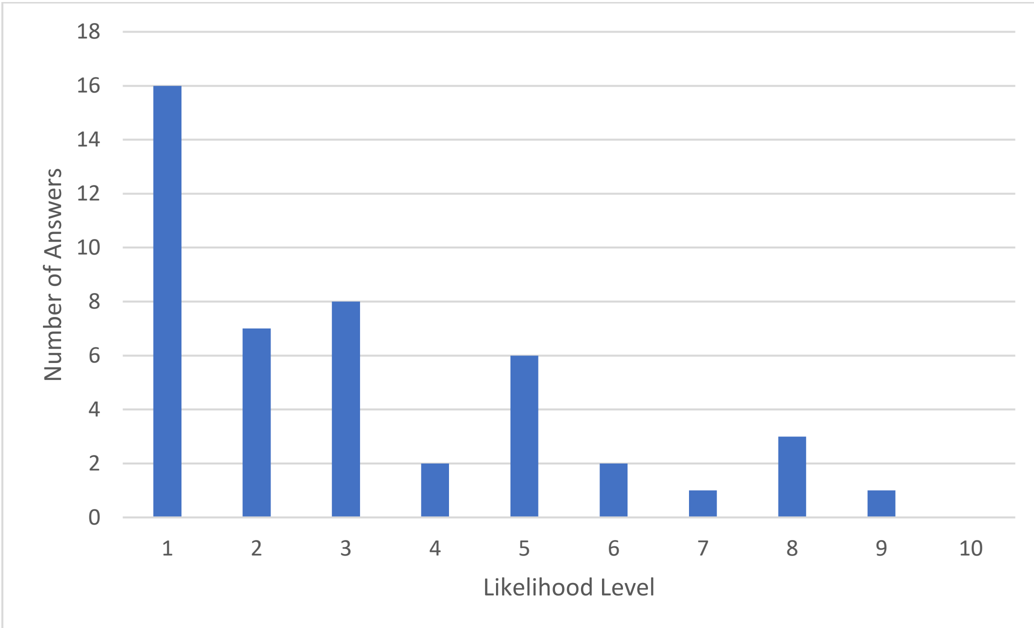


Figure 29: Answer distribution on the likelihood of having one's home hit by a landslide.

When asked how concerned they were about natural hazards, 15 participants (33.3%) said they were "Neither concerned or unconcerned", 13 participants (28.9%) said they were "Not very concerned", 7 (15.6%) said they were "Very concerned", 6 (13.3%) said they were "Extremely concerned" and 4 (8.9%) said they were "Not concerned at all" (Figure 30). To apply statistical analysis, these answers were converted into values ranging from 1 to 5 (1 being "Not concerned at all" and 5 being "Extremely concerned"). The following statistical values were calculated: 2.89 mean and 1.17 standard deviation; mode and median equal to 3. In this parameter, the sample shows an average level of risk perception. To summarise, the data and make it easier to understand, these last two questions are identified as questions A and B on risk perception, respectively, in the order in which they were presented.

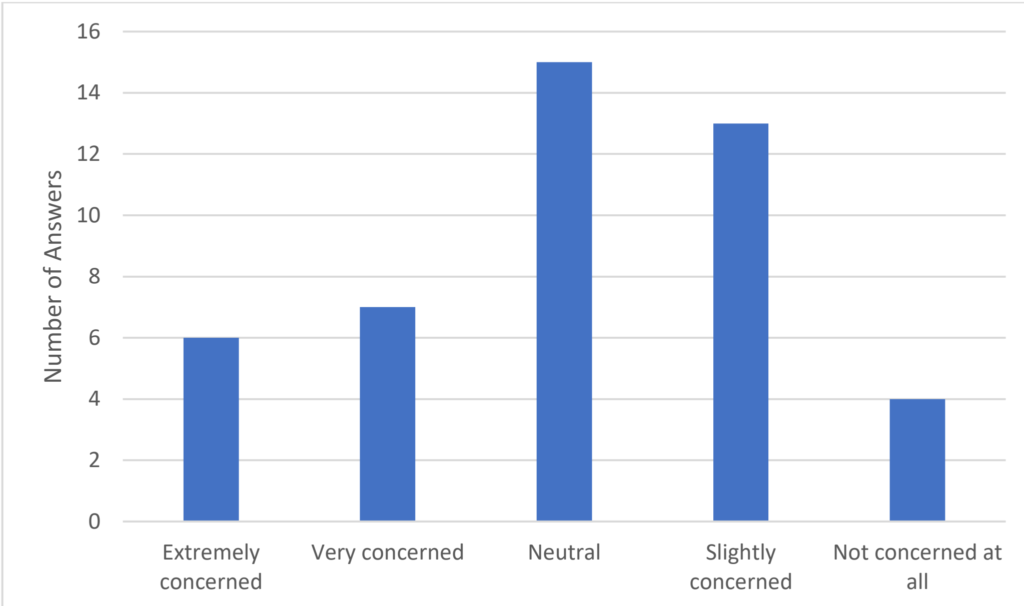


Figure 30: Answer distribution on the concern level about natural hazards.

5.3.1. Established Correlations

By adding the values collected for these last two questions into the IBM SPSS tool along with the values gathered on respondent characterization (age, education and duration of residence), it was possible to conclude that there are two Pearson correlations with acceptable significance levels (0.05 or lower). Age and duration of residence are the variables that share a correlation with the first risk perception question (A). Furthermore, there is a correlation coefficient equal to 0.527 (with a significance level of less than 0.001) which represents a moderate positive relationship between age and risk perception (question A), i.e., as age increases, the sample's perception of landslide risk also tends to increase. On the other hand, the correlation coefficient between question A and duration of residence was 0.380 (with a significance level of 0.017). This value corresponds to a weak positive relationship which indicates that as the duration of residence increases, the perception of landslide risk also tends to increase, albeit with little intensity and weak linearity.

Regarding gender, the independent t-test showed that there was no significant mean difference, t (44) = 1.928, p = 0.06, between the gender groups for question A. A similar conclusion can be drawn from the independent t-test applied to answers to question B, t (43) = 0.31, p = 740, despite women attaining higher risk perception scores than men (Table 9)

Table 9: Pearson coefficient between answers given to risk perception questions and age, qualification, and duration of residence.

Variables	Question A	Question B
Age	0.527	-0.049
Qualification	0.265	-0.170
Duration of residence (years)	0.380	-0.155

Table 10: Mean risk perception scores by gender, for question A and B.

	Mean values (scores)	
Gender	Question A (1 – 10)	Question B (1 – 5)
Female	3.67	3
Male	2.37	2.89

The same method was applied to two other groups: one made up of respondents who answered "Yes" to the question "Do you know anyone who has been seriously affected by a natural hazard (material loss and/or injuries)?" and the other by those who answered "No" to the same question. In this case, the independent t-test, $t(44) = -2.535$, $p = 0.015$, revealed that participants who answered "Yes" to question A demonstrated significantly higher perception of risk than those who answered "No". However, the same conclusion cannot be drawn regarding answers to question B, since the independent t-test, $t(43) = 0.089$, $p = 0.929$, showed that there is no significant difference between "Yes" and "No" groups when answering to question B. The mean values are presented in Table 11 These results show, for this sample, that people who knew someone who had been seriously affected by a natural hazard have a higher landslide risk perception.

Table 11: Mean risk perception scores by answer group, for question A and B.

	Mean values (scores)	
Group by Answer	Question A (1 – 10)	Question B (1 – 5)
"Yes"	4.25	2.93
"No"	2.53	2.97

When applying the anova-one-way test to the independent variable "parish of residence" and both question A and B, it is clear that there are no significant differences between the calculated means for each residence group and for each question, i.e. there is no significant effect from the parish of residence on the answers to both questions. A significance level of 0.654 was obtained between groups for question A and 0.559 between groups for question B.

Since the sample is not representative of the population of the selected parishes, it proved impossible to answer the third starting question (Is the landslide risk perception of the population of the selected parishes of Coimbra high?). However, for this sample, it does not prove to be the case that the risk perception is high (table 12), and, as described above, there is no significant difference between groups of residence.

Table 12: Mean risk perception scores by parish of residence, for question A and B.

	Mean values (scores)	
Parish of residence	Question A (1 – 10)	Question B (1 – 5)
Santo António dos Olivais	2.84	2.78
Union of parishes of Eiras and São Paulo de Frades	3.43	3.07
Ceira	3.57	3.29

The same method was applied to the groups based on qualification level (five groups in total, one for each level of qualification). The anova-one-way test showed that there are no significant differences between qualification groups when answering to question A ($p = 0.073$) and B ($p = 0.691$). The groups containing participants with a "master's degree" and "doctorate degree" were not included in the test since they had only two and one respondents, respectively. In both applications of the anova-one-way test, there was no need for carrying out a post-hoc test since there were no differences noted between the groups created.

5.4. Institutional Trust

In the question "How satisfied are you with the response of the institutions involved (Civil Protection, GNR, PSP, Town Hall) in cases of emergency?" (answered on a 10-point Likert scale), the most common answer was "5" (13 answers), which translates as "neither very satisfied nor not very satisfied". The remaining answers were evenly distributed across the scores.

Still about institutions, 21 participants consider Civil Protection to be "very responsible" in preventing and responding to natural hazards. The town hall was also mostly seen as "very responsible" (18 participants). However, most of the sample (51.2%) considers that these institutions do not have the necessary resources to manage flood and landslide risks.

Participants were asked about their degree of trust (through a 10-point Likert scale) in predictions and warnings made by Civil Protection and the Portuguese Institute for Sea and Atmosphere (PISA) (one answer was given to each of these entities). Results were very close between the two risk management actors. Both obtained a median value of 7. In addition, mean values were equal to 6.48 for Civil Protection and 6.38 for PISA with a standard deviation of 2.14 and 2.08, respectively. In this case, the sample expressed a similar degree of trust in both entities.

Final Considerations

The application of the susceptibility model made it possible to answer the first question, which concerned the distribution of susceptibility to landslides in the study area. This distribution contains abrupt heterogeneities in the susceptibility values that are especially explained by the landslide inventory used, which reinforces the idea that inventories should contain as many occurrences as possible and should not be restricted to one data gathering methodology.

The eastern section of the study area clearly stood out with higher susceptibilities, as had already been the case in previous studies (first chapter). The method used is not too complex and can easily be updated with the addition of new events to the database. However, the database should incorporate a wider variety of occurrences, not just those that are reported in the news, since those are restricted to a particular context.

The implementation of statistical analyses such as PCA should be applied whenever there is a change in the database or in the predisposition factors. The use of this method leads to a reduced subjectivity when applying weights to the different variables. In addition, PCA made it possible to answer the second starting question in which the most important variables were determined for the components used in the susceptibility assessment. However, both components had multiple variables with significant influence, the difference is more noticeable in the variables that obtained lower percentages of influence.

Conducting the questionnaire to evaluate risk perception was perhaps the most difficult part of the dissertation. Only three parishes in Coimbra were chosen to facilitate travelling around the municipality. Furthermore, as the target audience was the population of Coimbra, the most attractive option was to carry out the questionnaire in a door-to-door format, which proved to be a huge challenge given that most people did not want to answer the questionnaire and were often resistant to the idea of giving out information. This difficulty in obtaining data led to the creation of a purely exploratory sample, which was not statistically representative of the population of the parishes studied.

However, determining descriptive values (mean, mode, median, standard deviation, minimum and maximum value) and Pearson coefficients led to some interesting results, such as the correlation between age and risk perception. Additionally, it was also noticed that gender had no influence in risk perception.

The sample showed they had very little familiarity with the municipality emergency plans and expressed a desire to obtain information about said plans. In addition, most participants confirmed that they had never received information about the risk of landslides and flooding which are prominent natural hazards in Coimbra. If this is true to the extent of the municipality's population, it is important to develop communication strategies to provide individuals with precise information about the potential negative effects of the natural hazards to which they are subject.

The third research question was answered by calculating the means of the values obtained in the risk perception questions. This made it possible to establish that the sample did not have a high perception of risk, since the perception scores calculated were generally lower than the intermediate perception value of the questions they answered.

Regarding the fourth question, the sample showed that there was not a higher perception of risk in the parish of Santo António dos Olivais, which clearly displayed higher susceptibility classes. On the contrary, the highest perception values were obtained by respondents from Ceira. However, inferences are limited since only five respondents reside in the parish of Ceira.

The fifth question could not be answered by distinguishing two groups (one affected by landslides and the other not affected by the phenomenon) since almost all the respondents said they had never been affected. Therefore, another question related to possible acquaintances who might have been affected by the phenomenon was used, and it was then possible to separate the sample into two groups. The independent t-tests conducted suggest that people who know someone who has been affected by a natural hazard have higher landslide risk perception.

Finally, the answers to the questions related to the institutional trust allowed us to realise that the participants believe that civil protection and the city council are the entities most responsible for prevention and response in the event of an emergency, and that approximately half of the sample believes that these entities do not have the necessary resources to ensure good risk management.

As a way of improving the results obtained, here are some suggestions:

- Create a more robust landslide inventory, with occurrences that are not limited to the urban environment.
- Updating the predisposition factors if there are any significant changes to them.
- Extending the application of questionnaire to the whole municipality of Coimbra so that the variables explored can crossed with the information regarding the landslide susceptibility, enabling to detect areas with high susceptibility and low risk perception (which should be targeted first by risk management entities).

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Appendices

Appendix 1

Questionnaire:

Bom dia/Boa tarde. Sou estudante do mestrado Dinâmicas Sociais, Riscos Naturais e Tecnológicos da Universidade de Coimbra e gostaria de pedir a sua colaboração num estudo que estou a realizar no âmbito da minha dissertação de Mestrado centrada nos deslizamentos/derrocadas no município de Coimbra. Este estudo tem como objetivo conhecer as atitudes da população de Coimbra perante os perigos naturais. Toda a informação que for prestada é confidencial e anónima, e nunca poderá ser identificada com a pessoa que a fornece. Agradeço muito a sua disponibilidade em colaborar. Este questionário não demora mais do que 10-15 minutos a preencher.

Caracterização do inquirido

1. Género: M ☐ (1) F ☐ (2) Outro ☐ (3)

2. Idade _________. Não sei ☐ (-1) Não respondo ☐ (-2)[1]

3. Composição do agregado familiar**:** (Preencha, por favor, o seguinte quadro)

Parentesco	Sexo	Idade	Est. civil	Nível Instrução	Naturalidade	Condição trabalho	Profissão	Situação Profissão

Não se aplica (vive sozinho/a).. ☐

4. Em que freguesia reside? ___________________________

NS…………………………………………………………………………. ☐ (-1)

NR…………………………………………………………………………. ☐ (-2)

5. Escolaridade

[1] As opções “Não sei” e “Não respondo” surgem como “NS” e “NR”, respetivamente, em todas as questões posteriores à n.º 2.

1º Ciclo do Ensino Básico (4 anos de escolaridade) ☐ (1)

2º Ciclo do Ensino Básico (6 anos de escolaridade) ☐ (2)

3º Ciclo do Ensino Básico (9 anos de escolaridade) ☐ (3)

12º Ano.. ☐ (4)

Licenciatura……………………………………………………….. ☐ (5)

Mestrado………………………………………………………….. ☐ (6)

Doutoramento……………………………………………………. ☐ (7)

NS…………………………………………………………………….. ☐ (-1)

NR…………………………………………………………………….. ☐ (-2)

6. Qual é a sua condição no emprego?

Tem emprego .... ☐ (1)

Está desempregado(a)............................... ☐ (3)

Estuda.. ☐ (4)

Trabalha e estuda..................................... ☐ (5)

Reformado……………………………………………. ☐ (7)

Outra situação: _____________________ ... ☐ (8)

NS ☐ (-1) NR ☐ (-2)

7. Qual é ou era, caso esteja desempregado(a), a sua profissão?

____

8. Há quantos anos reside no Município de Coimbra? _________

NS…………………………………………………………. ☐ (-1)

NR…………………………………………………………. ☐ (-2)

8.1 E na atual zona de residência? _________

NS…………………………………………………………. ☐ (-1)

NR…………………………………………………………. ☐ (-2)

9. A sua habitação é:

Própria.. ☐ (1)

Arrendada.. ☐ (2)

Cedida... ☐ (3)

Outra. Qual? ____________________ ☐ (4)

NS... ☐ (-1)

NR.. ☐ (-2)

Planos de Emergência

10. Indique a opção que considera mais adequada em relação ao seu nível de conhecimento dos seguintes planos municipais:

	Muito baixo (1)	Baixo (2)	Médio (3)	Elevado (4)	Muito elevado (5)	NS (-1)	NR (-2)
Plano Municipal de Emergência de Coimbra	☐	☐	☐	☐	☐	☐	☐
Plano Municipal de Defesa das Florestas Contra Incêndios de Coimbra	☐	☐	☐	☐	☐	☐	☐
Plano Especial de Emergência para Cheias e Inundações no Concelho de Coimbra	☐	☐	☐	☐	☐	☐	☐
Plano Especial de Emergência de Proteção Civil do Centro Urbano Antigo de Coimbra	☐	☐	☐	☐	☐	☐	☐

11. Qual(ais) a(s) sua(s) fonte(s) da informação sobre os planos referidos (Pode indicar mais que uma)?

Televisão.. ☐ (1)

Rádio.. ☐ (2)

Internet.. ☐ (3)

Anúncios oficiais do Governo... ☐ (4)

Artigos de Imprensa... ☐ (5)

Amigos/Familiares... ☐ (6)

Outra. Qual? ________________________... ☐ (7)

NS...,,......... ☐ (-1)

NR... ☐ (-2)

12. Diga qual o seu grau de concordância com a seguinte afirmação "Gostaria de receber mais informação sobre os Planos de Emergência"

Discordo totalmente		Nem concordo Nem discordo		Concordo totalmente	NS (-1)	NR(-2)
1	2	3	4	5		
○	○	○	○	○	○	○

Perceção dos Riscos

13. Já recebeu algum tipo de informação sobre a redução do risco de inundação na sua comunidade?

Sim... ☐ (1)

Não.. ☐ (2)

NS.. ☐ (-1)

NR.. ☐ (-2)

13.a Já recebeu algum tipo de informação sobre a redução do risco de deslizamento/derrocada na sua comunidade?

Sim... ☐ (1)

Não.. ☐ (2)

NS.. ☐ (-1)

NR.. ☐ (-2)

14. Se respondeu **"sim"** na questão anterior, assinale qual(ais) a(as) suas fonte(s) de informação sobre estes riscos:

Televisão.. ☐ (1)

Rádio.. ☐ (2)

Internet... ☐ (3)

Anúncios oficiais de Governo.. ☐ (4)

Artigos de Imprensa... ☐ (5)

Amigos/Familiares... ☐ (6)

Outra. Qual? _____________________... ☐ (7)

NS... ☐ (-1)

NR... ☐ (-2)

15. Já foi, de alguma forma, afetado(a) por um deslizamento/derrocada/movimento de terra/lama (mesmo que de forma indireta)?

Sim... ☐ (1)

Não.. ☐ (2)

NS.. ☐ (-1)

NR.. ☐ (-2)

Se respondeu "**Não**" deve passar para a questão nº 19

16. Quantas vezes já foi afetado(a) por um deslizamento/derrocada/movimento de terra/lama?

Nunca... ☐ (1)

1 vez.. ☐ (2)

2 – 3 vezes... ☐ (3)

>3 vezes... ☐ (4)

17. Assinale, por favor, a forma como foi afetado:

Cortou uma via de acesso que atravesso com regularidade... ☐ (1)

Causou-me ferimentos... ☐ (2)

Feriu um conhecido/amigo/familiar.. ☐ (3)

Danificou bens materiais (e.g casa, carro, etc…) de um conhecido/amigo/familiar......... ☐ (4)

Danificou bens materiais que me pertencem.. ☐ (5)

Outra. Qual? : ____............. ☐ (6)

NS.. ☐ (-1)

NR…… ☐ (-2)

18. De um modo geral, quem é que tende a contactar primeiro quando a sua casa é afetada por um perigo natural (e.g inundação, incêndio florestal, deslizamento)?

Familiares……………………………………………………………………………………………………… ☐ (1)

Vizinhos…… ☐ (2)

Amigos……… ☐ (3)

Proteção Civil (Bombeiros)……………………………………………………………………………… ☐ (4)

Polícia……… ☐ (5)

Outro. Qual: _____________………………………………………………………………………………… ☐ (6)

NS……… ☐ (-1)

NR……… ☐ (-2)

19. Já alguma vez aplicou alguma medida para reduzir os estragos ou a probabilidade de ser afetado por uma inundação ou por um deslizamento/derrocada. Se sim, qual(ais) a(s) medida(s) que aplicou?

Sim. Qual(ais): ____ ☐ (1)

Não…… ☐ (2)

NS……… ☐ (-1)

NR……… ☐ (-2)

20. Em alguma ocasião, evitou frequentar um determinado local por considerar que o risco de ocorrência de um perigo natural naquele espaço é elevado?

Sim……………………………………………………………………………………………………… ☐ (1)

Não……………………………………………………………………………………………………… ☐ (2)

NS…… ☐ (-1)

NR…… ☐ (-2)

21. Quais das causas indicadas abaixo considera as principais para a ocorrência de deslizamentos/derrocadas:

Secas…………………………………………………………………………………………………… ☐ (1)

Chuva moderada e prolongada (com duração de vários dias)…………………… ☐ (2)

Chuva intensa……………………………………………………………………………………… ☐ (3)

Presença de um solo que se desprende facilmente (pouco coeso)............... ☐ (4)

Negligência das autoridades... ☐ (5)

Ocorrência de sismos.. ☐ (6)

Remoção de vegetação.. ☐ (7)

Construção de estruturas urbanas (habitações, lojas, vias de acesso e outros serviços) nas zonas de declive acentuado.. ☐ (8)

Outra. Qual? ________________________________.............................. ☐ (9)

NS.. ☐ (-1)

NR.. ☐ (-2)

22. Classifique, entre 1 e 10, a probabilidade dos seguintes cenários:

22.1 A sua moradia ser atingida por um deslizamento/derrocada

Nenhuma probabilidade	2	3	4	5	6	7	8	9	De certeza	NS(-1)	NR(-2)
○	○	○	○	○	○	○	○	○	○	○	○

22.2 A sua moradia ser atingida por uma inundação

Nenhuma probabilidade	2	3	4	5	6	7	8	9	De certeza	NS(-1)	NR(-2)
○	○	○	○	○	○	○	○	○	○	○	○

23. Qual o seu grau de preparação caso a sua moradia seja afetada por uma inundação?

Nada preparado (a)... ☐ (1)

Pouco preparado (a)... ☐ (2)

Nem muito nem pouco preparado (a) .... ☐ (3)

Muito preparado (a) .... ☐ (4)

Bastante preparado (a) .... ☐ (5)

NS.. ☐ (-1)

NR.. ☐ (-2)

24. E em caso de um deslizamento/derrocada?

Nada preparado (a)... ☐ (1)

Pouco preparado (a)... ☐ (2)

Nem muito nem pouco preparado (a) .... ☐ (3)

Muito preparado (a) .... ☐ (4)

Bastante preparado (a) .... ☐ (5)

NS... ☐ (-1)

NR... ☐ (-2)

25. Há quem acredite que o ser humano consegue sempre controlar os riscos naturais a que está exposto, podendo assim, habitar/estabelecer-se em qualquer sítio.

Indique o seu grau de concordância com a afirmação:

Discordo totalmente		Nem concordo Nem discordo		Concordo totalmente	NS (-1)	NR(-2)
1	2	3	4	5		
○	○	○	○	○	○	○

26. Como classifica a sua preocupação face aos perigos naturais (como incêndios, cheias, derrocadas, etc.)

Nada preocupado(a)... ☐ (1)

Pouco preocupado(a)... ☐ (2)

Nem muito nem pouco preocupado(a) .... ☐ (3)

Muito preocupado(a) .... ☐ (4)

Bastante preocupado(a) .... ☐ (5)

NS... ☐ (-1)

NR... ☐ (-2)

27. Conhece alguém que foi gravemente prejudicado (a) por um perigo natural (perdas económicas e/ou ferimentos)?

Sim.. ☐ (1)

Não.. ☐ (2)

NS... ☐ (-1)

NR... ☐ (-2)

28. Diga, por favor, se concorda ou discorda com as seguintes afirmações:

28. 1 “Os deslizamentos/derrocadas podem ser previstos e controlados”

Discordo totalmente		Nem concordo Nem discordo		Concordo totalmente	NS (-1)	NR(-2)
1	2	3	4	5		
○	○	○	○	○	○	○

28. 2 “A gestão dos solos pode prevenir danos associados aos deslizamentos/derrocadas”

Discordo totalmente		Nem concordo Nem discordo		Concordo totalmente	NS (-1)	NR(-2)
1	2	3	4	5		
○	○	○	○	○	○	○

28. 3 “A natureza é não pode ser controlada no que diz respeito aos perigos naturais”

Discordo totalmente		Nem concordo Nem discordo		Concordo totalmente	NS (-1)	NR(-2)
1	2	3	4	5		
○	○	○	○	○	○	○

29. Na sua opinião, qual é o melhor medida para proteger as pessoas que vivem em zonas de risco elevado de inundação e/ou movimento de vertente

Mais informação…………………………………. ☐ (1)

Deslocar a residência para outro local…. ☐ (2)

Planos de emergência…………………………. ☐ (3)

Outra. Qual? ________________________ ☐ (4)

NS……………………………………………………. ☐ (-1)

NR……………………………………………………… ☐ (-2)

30. Das seguintes medidas, escolha aquela que considera mais eficaz na redução do risco de deslizamento/derrocada:

Obras estruturais (e.g estabilização da vertente, construção de muros)………..,…… ☐ (1)

Restrições de ocupação e uso do solo…………………………………………………….,………. ☐ (2)

Planos de emergência……………………………………………………………………………………… ☐ (3)

Sistemas de alarme………………………………………………………………………………………… ☐ (4)

Outra. Qual? ______________________________……………………………………………… ☐ (5)

NS………,…… ☐ (-1)

NR………,……… ☐ (-2)

Confiança nas Instituições

31. Qual é o seu grau de satisfação com a resposta das instituições responsáveis (Proteção Civil, GNR, PSP, Câmara Municipal) em casos de emergência (como os descritos em cima):

Muito Insatisfeito				Nem satisfeito nem insatisfeito					Muito Satisfeito		
1	2	3	4	5	6	7	8	9	10	NS (-1)	NR (-2)
○	○	○	○	○	○	○	○	○	○	○	○

32. Qual é o seu grau de satisfação com a aplicação de medidas de mitigação do risco dos perigos naturais das instituições responsáveis (Proteção Civil, GNR, PSP, Câmara Municipal):

Muito Insatisfeito				Nem satisfeito nem insatisfeito					Muito Satisfeito		
1	2	3	4	5	6	7	8	9	10	NS (-1)	NR (-2)
○	○	○	○	○	○	○	○	○	○	○	○

33. Atribua, para cada uma das seguintes entidades, um nível de responsabilidade na gestão do risco dos perigos naturais à escala municipal. Considere o período de prevenção/mitigação e o de resposta.

	Nada responsável (1)	Pouco responsável (2)	Responsável (3)	Muito responsável (4)	NS (-1)	NR (-2)
Presidente da Câmara	☐	☐	☐	☐	☐	☐
Câmara municipal	☐	☐	☐	☐	☐	☐
Proteção Civil	☐	☐	☐	☐	☐	☐
PSP	☐	☐	☐	☐	☐	☐
GNR	☐	☐	☐	☐	☐	☐
Cientistas	☐	☐	☐	☐	☐	☐
A comunidade afetada	☐	☐	☐	☐	☐	☐

34. Considera que estas instituições tem os meios/recursos necessários para gerir (prevenção e recuperação) os riscos de inundações e movimentos de vertente?

Sim………………………………………………… ☐ (1)

Não………………………………………………… ☐ (2)

NS………………………………………………… ☐ (-1)

NR………………………………………………… ☐ (-2)

35. Qual é o seu grau de confiança na previsão deste tipo de fenómenos feita pelos especialistas (e.g Instituto Português do Mar e da Atmosfera)

Não confio nada				Nem confio nem desconfio					Confio muito		
1	2	3	4	5	6	7	8	9	10	NS (-1)	NR (-2)
○	○	○	○	○	○	○	○	○	○	○	○

36. E em relação aos avisos da Proteção Civil nestes casos?

Não confio nada				Nem confio nem desconfio					Confio muito		
1	2	3	4	5	6	7	8	9	10	NS (-1)	NR (-2)
○	○	○	○	○	○	○	○	○	○	○	○

37. Acha que o Governo deve proibir a construção de edifícios (incluindo habitações) nas zonas de maior suscetibilidade (onde é mais frequente a ocorrência de perigos naturais). Por favor, diga o porquê.

____
____
____
_____

38. Coloque por ordem de relevância (de 1 a 7, sendo 1 o que considera mais relevante) as fontes de informação que utiliza quando a região de Coimbra é afetada por tempestades (chuvas fortes e/ou prolongadas), movimentos de vertente ou por incêndios florestais:

Televisão……………………………………………………………………………………… ☐ (1)

Rádio………………………………………………………………………………………… ☐ (2)

Internet………………………………………………………………………………………………… ☐ (3)

Anúncios oficiais de Governo…………………………………………………………………… ☐ (4)

Artigos de Imprensa……………………………………………………………………………… ☐ (5)

Amigos/Familiares………………………………………………………………………………… ☐ (6)

Outra. Qual? ___________________……………………………………………………… ☐ (7)

NS…… ☐ (-1)

NR…… ☐ (-2)

O questionário chegou ao fim. Agradecemos muito a sua colaboração!