Chapter 5
(Physical) Geography and Environmental Issues in Portugal

Lúcio Cunha

Abstract The main aim of the present work is to draw a picture of the physical geography of Portugal in order to understand its contextualization in the framework of the Southern Europe Mediterranean environments. In this way, the research points out some of the main geomorphological, climatic, hydrological and biogeographic aspects and, at the same time, tries to synthesize some of the natural resources (climate, landscape, coastline) and natural hazards (forest fires, heat waves, floods, earthquakes) related to their environmental conditions. Thus, the author also seeks to reflect on the impacts of climate change on the country's environmental and geographic conditions with the intention to understand how the necessary mitigation and adaptation measures to the climate change can be articulated with the policies and practices of the territorial planning at different scales.

Keywords Portugal · Relief · Environment · Climate change · Forest fires

5.1 Geographical Knowledge of Portugal

With an area of approximately 92,225 km^2, of which 2322 belong to the Archipelago of the Azores and 802 to the Archipelago of Madeira, Portugal, in spite of its small size, is a very varied country in terms of physical, human and environmental features, geo-systems and landscapes, in addition to the natural resources found here and the natural hazards it faces.

It is perhaps because of this variety that so many geographies of Portugal have been published by reputable local and foreign geographers, in an attempt to understand and communicate the nuances of the nature and society of Portugal (Daveau 1992). As it is impossible to be exhaustive, the following is a list of some of the major works that explicitly refer to the nature and environments of Portugal: G. Pery (1875), B. Gomes (1878), H. Lautensach (1932-37), A. A. Girão (1941, 1942), O. Ribeiro (1945, 1955), P. Birot (1950, 1975), C. A. Medeiros (1976, 1987),

L. Cunha (✉)
CEGOT - University of Coimbra, Coimbra, Portugal
e-mail: luciogeo@ci.uc.pt

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B. Freund (1979), O. Ribeiro, H. Lautensach and S. Daveau (1987–91), F. Guichard (1990), J. Gaspar (1991), Portuguese Association of Geographers (A.P.G.) (1992), R. S. Brito (1993), S. Daveau (1995), P. Lema and F. Rebelo (1997), J. Matoso, S. Daveau and D. Belo (1997), C. A. Medeiros (2005), A. Domingos (2017).

Most of these works discuss the issues of Portugal's nature and society, linking them with each other and with the construction of different areas and landscapes and helping readers to understand the differences between the continent and the Azores and Madeira. At times, they obviously go much further and also link these elements with its natural resources, the impacts caused by their extraction and use and the hazards associated with the natural and social characteristics of the country.

5.2 Climate, the Underpinning of a Frankly Mediterranean Environment

As O. Ribeiro (1945) so wisely said 'Portugal is Mediterranean by Nature and Atlantic by Position'. Its nature comes directly from the climatic conditions, which are heavily influenced by the mainland Portugal's position between a band of dynamic subtropical high pressure, which has a decisive influence on the dry, hot summer weather and the area through which the disturbances of the polar front move, which determine the winter rainfall.

However, this generalised and simplistic characterisation masks an enormous diversity due to both the latitudinal distribution of continental Portugal, with a very much cooler and wetter north than south (Daveau and Coelho 1977), and its longitudinal distribution, i.e. distance from the sea, in which the inland areas may have annual and daily temperature variations 4–5 times greater than those on the coast (Daveau 1986), and, in particular, due to the orientation and size of the uplands, which increase precipitation and lower the temperatures but, above all, create a very pronounced climatic compartmentalisation between the land exposed to the moist winds blowing in from the West and the much drier areas on the leeward side. One example of the latter phenomenon is the role played by the mountains of the Alto Minho in differentiating between the damp climate of the Minho and the climate of Trás os Montes, which is much drier and has wide-ranging temperatures. This difference between west and east is highly influenced by the direction of the terrain, which runs N-S and NNE-SSW, producing two distinct situations within the general characteristics of the country's Mediterranean climate: one more Atlantic or oceanic and the other more continental.

In addition to this general difference, the increase in urban living has also had some significant implications for local climates. Today, the role played by some urban centres (Lisbon, Porto and Coimbra, among others) on the local climates (Alcoforado 1998; Ganho 1998; Monteiro 1993) is very obvious, with very marked heat islands during the night, especially during anticyclonic weather conditions.

5.3 The Land of Portugal

Despite its small size (88,500 km^2 on the continent), its geological and structural conditions and its essentially quaternary geomorphological evolution led to a very varied range of types of relief (Fig. 5.1) and landscapes, making the country an extremely diverse mosaic (Rebelo and Cunha 1991). The Iberian Peninsula is considered to consist of four big morpho-structural units, of which three are found in continental Portugal: the Hesperic Massif, the western (Lusitanian) and southern (Algarvian) Meso-Cenozoic borders and the Tertiary basins of the Tejo and Sado rivers.

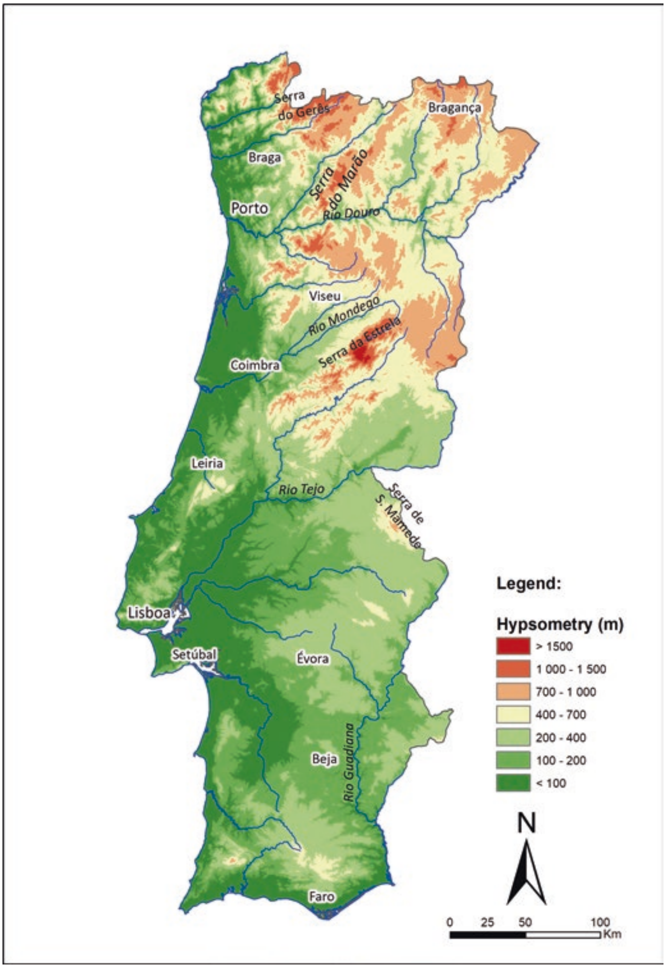

Fig. 5.1 The relief of mainland Portugal – Hypsometry

Granite and schist predominate in the Hesperic Massif, with quartzite and other metasedimentary rocks, which are responsible for the abrupt relief (1993 m in the Serra da Estrela, the highest point in continental Portugal) resulting from Alpine tectonics, with crustal weakness inherited from previous tectonic phases, especially the last of the Hercynian orogeny. This is young terrain, recently thrust up by tectonic movement and heavily dissected by the Quaternary river network. Many of these features rose up or were inserted onto flat surfaces inherited from the end of the Paleozoic era, but essentially worked during the Cenozoic era. Perhaps the best-known example of these is the Mirandês Plateau, at an altitude of some 700–800 m, which is one of the remnants of the northern plateau of the Iberian Peninsula.

The western and southern borders, made up basically of sedimentary rock, reach lower altitudes, and the main relief features are related with limestone outcrops, also the result of tectonic uplifting, giving rise to the limestone hills of Condeixa-Sicó-Alvaiázere, the Extremadura limestone plateau, the Serra de Montejunto and the Serra da Arrábida, which, despite being the major uplands, rarely go above 600 m.

The so-called Tertiary basins of the Tejo and Sado rivers are tectonic basins, where, during the Cenozoic era, continental sediment and limestone from the marshes and sea were deposited on the rocky structures of the border and even on the Hesperic Massif, forming an only slightly deformed table-like relief that rarely goes above 200 m.

A reference is also due to the flood plains of the terminal sectors of the main rivers (Vouga, Mondego, Tejo, Sado and Guadiana), which were carved into the soft materials of the ridges or the Cenozoic basins, demonstrating the recent formation of the valleys, in the Holocene. These plains have strong geo-human significance (especially because of their importance for agriculture) due to the recent filling in of the deepest valleys, which were carved out in the final glacial period. Some valleys were then invaded by water from the ocean (Flandrian "Rias") and were progressively filled with fluvial sediment, following the torrential regime associated with the Mediterranean character of the climate.

Finally, a presentation must be made, also unjustly brief, of the characteristics of the coastline as it is responsible for the location of many of Portugal's major cities and the development of various economic activities, especially beach tourism, and has a particularly high environmental and cultural value. The coast of continental Portugal measures some 943 km from the mouth of the R. Minho at Caminha (Viana do Castelo) to the mouth of the R. Guadiana at Vila Real de Santo António (Albergaria 1991). It has rocky shores with cliffs and sandy shores with beach-dune systems, interspersed by the estuaries of the major rivers that flow out there.

The cliffed coasts are linked either with rocky outcroppings of the Hesperic Massif in the north, granitoids north of Espinho and in the Serra de Sintra and schist in the Alentejo south of Sines or with sedimentary rocks, generally limestone (e.g. Cabos Mondego and Espichel), limestone-marl between S. Pedro de Muel and Sintra and the western Algarve or sandstone in the western Algarve, which evolve more rapidly.

The sand coasts can be of three types (Albergaria 1991): straight, narrow, sloping beaches at the base of cliffs; crescent-shaped beaches in small bays protected by cliffs (e.g. Nazaré, Guincho); and beaches linked with large dune systems that are associated with the estuaries of rivers with well-developed shallows as in the Aveiro lagoon area, the estuary of the Vouga, the Figueira da Foz area, the mouth of the Mondego and areas associated with the estuaries of the Tejo, Sado and Guadiana. Fine sand beaches are associated with the dunes formed at the top of the beach that give way to primary dunes, parallel with the coastline and mutually dependent on each other.

The estuaries are fed by the major, generally long rivers flowing from inland (Douro, Mondego, Tejo, Sado and Guadiana) and the big lagoon systems of Aveiro on the west coast and Ria Formosa in the Algarve. Because of the tide dynamics, the mixture of water they provide and their size, estuaries and lagoon systems are responsible for the existence of special ecosystems and warrant special attention in terms of nature conservation and protection.

5.4 Semi-torrential Rivers and River Systems

Because Portugal is part of the Mediterranean climate band, Portugal's rivers are, in many cases, peninsular, with their sources in Spain (the Minho, Lima, Douro, Tejo and Guadiana) and can be characterised as being semi-torrential, with a dramatic variation in their flows inter- and intra-annually. Taking as an example the R. Mondego, which is the largest river with its entire length in Portugal (258 km), before its regularisation in the 1980s with a number of dams or, in other words, when flowing naturally, at the city of Coimbra the ratio between the weakest flow in the summer and the strongest flow in the winter could be around 4000 to one (from 1 to 4000 m^3/s). The torrentiality of this pluvial hydrological regime (since little snow falls on the major hills) was, and to a certain point still is, responsible for the serious rises in level and the calamitous flooding in the winter and also at times in the autumn and spring, especially in the lower reaches of the river, the so-called Lower Mondego. As the R. Mondego has been regularised with a number of dams, flooding is now less frequent in this river, but it does continue and causes damage on the Tejo floodplain, the terminal sector of the Douro and many other small water courses in the country.

On the other hand, the growth of cities and poor urban planning, with inappropriate occupation of the land, either badly planned or just badly executed, often leads to a number of cities having flash floods, caused essentially by the intense autumn or spring rains and the serious impermeability of the urban grounds. People still remember the Lisbon floods of 1967, which led to over 500 deaths (Rebelo 2001), but many other floods of the same type, if without the same consequences in terms of human lives, have occurred in Lisbon (e.g. November 1983) and in other big cities around the country.

5.5 Vegetation in Constant Change

Because of the intense human occupation of the Mediterranean regions since ancient times, it is not easy to find extensive remains of plant formations that show a systemic balance between the relief, the climate and the soils. This situation is also found in Portugal, where plant formations, and forest formations in particular, have a very high degree of artificiality, as demonstrated by the rarity of native species and, especially, the introduction of commercially valuable exotic species (eucalyptus is the most notable example).

In Portugal, the meeting of Mediterranean and Atlantic influences is still expressed today in the distribution of what remains of the native tree species. In the north deciduous forest, species typical of temperate maritime regions (such as sessile oak and Pyrenean oak) are found; and in the south evergreen species (cork oak and holm oak), more typical of Mediterranean influences are found. The transition between these two major groups is marked by the presence of the Portuguese oak with its marcescent leaves on the coast between Setúbal and Figeuira da Foz and, in particular, the limestone massifs of the western Meso-Cenozoic border.

However, the native forest formations were significantly altered and even progressively supplanted by agricultural land and pasture. They were destroyed because of the need for wood and charcoal, and the original species were replaced first by the maritime pine and then eucalyptus, which gave a higher commercial return, justified by the presence in this country of several pulp mills. More recently, the demographic outflow from rural areas and agriculture, especially in the centre and north of the country, has led to the abandonment of forested areas. In conjunction with the climatic conditions, this situation is responsible for the forest fires that, unlike in other European Mediterranean countries, have intended to increase in number, in the size of the areas burned and in the ecological, economic and social consequences that they entail.

Overall, environmentally protected areas are enhancing the presence of some remnants of native forests and Mediterranean shrub formations, such as the maquis and garrigue scrubland of the limestone massifs or some formations characteristic of estuaries, coasts and dunes.

5.6 Azores and Madeira

The archipelagos of the Azores and Madeira extend the territory of Portugal into the Atlantic Ocean. They are responsible for a great part of the continental shelf and the exclusive economic zone in the Atlantic. These are archipelagos whose volcanic origin marks the general and detailed morphology of the islands and, with it, the climate, hydrological conditions and vegetation and even, in some cases, the way of life of their inhabitants.

Almost 2000 km west of the continental shore, the Archipelago of the Azores is situated on the great mid-Atlantic rift that separates the Eurasian and African plates from the North American plate. It is made up of three groups of islands (eastern: Santa Maria and São Miguel; central: Terceira, Graciosa, São Jorge, Pico and Faial; and Western: Flores and Corvo). The oldest and most easterly island, the Island of Santa Maria, includes Miocene limestone sediments in its composition. All the islands exhibit volcanic features, more or less degraded, in their composition and in the case of the islands of São Miguel, Terceira, São Jorge, Pico and Faial eruptions have been recorded in historical times. The most recent big eruption on the islands was the Capelinhos volcano (1957/8), which is still remembered in the collective memory and culture of the islands. Like volcanic activity, earthquakes are frequent and at times can be destructive. For example, the earthquake on Terceira on 1 January 1980 led to the partial destruction of the town of Angra do Heroísmo and 73 deaths. The heavy, intense rainfall and the steep slopes are responsible for the frequent occurrence of mass movements, ravinements and even mud flows that can seriously harm the local communities.

The Archipelago of Madeira is made up of the islands of Madeira and Porto Santo, and the small Desertas and Selvagens islands. These are also volcanic islands, older than the islands of the Azores. Today, their volcanic features have been almost totally dismantled and are therefore not very obvious in the topography of the islands. On the island of Madeira, intense rain, steep slopes and the poor resistance of the pyroclastic material often give rise to flash floods, sometimes real torrents, known locally as *aluviões* (mudflows), with absolutely catastrophic effects. In recent years, the destruction of the vegetation by summer forest fires has reached the remains of the laurel forest, which is still well preserved in the center of the island, contributed to a significant increase in these dangerous erosive processes.

5.7 Environment, Resources and Natural Hazards

The characteristics of Portugal's nature and environment, based on its position in the global geological scheme, its morphology, the Mediterranean characteristics of its climate, its position on the Atlantic and the recent evolution of the ecosystems (especially the vegetation), have provided the country with invaluable resources but also are responsible for certain hazards. And when these hazards are not countered by suitable planning and land management, they can threaten the sustainability of development.

In terms of resources, it can be said that there is an abundance of metal and non-metal mineral resources (the value of metals is shrinking due to the situation on the international markets, while that of minerals is also decreasing because of the slowdown in civil engineering and public works), water resources and their use in agriculture, industry, energy production and domestic consumption, coastal resources (fish, salt), forestry resources, to list only the most important conventional resources. Less conventional but no less important, the country's landscapes and climate also have great significance as resources, especially for tourism, whether for classic sun and sea tourism or new segments, such as nature tourism, rural tourism and geotourism. Regarding the climate, and in particular its Mediterranean characteristics, the absolutely dry, hot summers are the main reason for coastal tourism all around the Mediterranean basin and therefore this country too. However, on the Portuguese coast, the south-facing coastal areas of the Algarve and, less importantly, the Setúbal coast and the Costa del Sol, from Cascais to Lisbon, have better weather conditions than the long, west-facing coast, where morning fog and fresh winds from the north or north-east at the end of the afternoon affect beach going and bathing, lessening the value of the beaches (Cravidão and Cunha 1991). The landscape and its natural values (geomorphology, abundant water, a varied patchwork of plants) form an important resource for tourist activities on the coast and in the interior of the country, where many protected areas (especially the Peneda-Gerez National Park and the various Natural Parks) invite tourists or mere passers-by to enjoy the natural values. Recently, what is called geotourism has been increasing because of the natural and cultural landscapes, which are enhanced by the value of the landforms, the geological circumstances of the evolution of the Earth, water and soils, giving a scientific, cultural and economic significance to the formation of Geoparks (in the case of Portugal, the Geoparks of Naturtejo, Arouca, Terras de Cavaleiros, Azores and, very recently, Estrela).

As far as the natural hazards facing Portugal are concerned, the volcanic and seismic hazards in the Azores islands have already been mentioned. There is no volcanic hazard on the continent but there is seismic hazard, given the proximity of seismogenic areas, such as the Azores-Gibraltar fault. The great 1755 earthquake offers ample proof that the risk is on-going and also shows a possible link with a tsunami hazard, while other smaller earthquakes (such as the Benavente earthquake in 1909, a crustal earthquake) show the importance of active faults in the distribution and propagation of the effects of earthquakes.

The Mediterranean characteristics of the climate (the marked annual pattern and strong inter-annual variability in particular) are also responsible for some climatic hazards, both direct and indirect. Among the direct climatic hazards are heat waves (the most deadly in recent decades led to 2696 deaths in August 2003, according to Emdata – CRED; EM-DAT (2018)) and cold waves, strong winds and storms, snowfall, fog, frost and drought. The so-called indirect climatic hazards consist of geomorphic hazards (ravinements and mass movements, which occur more often in the north of the country as it has more rain and is more mobile from a topographical point of view) and hydrological hazards (progressive flooding of the major rivers: Douro, Mondego and Tejo; and flash floods of small watercourses that can cause great damage, especially in seriously impermeable urban environments).

One very special case, directly related with the Mediterranean climatic conditions and, in particular, the dryness of the summers is the risk of forest fires, which are responsible not only for great financial and environmental damage but also great social concern. Forest fires are a dangerous phenomenon that is considered to be mixed, i.e. their origins almost always involve human factors, whether direct or indirect (crime or negligence), but their geographical evolution and consequences follow the rules of natural processes (weather, land use, topography, layout of watercourses).

Because of the climate, forest fires especially affect the Mediterranean. Here they have a great impact not only on the environment, with the devastation of wide areas of plant cover, but also on the economy and society, with the destruction of forestry resources, homes and infrastructure and, in some more extreme cases, the loss of human life.

In southern European countries, owing to their Mediterranean climates, with a shortage of water during a good part of the year, and uncontrolled forested areas, forest fires have been increasing in alarming proportions in recent decades (Cunha and Gonçalves 1994; Lourenço 2004a, b; Pereira et al. 2006; Dimuccio et al. 2011). In Portugal, between 1990 and 2007, more than 1,600,000 ha of undergrowth and forests were consumed by fire (AFN 2008), the equivalent of over 17% of continental Portugal. Between 2003 and 2005, one of the most devastating series of forest fires in living memory occurred in Portugal. The fires resulted in the destruction of an area of over 750,000 ha (DGRF 2006) and 38 lives were lost. In 2017, over 500,000 ha burned and more than 120 people were killed, during two great heat waves somewhat outside the summer season as they occurred in spring (June) and autumn (October).

In spite of forest fires being linked with natural phenomena (climate, topography and plant cover), the socio-economic change and democratic trends demonstrated during the last half-century in the rural regions of the north and centre of Portugal are perhaps the major factor in the great increase in these areas' susceptibility to fires. Rural areas have been suffering an on-going loss and ageing of the resident population, with the resulting abandonment of cultivated agricultural areas, a reduction in the number of flocks and the animals per flock and shrinking consumption of undergrowth and secondary wood products (Almeida 2007). Vast agricultural areas comprised of smallholdings and very small properties were purely and simply abandoned or increasingly converted into single species forested areas, mostly of eucalyptus, that received little or no care and even less management. In addition, there has been a strong increase in risk due to an increase in the exposure of the population and their assets (homes, business and industrial establishments, infrastructure) that is taking place in two opposite directions: the encroachment of forested areas on rural populations, as a result of agricultural decline, and the encroachment of homes, businesses and urban infrastructure on these forested areas in the process of diffuse urbanisation that has characterised urban growth in this country in recent decades.

In Portugal, the amount of land consumed by forest fires is mostly controlled by two climatic factors: a relatively long dry period that starts at the end of spring or the beginning of summer (the effect of a long-term reduction in precipitation) and the occurrence of series of extremely hot, dry days associated with specific synoptic situations (the short-term effect of hot waves). In addition to these factors, which could increase in the near future due to the process of climate change to which the Mediterranean regions are particularly prone, the occurrence of forest fires and the areas devastated by them will continue to depend strongly on social factors associated with the demographic dynamics currently affecting rural areas.

5.8 The Example of the Forest Fires in 2017

In the fateful year of 2017, the forest fires were marked by two particular circumstances. One is the fact that they included huge, more dangerous fires that were "out of season" as they occurred in spring and autumn. The Pedrógão fire, which burned up 53,000 ha and caused 66 deaths (AR CTI 2017), started on 17 June and the fires in Pinhal de Leiria and the Coimbra and Tondela regions, which affected over 50,000 ha and caused 45 deaths, started on 15 October (AR CTI 2018). That year more than 500,000 ha burned (Fig. 5.2), i.e. more than 50% of the total for all the countries of southern Europe, and there were at least 114 deaths, more than 1000 companies affected and over €500 million in damage just to public infrastructure and companies, in other words, without counting the damage to the forest and to rural homes.

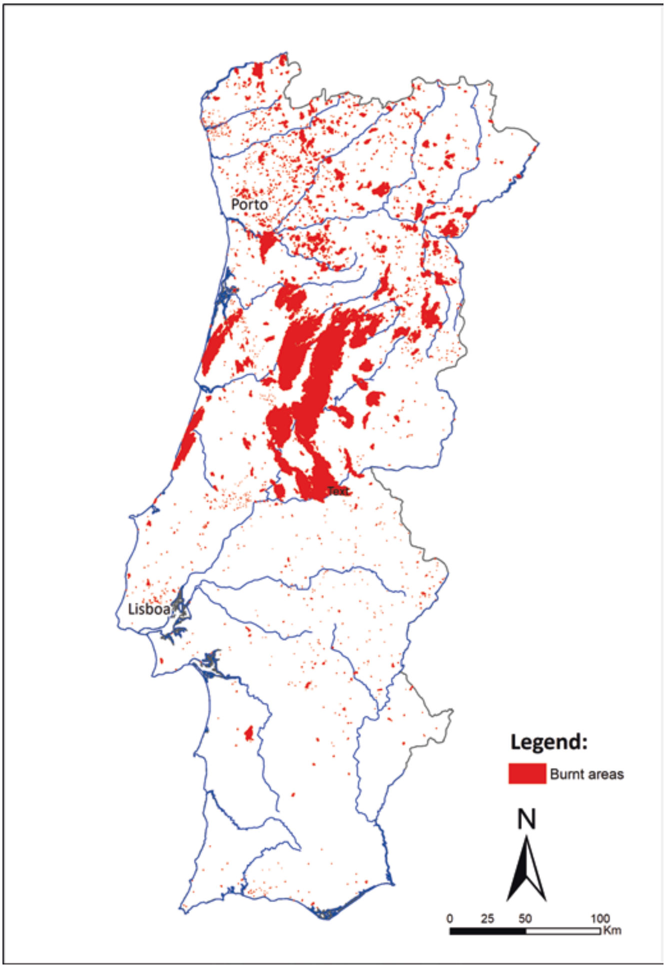

Fig. 5.2 Forest fires of 2017 in Portugal – Burnt areas

The other unusual feature of these fires has to do with the fact that they were big fires related with special weather conditions that affected very different areas and populations. In regard to the weather, the fires of 17th to 23rd June were linked to anticyclonic circulation from the East that made the maximum temperatures in the central region of the country rise to around 40 °C, with a minimum relative humidity of 15–20%. The dryness of the vegetation was greater at that time of year because of the preceding low rainfall. On 15 October, the fires were linked to the circulation of air masses from the south: hot, dry air with strong winds circulating around the outer edges of hurricane Ophelia. Despite its being October, the temperatures in Coimbra reached 36 °C and the relative humidity fell to almost 35%.

As for the areas affected, while the June fires had what could be called a "classic" distribution, affecting predominantly rural areas and populations and small private properties in the centre interior of the country, in October their distribution was more dispersed and, in addition to rural areas in the interior, the public national forests on the coast to the north and south of Figueira da Foz and some industrial areas and even peri-urban areas were affected, causing damage and social concern possibly even greater than during the June fires.

5.9 Climate Change and Territorial Planning in Portugal

Climate change is a major environmental problem worldwide and little by little it is setting the agenda for environmental policy and territorial planning in the different countries and regions. Even though science has some doubts as to the mechanisms, values and consequences of climate change, it is now a reality accepted by the vast majority of the world's scientific community, the major economic agents, the political decision-makers in international organisations and big countries, environmental associations and, in particular, the social media (Teles et al. 2016).

According to the IPCC summary report for 2014 (IPCC 2014), because of emissions and the increasing accumulation of greenhouse gases in the atmosphere, there was an average increase in world temperatures of 0.85 °C between 1880 and 2012. This warming has been responsible for increasing the temperature of the upper layers of the ocean and an average rise in its level of around 19 cm since 1900. In more recent years, there seems to have been a decrease in mass of the Antarctic and Greenland ice sheets, with a similar drastic reduction in sea ice in the Arctic Ocean.

Setting the time horizon at the end of the twenty-first century, the IPCC presents a series of predictions based on different scenarios of the use of fossil fuels, expecting an average increase of 1 °C over the 1986–2005 period, if the more mitigating scenario is followed, and around 4 °C if the more conservative model of predicting greenhouse gas emissions is followed. This warming will be felt in the high latitudes, especially in the Arctic. Sea levels will continue to rise, so that it is expected that at the end of the century the increase will be around 40 cm, with the more mitigating scenario, or around 80 cm under the more conservative scenario. The changes in annual rainfall, which is tending to drop, will also not have a uniform distribution. They will particularly affect the middle and subtropical latitudes (which include the Mediterranean belt), and it is very probable that the occurrence of episodes of extreme rain will increase.

Even if the more mitigating scenarios are adhered to, climate change will undoubtedly have a serious effect on physical systems, with shrinking glaciers and permanent snows, flooding, rising ocean levels and coastal erosion, biological systems, with the forced migration of species, in both marine and land ecosystems, and an increasing number of forest fires, and socio-economic systems, affecting food production, health and energy production.

The middle latitudes, the Mediterranean region and Portugal could be affected directly and indirectly on several levels (Santos and Miranda 2006) so that there is a need to analyse the problem and try to develop climate change mitigation and adaptation policies, on the national scale at the very least. These policies require a multi-scale understanding and approach, bearing in mind that the necessary and pressing resolution of local environmental problems, at the same time as helping to resolve the problems of the people, may also constitute, in some cases, a way of adapting to and mitigating climate change worldwide.

When these issues are analysed at the national level, in other words, as part of territorial planning policy, the major concerns are energy, water resources (either because of the processes of desertification and soil erosion or the country's agricultural production and food safety), ecosystem conservation, natural hazards and the health of the population. Thinking particularly of the implications of climate change for risks to the population, the issue should be tackled bearing in mind three types of area: the cities, countryside and coast.

In Portugal, almost half of the population lives in medium-sized and big cities. These cities are responsible for consuming almost 3/4 of the energy and emitting 4/5 of the greenhouse gas emissions (Lopes and Alcoforado n.d.). The different warming in the cities, caused by the so-called urban heat island, which is closely related to the size and structure of the city, may be accentuated by climate change, which leads to emphasising the problem of climatic hazards, particularly the hazard of heat waves, one of the most deadly in Mediterranean regions. Urban air pollution, currently produced mainly by transportation, is responsible for a high morbidity and mortality rate, especially in bigger and more densely populated cities with greater land planning problems. According to data from the European Environment Agency, in 2014, 632 years of life were lost per 100,000 inhabitants, just as a result of the concentration in the air of $PM_{2.5}$, a particulate material with a dimension of less than 2.5 μ that particularly affects chronic obstructive pulmonary diseases and cardiac diseases (EEA 2016). In 2013, this value was 570 years (EEA 2015), significantly less than the average figure of 898 years per 100,000 inhabitants for the 28 members of the European Union as a whole. Without any other reasons, these issues alone would mean that national land planning policies need to pay particular attention to the national urban network and to the structure and size of the major cities, so as to accommodate a different, complex demographic evolution and optimise the resources and the impacts of their use by the economy and society. At the same time as these policies help with adaptation to climate change, they will contribute in some way to its mitigation nationwide.

In rural areas, understood as areas with low population density, the environmental problems are different and have to do in great part with demographic issues. The shrinking and ageing population, the agrarian structure with a prevalence of smallholdings in the north and centre of the country, the fragmentation of rural properties, the abandonment of agriculture and the increase in forested areas, with a poor registration system and a great lack of organisation, together with a lack of capacity on the part of municipal bodies to carry out the necessary forest management, make forest fires one of the major and most scandalous environmental problems in the rural areas of this country, where hundreds of thousands of hectares have gone up in flames over the years. Too often, in very different political and media contexts, climate change is invoked to justify the fires, which, although dependent on climatic conditions that are characteristic of the Mediterranean climates, have as their main cause an absence of forest planning and management. Here too, if for no other reason, it would be enough to think of forest fires to design national public policies that pay particular attention to rural, low-density areas, located above all in the interior of the country, and that try to work out, or at least suggest, some solutions for increasing the economic, social and therefore demographic density of these areas. Their valuable natural, rural, gastronomic and historical and archaeological heritage and the high social value of the ecosystem services that rural areas can provide are not enough to revitalise them with tourism and the so-called green economy. It is therefore absolutely necessary to have a policy for the rural communities, capable of promoting their development and mitigating the innumerable hazards to which they are subject, especially forest fires.

A similar rationale can be used to explain and correct the environmental problems of the coastal areas and, in particular, on the coast itself, where there are frequent problems of erosion on the beaches and cliffs that affect the people and their assets, especially during winter storms. Also, in this case, climate change is frequently called upon as being the major cause, due to a logic that ignores almost ostentatiously the role played by the dozens of dams on the major rivers in reducing the amount of sediment brought down to the coast and the role of heavy-handed coastal protection work, which very often just shifts the problem of erosion from one area to another. However, even if many of these problems are currently linked to the over-intensive and abusive use of most of this country's coastal areas, everything leads us to believe that climate change is not only going to intensify them but also to preclude some human uses of the coast in the coming decades. It is therefore necessary to discuss and implement comprehensive policies for managing coastal areas, so as to predict the future of land that is very valuable from the economic, social and cultural viewpoint, with a heavy population density at certain points and with a strategic importance for the development of the country.

5.10 Conclusion

To quote O. Ribeiro (1945) again 'Portugal is Mediterranean by Nature and Atlantic by Position'. Apart from its geological characteristics, these conditions and, in particular, the transition between them justifies the environment and natural conditions of Portugal; they are responsible for significant resources and natural hazards. If the Mediterranean climatic conditions are important resources for agriculture and tourism, with significat implications to the social dynamics they involve, the main source of many of the hazards to which Portugal is prone, such as droughts, heat waves and flooding can also be found in these conditions. The exposure of the country to the vast Atlantic Ocean obviously affects the climate and, in addition to all its cultural significance, it determines many of the environmental hazards faced by Portugal, particularly the coastal erosion. The transition between the two influences imposes rules on the distribution of vegetation, natural and anthropised, setting the conditions for the hazard of forest fires, among others.

The physical geography of Portugal, in the tradition of researchers like Orlando Ribeiro, Fernandes Martins, Susanne Daveau, Brum Ferreira and Fernando Rebelo, includes a good knowledge today of the physical characteristics of the country, even if it is more focused on geomorphology and climatology, also the topics of most doctoral theses in physical geography made in Portugal (Cunha 2013). It has also come to be the hallmark of studies of impacts, resources and hazards, helped by the necessarily interdisciplinary of these studies and the use, in terms of technique and methodology, of automatic cartography and the modelling of natural processes using Geographical Information Systems (GIS). This conceptual and methodological breakthrough is also responsible for an approach to human geography, an approach that is being tackled after decades of works that ignored it and which has helped to incorporate a knowledge of physical geography and environment studies into planning and territorial planning studies on different levels.

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