

Taming wildfires in the context of climate change: The case of Greece

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COUNTRY CASE STUDY

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1 Introduction: Wildfire risk in Greece

Greece is one of the Mediterranean countries characterised by the highest wildfire¹ hazard (Salvati and Ranalli, 2015^[1]). The climate in most of Greece is Mediterranean, with mild and rainy winters that facilitate abundant vegetation growth and hot, dry and windy summers that tend to increase fuel flammability (Hellenic Republic, 2018^[2]) (Morehouse et al., 2011^[3]). In particular, in the eastern regions of Greece, summers are characterised by high temperatures combined with low relative humidity and strong winds (Karali et al., 2014^[4]), which contribute to particularly high wildfire hazard between May and October. Forests cover between 50 to 60% of Greece's territory, providing abundant fuel for wildfires (Eurostat, 2022^[5]) (Forest Europe, 2020^[6]) (Hellenic Republic, 2019^[7]).

Over the past decades, wildfire risk in Greece has increased. The extent of yearly burned area has increased along with the number of yearly wildfire occurrences, though changes in how fires have been counted over time make it difficult to draw long-term conclusions on the latter trend (GFMC, 2019^[8]) (Xanthopoulos, 2013^[9]). Recent estimates also show that, in Greece, 4% of wildfires are responsible for 75% of burned area (GFMC, 2019^[8]). In addition, areas usually less prone to wildfires – such as northern and western Greece – have recently experienced higher-than-usual wildfire frequency and severity (Dimitrakopoulos et al., 2011^[10]) (Mitsopoulos, Raftoyannis and Bakaloudis, 2015^[11]). The most extreme wildfire events in the country's history have also been recorded in recent years, with the ones occurring in 2007, 2018, 2021 and 2023 standing out in terms of the extent of burned area and the number of lives lost (Table 1). The 2007 Peloponnese wildfires, in particular, reached a record in area burned (i.e. 2% of Greece's territory) (Hellenic Republic, 2021^[12]), besides causing at least 65 fatalities and making nearly 4 000 people homeless (EM-DAT, 2023^[13]) (Mitsopoulos, Raftoyannis and Bakaloudis, 2015^[11]). As the second most deadly wildfire event of the current century (second only to the 2009 Black Saturday wildfires in Australia) (Hellenic Republic, 2021^[12]), the 2018 Mati wildfire claimed the lives of more than 100 people and injured hundreds more, directly affecting more than 4 500 people (Ganteaume et al., 2021^[14]) (Triantis, 2022^[15]) (EM-DAT, 2023^[13]). In 2023, the single largest wildfire ever recorded in the European Union (EU) took place in Evros, burning more than 90 000 hectares (Copernicus, 2023^[16]). The Evros wildfire displayed a particularly extreme behaviour – with estimated mean flame heights of more than 40 meters, spread rate greater than 5-6 kilometres per hour, spot fires ignited up to 500 meters away from the main fire, significant convective activity caused by the column of smoke, and a frontal intensity of about 90 000 Kw per metre (Bustamante López-Chicheri, 2023^[17]). These extreme and unprecedented figures far exceeded the country's fire suppression capacity.

¹ Wildfires are fires that occur in wildland areas such as forests, grasslands and peatlands, and whose occurrence or development is unintended or uncontrolled (OECD, 2023^[18]).

Table 1. The most extreme wildfires in Greece and their impacts

Year	Fire	Area burned (ha)	Fatalities
2007	Peloponnese wildfires	191 000	65
2018	Mati wildfire	1 280	100
2021	Evia wildfire	51 000	3
2023	Evros wildfire	93 880	20

Note: Extreme wildfires are hereby defined as wildfire events that are particularly severe in terms of their size, duration, intensity, and impacts (OECD, 2023^[18]). The exact estimates on the socio-economic impacts of each wildfire season or event reported in the table vary among different sources. The table includes both single wildfire events (2018, 2021, 2023) and more complex multi-fire events (2007), so the statistics provided in the first line are not directly comparable with the others.

Source: Based on data from (EM-DAT, 2023^[13]) (San-Miguel-Ayanz et al., 2022^[19]) (Hellenic Republic, 2021^[12]) (Copernicus, 2023^[16]) (Gemitzis and Koutsias, 2022^[20]) (Hellenic Fire Brigade, n.d.^[21]).

Wildfires have had lasting negative impacts on the quality of people's life and health (OECD, 2023^[18]). For example, between 1998 and 2004, wildfires in the greater Athens area were associated with a 6% increase in the number of cardiovascular deaths and a 12% increase in the number of respiratory deaths (Analitis, Georgiadis and Katsouyanni, 2012^[22]). A survey on psychological distress six months after the Peloponnese wildfires also found that nearly 30% of surveyed adolescents in the area likely suffered from post-traumatic stress disorder (PTSD) while 20% likely suffered from depression (Papadatou et al., 2012^[23]). At the same time, the occurrence of extreme wildfires – i.e. wildfire events that are particularly severe in terms of their size, duration, intensity and impacts – has also had negative environmental consequences (OECD, 2023^[18]). For example, after the extreme Mati wildfire in 2018, soil erosion rates increased fivefold compared to pre-fire levels (Efthimiou, Psomiadis and Panagos, 2020^[24]), while following the 2007 Peloponnese wildfires, flood risk in the region increased for close to a decade after the event (Diakakis et al., 2017^[25]). Extreme wildfires have had negative impacts on biodiversity, too. Between 2001 and 2021, 6% of Greece's NATURA 2000 protected areas burned at least once, with burned surface in some areas (e.g. Evia) reaching 13% (Biodiversity Recovery Hub, 2022^[26]). In addition, extreme wildfires have undermined Greece's climate change mitigation efforts. For instance, the 2007 wildfires accounted for around 37% of the total carbon dioxide (CO₂) emissions recorded in Greece for that year (EFFIS, 2022^[27]) (Sarris et al., 2014^[28]).

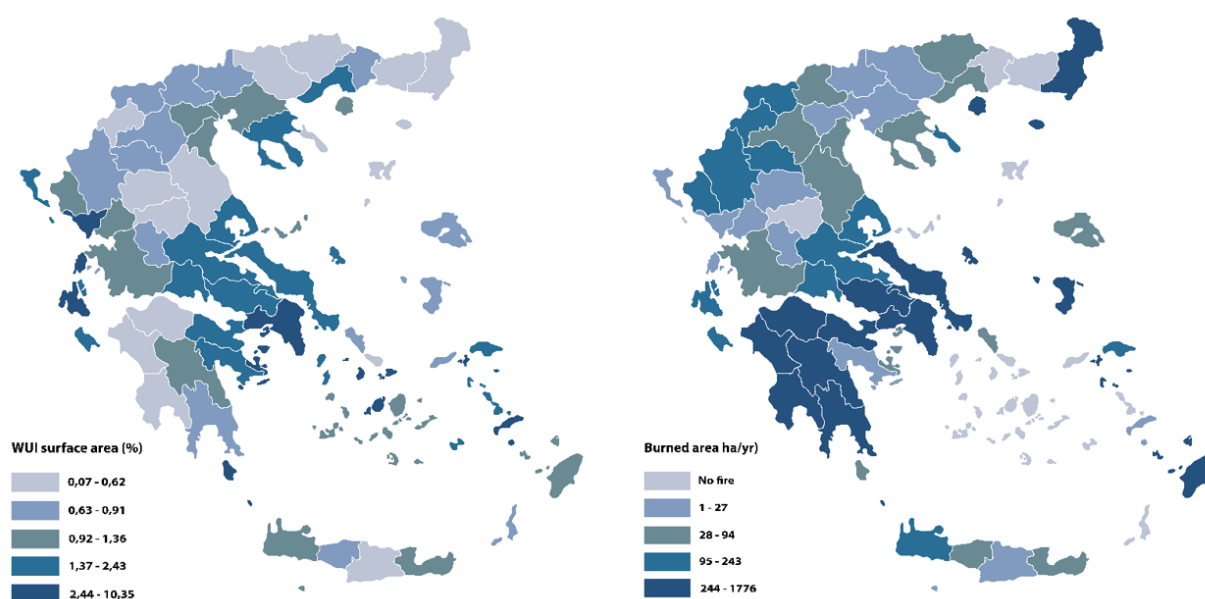
In most cases, extreme wildfires also have severe economic repercussions (OECD, 2023^[18]). The 2007 wildfires caused an overall estimated damage of EUR 1.9 - 3.0 billion (Hellenic Republic, 2021^[12]). Asset losses were also particularly high during the Mati wildfire, which destroyed 3 000 houses and considerably damaged the area's electricity distribution and water networks (Ganteaume et al., 2021^[14]). Sectoral impacts are also significant. For example, in 2012, the loss of 180 000 mastic trees on the island of Chios caused an overall economic loss of EUR 4 million and affected beekeeping, which suffered a 60% production loss (GFMC, 2019^[8]). In addition, in 2018 and 2019, wildfires disrupted travel infrastructure and induced mass evacuations at major tourist destinations during the peak of the season (Ross, Gannon and Steinberg, 2020^[29]), causing significant losses to the tourism sector.

The growing wildfire risk experienced by Greece in recent decades is largely associated with socio-economic and land-use changes, including rural depopulation and land abandonment and the often unplanned development of the wildland-urban interface (WUI), i.e. the area where the built environment and wildland vegetation meet (OECD, 2023^[18]). Indeed, since the 1970s, Greece has witnessed a significant migration from rural villages to urban areas (Xanthopoulos, 2013^[9]). As rural population is key in maintaining rural land, the progressive depopulation of rural areas has facilitated the uncontrolled growth of vegetation, increasing fuel loads and thus wildfire hazard (Koutsias et al., 2012^[30]) (Fernandez-Anez et al., 2021^[31]). At the same time, the depopulation of rural areas has also reduced the presence of agricultural and grazing activities in rural areas, thus facilitating the accumulation of unmanaged fuel loads. For example, in the Attica region, the abandonment of nomadic livestock activity – which effectively helped

to control vegetation growth – might have contributed to the extreme nature of recent wildfire events in the region. Overall, agricultural land abandonment is estimated to be the main driver of landscape changes enhancing wildfire hazard in Greece (Moreira et al., 2011^[32]).

In parallel, since the 1970s, the extent of wildland-urban interface areas has rapidly expanded in Greece (Xanthopoulos, 2008^[33]) (Mitsopoulos, Mallinis and Arianoutsou, 2015^[34]). This trend has been particularly pronounced in Attica, Central Greece, and the eastern Peloponnese (GFMC, 2019^[8]) (Figure 1). In most cases, the planning for these developments has been poor (Fernandez-Anez et al., 2021^[31]; Sapountzaki et al., 2011^[35]), increasing the likelihood of fire ignition along with the potential for damage (see Section 3.3.2). For example, since the second half of the last century, the city of Athens has expanded substantially into the surrounding countryside, and this trend that has been associated with the high number of wildfires registered in the area (Salvati and Ranalli, 2015^[1]). With the development of WUI areas, the use of flammable species has also increased. For example, the scattered and unmanaged presence of Aleppo pines among buildings is likely to have contributed to the extreme nature of the Mati wildfire (Blandford, 2019^[36]). While in recent years overall WUI development rates have slowed down in certain regions, including in Attica (Triantis, 2022^[15]), WUI areas are often still subject to uncontrolled development (Sapountzaki et al., 2011^[35]), posing growing threats to human health and security, public and private assets, and critical infrastructure (GFMC, 2019^[8]). As a result of these trends, regional units that include a large WUI surface tend to correspond with those characterised by larger burned area (Figure 1).

Figure 1. Share of WUI area and total burned area per year by regional unit



Note: The share of WUI surface area (represented in the map on the left) refers to 2018. The extent of area burned (represented in the map on the right) portrays the average area burned per year between 2007 and 2018. Both maps display data at regional unit level. Regional units are sub-regional administrative units.

Source: Adapted from (Mitsopoulos et al., 2020^[37]).

Climate change adds to all these drivers, increasingly exacerbating wildfire hazard in the country. In recent decades, summer and spring temperatures in Greece have shown a warming trend, which is projected to continue in the decades to come (Feidas, 2017^[38]). Under a high-emission scenario (i.e. RCP 8.5),² annual mean temperatures over the national territory are projected to increase by up to 2.4°C between 2031-2060 and by up to 5.0°C by 2071-2100. At the same time, under most scenarios, annual precipitation levels are projected to decrease, while the number of dry days per year and the duration of dry spells (i.e. the occurrence of consecutive days with precipitation levels below 1 millimetre) are both projected to increase throughout the whole country. Most notably, under a high-emission scenario, precipitation levels might decrease by 23% before the end of the century – with the most significant changes expected in the western part of the country, the Aegean Islands and Crete – while the average duration of dry spells is projected to increase by 30 days, with the largest increases expected in Attica, Peloponnese, the Aegean Islands and Crete (Ministry of Environment and Energy, n.d.^[39]). Soil moisture is projected to decrease under all emission scenarios (National and Kapodistrian University of Athens, 2021^[40]) (De Rigo et al., 2017^[41]). All these trends enhance the conditions for the occurrence and spread of extreme wildfires. This was observed for example during the 2007, 2018, 2021 and 2023 extreme wildfires, which have all been associated with the unusual heat, drought, and/or wind speed recorded in those years (National Observatory of Athens, 2023^[42]) (Komac, 2020^[43]) (Founda and Giannakopoulos, 2009^[44]). Drought conditions have also been associated with the unusual number of wildfires and the extent of yearly burned area in northern and western Greece – two regions historically less prone to wildfires (Dimitrakopoulos et al., 2011^[10]) (Mitsopoulos, Raftoyannis and Bakaloudis, 2015^[11]).

Due to increasingly extreme weather conditions, wildfire frequency and intensity are projected to increase in the whole country. In particular, under RCP 8.5, the yearly number of extreme fire danger days³ is projected to increase by 24 by 2060 and by 40 by the end of the century, especially in the northern and eastern part of the country. Crete, the Aegean Islands, the Attica region, East Macedonia and Thrace, as well as parts of Peloponnese, are projected to experience the most significant increases in fire danger (Ministry of Environment and Energy, n.d.^[39]) (Rovithakis et al., 2022^[45]) (Figure 2). In addition, under RCP 8.5, the duration of the fire season is expected to increase, reaching an additional 40 days in some areas before the end of the century. Overall, by 2100, yearly burned area in Greece's forests is projected to increase by 10% to 20% (i.e. an additional 20 000 - 40 000 hectares every year) compared to early-2010s levels under a modest- to high-emission scenario.⁴ This projected increase in burned area, alone, is expected to lead to an additional economic impact of EUR 40 - 80 million every year (Bank of Greece, 2011^[46]).⁵

² Representative Concentration Pathways (RCPs) are climate change scenarios that project future greenhouse gas concentrations in the atmosphere. The RCPs discussed in this paper include low-emission (RCP 2.6), moderate-emission (RCP 4.5) and high-emission (RCP 8.5) scenarios.

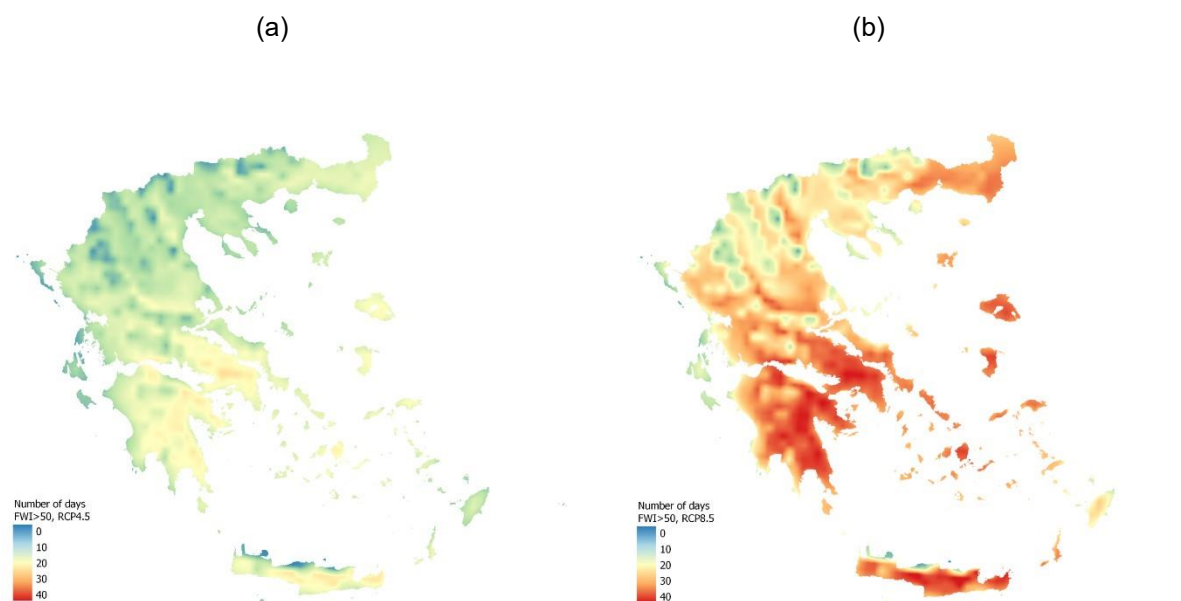
³ Extreme fire danger days are those days in which the fire weather index (FWI) value is above 50.

⁴ The lower bound estimate refers to a scenario of global atmospheric CO₂ concentrations reaching 620 ppm by 2100, while the upper bound refers to a scenario reaching 850 ppm by 2100 (Bank of Greece, 2011^[46]).

⁵ This estimate only considers the increase in direct damages, suppression costs and restoration costs that would result from the projected increase in burned area.

Figure 2. Change in number of days with extreme fire danger by 2071-2100

Change in number of extreme fire danger days under RCP 4.5 (a) and RCP 8.5 (b), compared to 1971-2000



Note: Days with extreme fire danger are those characterised by a fire weather index (FWI) value above 50.

Source: (CLIMADAPT group-National Observatory of Athens, 2024^[47]), based on data developed in the framework of LIFE-IP AdaptInGR project (LIFE17 IPC/GR/000006).

In the context of growing wildfire risk, public policies and practices on the ground play a key role to reduce risk and enhance resilience. The following sections provide an overview of how Greek national and local authorities are responding to this challenge. Section 2 discusses the existing policy and institutional framework for wildfire management in Greece, while Section 3 highlights existing practices as well as the remaining challenges in Greece's adaptation to changing wildfire risk.

2 The enabling environment for adapting to growing wildfire risk in Greece

Over the past decades, several policy and institutional reforms in Greece have increased the fragmentation of roles and responsibilities for wildfire management, which in many cases has facilitated the development of misaligned or disconnected interventions (GFMC, 2019^[8]) (Palaiologou et al., 2018^[48]). Yet, in recent years, considerable efforts have been made to enhance co-ordination among policy actors, as well as to mainstream wildfire prevention in the country's strategic policy framework.

2.1 The policy framework

To date, Greece does not have an overarching wildfire management strategy at the national level. Wildfire emergency management in Greece is governed on the basis of the General Plan for Dealing with Emergencies due to Forest Fires "IOLAOS 2", which provides the legal framework for wildfire preparedness, response and immediate recovery and details the roles and responsibilities of all public agencies involved in emergency management. The "IOLAOS 2" plan is complemented by the 2018 Action Plan for the Management of Forest Fires, which outlines several wildfire prevention, preparedness and response measures and projects, as well as a process chain of roles, responsibilities and co-ordination mechanisms for the emergency preparedness and response communities. While these plans play a major role in co-ordinating civil protection and emergency management across the territory, the lack of a comprehensive wildfire management strategy covering all steps of the wildfire management cycle and establishing clear policy goals, targets, institutional responsibilities, and monitoring cycles remains a major policy gap in Greece. This gap was identified by several stakeholders and experts, including by the Independent Committee established after the Mati wildfire⁶ (GFMC, 2019^[8]).

Nonetheless, wildfire risk and prevention have increasingly been addressed in several strategic policy plans:

- The **National Forest Strategy** (2018-2038), developed by the Ministry of Environment and Energy (henceforth Ministry of Environment), recognises the effect of climate change on forests and identifies climate adaptation as a priority in the management of forests and WUI areas (Ministry of Environment and Energy, 2018^[49]) (Climate ADAPT, 2022^[50]). The strategy calls for the protection of forested areas from wildfires through both fire prevention and suppression efforts and sets out the goals to (i) prevent and limit the occurrence and extent of wildfires; (ii) reduce wildfire severity and negative impacts; and (iii) reduce wildfire risk in WUI areas. These goals are matched with specific actions and monitoring indicators. The strategy also sets out a list of objectives specifically

⁶ The Committee, established by the Prime Minister, was tasked to assess the underlying causes of wildfires in Greece, including the Mati wildfire (GFMC, 2019^[8]). A similar effort has been undertaken after the 2021 wildfire in Evia.

focused on strengthening wildfire prevention. These include (i) the improved and systematic management of forest ecosystems; (ii) the identification of priority areas for wildfire prevention (e.g. WUI areas, vulnerable parts of national forests, etc.); (iii) the development and implementation of a comprehensive national reforestation plan (see below); and (iv) the update of existing guidelines on the preparation of forest fire prevention plans. In addition, the strategy encourages the reinforcement of the local Forest Service Offices, as well as the development of detailed forest maps to provide an inventory of forest land that can effectively inform wildfire management interventions. Finally, the strategy recognises that wildfire risk has a cross-sectoral and transboundary character – thus making the case for policy coherence and co-ordination among sectors, agencies, and levels of government. International co-operation, most notably throughout the Balkan and Mediterranean regions, is also encouraged (Ministry of Environment and Energy, 2018^[49]). The strategy has a twenty-year time horizon and action plans for its implementation are developed on a three-year basis.

- Greece's **National Reforestation Plan** (2020-2030) was developed in 2020 by the Ministry of Environment. The plan aims at restoring degraded forest ecosystems with a view to strengthening the resilience of forest areas while also contributing to the country's biodiversity conservation and climate change mitigation objectives. The plan foresees the reforestation of 13 priority areas by 2026, which will be followed by regular maintenance interventions and a monitoring exercise until 2030. In addition, the plan supports a range of measures and activities which include, among others, the treatment of forests affected by bark-eating parasites, the upgrading of existing forest nurseries, and the monitoring and recovery of soil layers in severely burned areas.
- The **National Biodiversity Strategy** (2014-2029), developed and implemented by the Ministry of Environment, also identifies wildfires as a key threat to Greek forests (especially to those undergoing regeneration) and recognises the links between climate change and growing wildfire risk. The strategy emphasises the critical role of effective wildfire management to ensure the sustainability of forest ecosystems, and identifies prevention, early detection, firefighting, and post-fire ecosystem restoration as key strategic steps of wildfire management (Ministry of Environment and Energy, 2014^[51]).
- Since 2016, Greece has a **National Adaptation Strategy**. The strategy has a ten-year implementation horizon and builds on the climate impact and vulnerability assessment developed by the Bank of Greece in 2011. In line with the other strategies mentioned above, Greece's National Adaptation Strategy acknowledges the growing risk of extreme wildfires as well as the need for a greater emphasis on wildfire prevention, which is highlighted as the most cost-effective policy option to reduce wildfire risk (Ministry of Environment and Energy, 2016^[52]). The strategy also includes potential actions and measures that aim at mainstreaming wildfire risk management across sectors, for example in policies relevant to forestry, tourism, livestock, and agricultural activities (Hellenic Republic, 2018^[2]) (Ministry of Environment and Energy, 2016^[52]). These include, for example, (i) the development of a forest land registry compiling information on vegetation types, land cover and ownership status, (ii) the implementation of controlled grazing to manage fuel loads, and (iii) the prompt management of burned land in the immediate aftermath of wildfire events, with a view to reducing the risk of land erosion. While the country does not have an overarching national plan to implement the National Adaptation Strategy, Greece's 13 regional authorities are mandated to develop and implement their own Regional Climate Change Adaptation Action Plans (RAAPs), which follow a 7-year cycle (OECD, 2020^[53]). However, while all regions have prepared a RAAP⁷, these often contain few concrete measures for climate adaptation at the local level, not least due to the limited availability of local and regional data. Most recently, with the adoption of the National Climate Law (see below), Greece transferred the responsibility for the National Adaptation Strategy

⁷ At the time of writing, 7 RAAPs have been approved, while the remaining 6 are to be approved in the first half of 2024.

and national adaptation policy to the Ministry of Climate Crisis and Civil Protection (see Section 2.2) (Hellenic Republic, 2022^[54]) (Government of Greece, 2021^[55]). The latter is also in the process of finalising its Strategy and Action Plan on Climate Change Adaptation and its Linkages with Civil Protection (2023-2027), with a view to strengthening the links between the climate change adaptation and civil protection agendas.

- The **National Climate Law** adopted in 2022 promotes the mainstreaming of climate adaptation across sectors. To achieve this objective, the law mandates central government departments to integrate adaptation into sectoral strategies and plans and foresees the possibility to adopt policies and measures to increase climate resilience and reduce vulnerability to climate risks throughout all economic sectors, as well as through the management of biodiversity and the natural environment (Hellenic Republic, 2022^[54]). This is expected to strengthen the integration of climate adaptation considerations into the wildfire-related strategies and plans in place in Greece.
- Finally, the **National Action Plan for Combating Desertification**, approved in 2001 and implemented under the oversight of the Ministry of Rural Development and Food, also outlines a set of prevention measures to be adopted to reduce wildfire risk in Greece. These include (i) the use of wildfire-resilient plant species; (ii) the clearing and maintenance of forests, e.g. through tree thinning and controlled grazing; and (iii) improved wildfire detection systems (Hellenic Republic, 2018^[2]). In 2021, a National Committee for Combating Desertification was also established.
- The **National Disaster Risk Management Plan** is currently under development. Once finalised, it will serve as the key strategic document to guide disaster risk management and encourage risk reduction in Greece. Following a multi-risk approach, the plan will encompass a list of actions to enhance disaster prevention, preparedness, response, recovery as well as a lesson-learnt system.

2.2 Institutional arrangements

Greece's institutional framework for wildfire risk management has historically been characterised by a high level of fragmentation. Today, several public agencies are involved in wildfire management at different levels of government. At the national level, key agencies include the Ministry of Climate Crisis and Civil Protection – which, among others, includes the General Secretariat for Civil Protection, the Secretariat for Natural Disaster Recovery and State Support, and the Hellenic Fire Brigade – and the Ministry of Environment and Energy – most notably through its Forest Service, as well as through the Green Fund and the Natural Environment and Climate Change Agency (NECCA). In addition, the Ministry of Infrastructure and Transport, the Ministry of the Interior, Public Administration and Decentralisation (henceforth Ministry of the Interior), the Ministry of Rural Development and Food, the Ministry of Culture, the Ministry of Health, the National Meteorological Service, and the National Observatory of Athens also play a role in wildfire management (Table 2).

Table 2. National public entities engaged in wildfire management

Agency	Risk assessment	Risk communication	Prevention	Preparedness & response	Post-fire recovery	Funding
Ministry of Climate Crisis and Civil Protection	X	X	(X)	X	(X)	
Hellenic Fire Brigade	X	X		X		
Ministry of Environment and Energy	X		X	(X)	X	X
Forest Service	X		X	(X)	X	
Green Fund						X
Natural Environment and Climate Change Agency (NECCA)			(X)	X	X	
Ministry of Infrastructure and Transport			X	X	X	
Ministry of the Interior						X
Ministry of Rural Development and Food			X			X
Ministry of Culture	(X)		X	X		
Ministry of Health		(X)				
National Meteorological Service	X	(X)		X		
National Observatory of Athens	X			(X)		

Note: The stakeholders listed in this table include entities of various nature, including ministries as well as public agencies that operate under specific ministries (e.g. the Forest Service, the Green Fund, and NECCA all operate under the Ministry of Environment, while the Hellenic Fire Brigade, the National Meteorological Service, and the National Observatory of Athens all operate under the Ministry of Climate Crisis and Civil Protection). Their inclusion in this table as separate entries aims to provide a more granular overview of the roles of the key national public entities discussed in this paper.

Local and regional actors also play a prominent role in wildfire management in Greece (Table 3). Since the early 2000s, regions and municipalities have acquired growing responsibilities and resources for wildfire management (Papanikolaou et al., 2013^[56]) (Sapountzaki et al., 2011^[35]). Overall, wildfire prevention in wildland areas is articulated at the subnational level through 42 Directorates of Forests – i.e. regional extensions of the Forest Service – and their 103 subordinate Forest Service Offices, which operate at the local level carrying out forest and fuel management activities (Hellenic Republic, 2021^[57]). Regional and local civil protection authorities also play a key role in raising public awareness and strengthening preparedness by contributing to prepare preventive evacuation plans, co-ordinating emergency drills, and undertaking outreach campaigns (see Section 3.4) (Papanikolaou et al., 2013^[56]). Both municipal and regional authorities work closely with the General Secretariat for Civil Protection and are required to update and align their emergency management plans with the “IOLAOS 2” plan (see Section 2.1).

Table 3. Key subnational public entities engaged in wildfire management

Agency	Risk assessment	Risk communication	Prevention	Preparedness & response	Post-fire recovery	Funding
Regions (13)		X	X	X	X	
Municipalities (325)		X	X	X	X	
Directorates of Forests			X		X	
Forest Service Offices	X		X		X	
Regional Directorates of Civil Protection	(X)	X		X	(X)	
Municipal Civil Protection Offices		X		X		

Note: The stakeholders listed in this table include entities of various nature, including local governments as well as subnational articulations of national agencies. The list is not comprehensive and aims to provide an overview of the key subnational public entities discussed in this paper.

Overall, the Greek institutional framework for wildfire management has long been characterised by high fragmentation and a complex distribution of information, roles, and responsibilities. For instance, as highlighted by the Independent Committee that was set up after the Mati wildfire, wildfire prevention alone has fallen under the responsibility of more than 45 agencies and bodies (GFMC, 2019^[8]). This, along with limited institutional co-ordination among key agencies, has represented a major barrier to effective wildfire management in the country (Sapountzaki et al., 2011^[35]) (Morehouse et al., 2011^[3]). Until recent years, co-ordination has been particularly low between the Hellenic Fire Brigade and the Forest Service, as well as among different relevant ministries. In turn, the resulting policy misalignments have historically been reflected at the subnational level, with different agencies and bodies often receiving conflicting policy directions and facing few opportunities and incentives to co-ordinate and share information with each other. In some cases, this situation has been exacerbated by incompatible policy frameworks and procedures for action across different policy communities (Sapountzaki et al., 2011^[35]).

In recent years, efforts to enhance co-ordination and collaboration among public agencies and bodies have significantly increased. Since 2019, collaboration between the Forest Service and the Hellenic Fire Brigade has significantly improved, thanks to a joint ministerial decision signed by the two overseeing Ministries, which established a clear framework for institutional collaboration outlining responsibilities and areas of co-operation (Hellenic Republic, 2019^[58]). The provision of immediate mutual assistance between these bodies during wildfire emergencies was also set out in law in 2020 and 2023 (Hellenic Republic, 2020^[59]) (Hellenic Republic, 2023^[60]). The creation of the Ministry of Climate Crisis and Civil Protection (previously Ministry of Citizen Protection)⁸ in 2021 represents another key step in this direction (Government of Greece, 2021^[61]), as the new ministry aims to improve co-ordination among the institutional actors involved in the management of climate risks. Overall, these institutional reforms have sought to enhance collaboration and co-ordination among the policy communities dealing with wildfire prevention and suppression, as well as to adapt emergency preparedness and response operations to the context of climate change. For example, since summer 2022, various meetings initiated by the new Ministry of Climate Crisis and Civil Protection have facilitated co-ordination and dialogue among national and subnational stakeholders, including between the Hellenic Fire Brigade and the Forest Service. The new ministry has also worked with subnational stakeholders to establish local protocols of action to guide wildfire management across Greece's 13 regions. In addition to these top-down institutional reforms, various EU-funded projects, such as FirEURisk and FIRE-RES (Box 1), have also sought to enhance policy integration, institutional co-ordination and knowledge exchange on wildfire prevention among Greek stakeholders (Cordis, n.d.^[62]) (FirEURisk, n.d.^[63]) (FIRE-RES, n.d.^[64]) (LIFE Public Database, 2013^[65]).

Another long-standing institutional challenge to effective wildfire prevention in Greece has been the eroding mandate and capacity of wildfire prevention agencies. While until 1998 forest management – encompassing both wildfire prevention and suppression – fell under the responsibility of the Forest Service, in 1999 the responsibility for wildfire suppression was transferred to the Hellenic Fire Brigade (GFMC, 2019^[8]) (Xanthopoulos, 2008^[33]) (Morehouse et al., 2011^[3]). Over the same period, the Forest Service's institutional structure underwent several changes. The agency, which at first operated under the Ministry of Rural Development and Food (back then Ministry of Agriculture), was moved to the Ministry of Environment and Energy where it operates today. Its subordinate Directorates of Forests, which also operated under the Ministry of Agriculture until 1998, were then moved under the responsibility of the decentralised administrations of the country, under the oversight of the Ministry of the Interior (Xanthopoulos, 2008^[33]). This fragmentation of responsibilities and frequent institutional changes, aggravated by repeated cuts in resources, have eroded the Forest Service's capacity and leadership and thus weakened the country's forest management and wildfire prevention capacity (Hellenic Republic, 2019^[7]).

⁸ This change induced the transfer of the responsibility for the co-ordination of climate change adaptation matters from the Ministry of Environment to the new Ministry of Climate Crisis and Civil Protection (Hellenic Republic, 2022^[54]).

In recent years, there have been notable improvements in this area, thanks to an enhanced institutional attention to (and investment in) wildfire prevention (see Section 3.6). Since 2022, following the extreme Evia wildfire, the Directorates of Forests were moved under the responsibility of the Ministry of Environment and Energy, which allowed to simplify procedures and facilitate the implementation of forest policy across levels of government (Hellenic Republic, 2021^[57]). In addition, an inter-ministerial committee has been established to facilitate wildfire risk assessment in the wildland-urban interface as well as the prioritisation and implementation of prevention measures (Hellenic Republic, 2023^[60]). Nonetheless, more efforts are needed to further strengthen the capacity and mandate of Greece's Forest Service, with a view to stepping up wildfire prevention throughout the national territory.

3 Wildfire risk reduction in Greece: current measures, practices, and existing challenges

While historically wildfire management in Greece has primarily relied on wildfire suppression, the extreme wildfires experienced in recent years have showed that responsive measures – even if these were to be increased – are not sufficient to manage growing wildfire risk in the context of climate change. On the contrary, in some cases, an excessive reliance on wildfire suppression in fire-adapted ecosystems can facilitate the accumulation of fuel, further increasing landscape flammability (OECD, 2023^[18]) (Ganteaume et al., 2021^[14]) (Morehouse et al., 2011^[3]) (Tedim, Leone and Xanthopoulos, 2016^[66]). In recent years, following the occurrence of particularly extreme wildfires, the need to adapt to changing wildfire risk by scaling up prevention has gained increasing attention in Greece, and growing efforts have been channelled towards improving hazard and risk assessments, risk awareness and communication, and physical and organisational measures for wildfire prevention. Significant improvements have also been observed in emergency preparedness and post-fire recovery practices, as well as in the availability of financing for wildfire risk reduction. International co-operation has also contributed to improve wildfire practices and measures in Greece (Box 1). However, further steps are needed to strengthen, co-ordinate, and complement the policies and measures already in place.

Box 1. Improving wildfire risk reduction through EU projects and international co-operation

In recent years, Greece has benefitted from various EU-funded initiatives aimed at improving wildfire management throughout its territory. Currently, Greece is involved in several EU projects:

- The LIFE-IP **AdaptInGR** project aims to support the implementation of climate change adaptation policy in Greece. By 2026, the project intends to (i) accelerate the implementation of the National Adaptation Strategy and the Regional Adaptation Action Plans; (ii) enable local adaptation planning; (iii) strengthen adaptation mainstreaming across sectoral policies; (iv) enhance the monitoring and evaluation of the adaptation measures and policies in place in Greece across different sectors; and (v) mobilise additional EU and national funding in support of climate adaptation. The project has already established a national adaptation hub to pool together data, information, and good practices on adaptation in Greece, including a climate projection tool on climate risks such as wildfires⁹. The project has also developed open GIS maps based on climate projections to improve the climate services available to public and private stakeholders (Ministry of Environment and Energy, n.d.^[39]) (see Section 3.1). As part of the LIFE-IP AdaptInGR, a pilot project on improving wildfire prevention has also started in the

⁹ The national adaptation hub is available at <https://adaptivegreecehub.gr>. The climate projection tool is available at <https://geo.adaptivegreecehub.gr>.

Municipality of Iliida. Overall, the LIFE-IP AdaptInGR project has a budget of more than EUR 14 million provided by the European Union's LIFE Programme and the Hellenic Green Fund, as well as by a number of private entities. Specifically, the EU provides EUR 8.3 million, while the Hellenic Green Fund provides EUR 2.5 million. The remaining funding is provided by the project partners' own resources and private funds (AdaptiveGreece Hub, n.d.^[67]).

- The **FirEURisk** project aims to develop an integrated strategy for wildfire management as well as a platform to facilitate co-ordination among stakeholders. The project aims at improving existing wildfire risk assessments, developing measures to reduce wildfire risk, and ensuring wildfire management strategies are well-adapted to future climate and socio-economic changes. The project, which receives EUR 10.7 million from the EU Horizon 2020 Programme for the period 2021-2025, brings together 43 organisations from different countries and focuses on five pilot areas across the EU, including the Attica region (Cordis, n.d.^[62]) (FirEURisk, n.d.^[63]).
- Similarly, the **FIRE-RES** project aims to strengthen the prevention of extreme wildfires and promote integrated wildfire management through awareness-raising and capacity building activities. The programme, which receives approximately EUR 20 million from EU Horizon 2020 Programme for the period 2021-2025, is set to develop innovative approaches for territorial resilience and integrated wildfire management. These will then be implemented in 11 pilot areas in Europe and beyond and then upscaled at wider level. In Greece, the selected pilot areas are the Lesvos island, the Kassandra peninsula (Chalkidiki), and the Peloponnese region (FIRE-RES, n.d.^[64]). The project involves several organisations from 13 countries, including the National Observatory of Athens and the Aegean University (Cordis, n.d.^[68]).

Complementing these EU-funded projects, in January 2023 Greece also signed a bilateral co-operation agreement with Portugal, aimed at providing mutual assistance on the prevention and management of disasters such as wildfires.

Source: (Ministry of Environment and Energy, n.d.^[39]) (AdaptiveGreece Hub, n.d.^[67]) (Cordis, n.d.^[62]) (FirEURisk, n.d.^[63]) (FIRE-RES, n.d.^[64]) (Cordis, n.d.^[68]) (LIFE Public Database, 2013^[65]).

3.1 Wildfire risk assessment

Wildfire risk assessment is a fundamental step in wildfire management, as it provides the information base for all prevention and adaptation policies and measures (OECD, 2023^[18]).¹⁰ Overall, according to the analysis undertaken by the Independent Committee set up after the Mati wildfire, today 12% of Greece's territory is characterised by "extremely high" or "very high" ignition risk, and a further 18% of the national territory is characterised by "high" ignition risk (Figure 3).¹¹ The remaining territory (i.e. approximately 70% of the country) shows "moderate" or "low" hazard levels (GFMC, 2019^[8]).

To inform wildfire policy at the national and subnational level, Greece uses a wildfire hazard map that identifies areas prone to wildfires (Government of Greece, 1980^[69]). Yet, since its creation in 1980, this map has not been updated (Mitsopoulos et al., 2020^[37]). This represents a major challenge, as

¹⁰ In this paper, wildfire risk assessment refers to the wealth of information and tools available to inform wildfire prevention and climate adaptation over the medium and long term. These differ from the short-term weather and hazard forecast products that are used to inform civil protection and emergency preparedness and response purposes. The latter are discussed in Section 3.4.

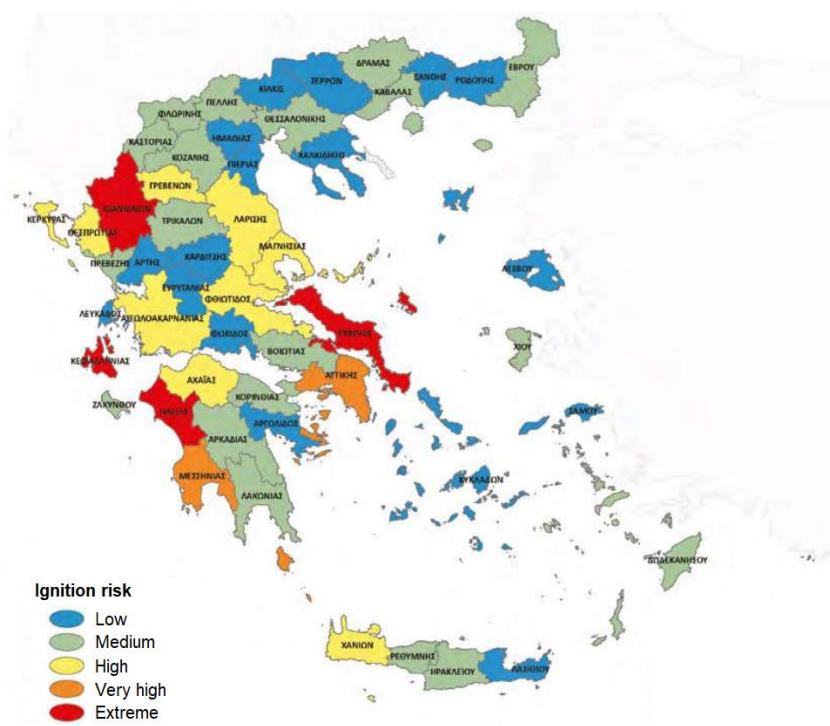
¹¹ The areas exposed to extremely high ignition risk are Ioannina, Kefallinia, Iliia, and Evia, while those subject to very high risk are Attica and Messinia. Those exposed to high risk are Aitolokarnania, Chania, Thesprotia, Fthiotida, Grevena, Corfu, Larissa, Achaia, and Magnesia (GFMC, 2019^[101]).

environmental, climate and socio-economic conditions in the country have significantly changed over the past decades (Hellenic Republic, 2021^[12]). To address this gap, the Ministry of Climate Crisis and Civil Protection is currently working on updating this map, based on a wealth of information provided by the Forest Service, the Hellenic Fire Brigade, and other relevant agencies, e.g. on past and projected wildfire activity, land cover types, and WUI areas' characteristics. Complementary data products available to date in Greece include maps of the ignition risk distribution throughout the country, with resolution at the prefecture level. In recent years, the National Observatory of Forest Fires (NOFFI) has also developed a fuel type mapping service based on remote sensing and cartographic data, which is used as an input for wildfire behaviour modelling, as well as to inform wildfire prevention planning (NOFFI, n.d.^[70]).

To complement this information, the Hellenic Fire Brigade also collects data on past wildfires based on different land type and cover categories (e.g. forested land, grazing land, agricultural land, wetlands, agricultural residues, urban parks). Since 2000, these data have been regularly updated and made public through the website of the Hellenic Fire Brigade (Hellenic Fire Brigade, 2022^[71]). While data on past wildfire activity are also available for the years preceding 2000, these are not directly comparable to post-2000 entries, as before this date wildfire data were collected by the Forest Service using a different classification system (Xanthopoulos, 2013^[9]). This lack of consistency in wildfire history statistics was identified as a key obstacle to effective risk assessment and prevention planning (GFMC, 2019^[8]), as it hampers the observation of long-term trends in wildfire hazard in Greece. Since 2016, the mapping of burned area undertaken by the National Observatory of Forest Fires has provided an innovative service in support of wildfire management throughout the national territory (NOFFI, n.d.^[72]). Observed data on extreme events, as well as on a number of climatological indicators relevant to wildfires (e.g. on temperature, rainfall, and wind intensity and direction, among others) are also recorded and regularly published by the National Meteorological Service and the National Observatory of Athens (National Observatory of Athens, n.d.^[73]).

In the context of the LIFE-IP AdaptInGR project (Box 1), the National Observatory of Athens and the Academy of Athens have developed projections of future wildfire hazard across the national territory under low-, moderate- and high-emission scenarios (i.e. RCP 2.6, RCP 4.5, and RCP 8.5). These projections include, among others, projected changes in the fire weather index values, as well as in meteorological parameters favourable to wildfires (e.g. precipitation levels, drought, atmospheric temperatures, wind speed, relative humidity) for the periods 2031-2060 and 2071-2100, compared to the baseline period 1971-2000 (Ministry of Environment and Energy, n.d.^[39]). These projections are publicly available through the GIS portal of the Ministry of Environment and Energy and the national adaptation hub (Box 1) (AdaptiveGreece Hub, n.d.^[74]). Adding to this effort, the National Observatory of Athens and the National Meteorological Service are also running a joint research project to better understand the interaction between extreme weather and fire behaviour (National Meteorological Service and National Observatory of Athens, 2023^[75]).

Figure 3. Likelihood of wildfire ignition in Greece by regional unit, 1984-2009



Note: This map represents the latest data available, which might not precisely describe the situation as of 2024.

Source: Adapted from (GFMC, 2019^[8]) and (Dimitrakopoulos, 2001^[76]).

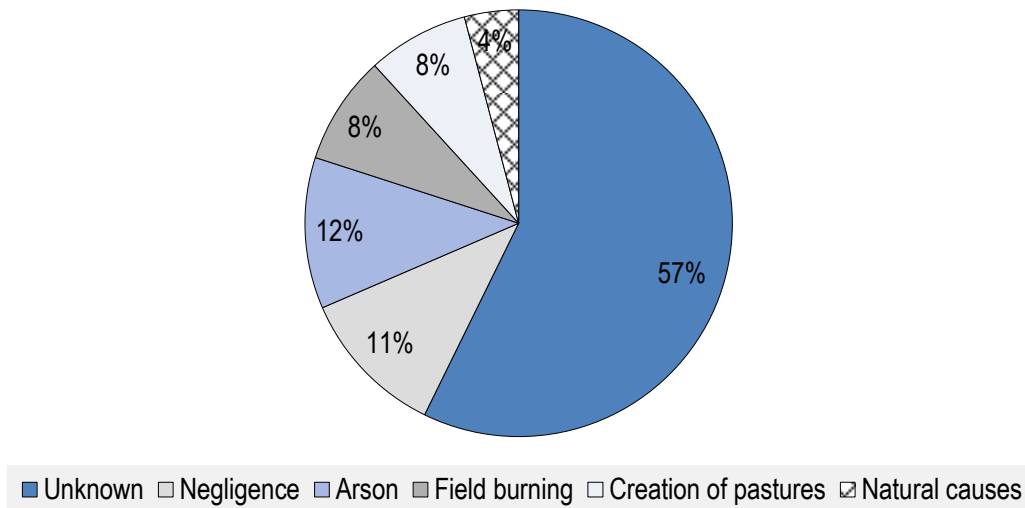
In 2019, Greece also developed a National Risk Assessment document, which includes information on wildfire risk in the country, among other risks. The document provides an overview of the causes, impacts, and geographical distribution of wildfires and highlights the significant risk and management challenges posed by fires that occur in WUI areas. It also includes a brief overview of fuel types in the country (based on observed burned area statistics) and a summary of the link between weather conditions and wildfires, including the projected effects of climate change on future wildfire trends (Hellenic Republic, 2021^[12]). However, to date,¹² the document does not provide in-depth details or data useful for effectively assessing wildfire hazard or risk across the territory and thus serves as an overview document more than an actual risk assessment that can concretely inform policies and operations on the ground.

Risk assessment efforts are also limited at the regional and municipal level. Notable exceptions include the risk assessment efforts currently undertaken by the Directorate of Civil Protection of the Attica region, which – in co-operation with the National and Kapodistrian University of Athens – is implementing a pilot project to map hazard, exposure and vulnerability to wildfires and other climate risks in selected high-risk areas, with resolution at the neighbourhood level. To address the existing data gaps on exposure and vulnerability to hazards including wildfires, the Ministry of Climate Crisis and Civil Protection is currently working on the development of a risk and disaster data platform called “Integrated Risk Management and Prevention Information System” to be delivered by 2027. The platform aims to provide regularly updated risk maps inclusive of data on all buildings and critical infrastructure assets across the territory. In addition, the platform will also host a database on past disasters, which will gather the available information on observed losses and damages as well as the costs incurred for post-disaster restoration.

¹² Since 2019, Greece has undertaken further work to assess existing risks and the country’s risk management capacity. These have not yet been published.

One additional challenge to wildfire risk assessment and management in Greece is that the causes of wildfire ignition are not thoroughly assessed. According to recent estimates, the causes of ignition are unknown for more than 57% of the wildfires registered between 1984 and 2009 (GFMC, 2019^[81]) (Figure 4). Compared to other Mediterranean countries, Greece rarely uses forensic analysis to identify the causes of wildfire ignition. In most cases, wildfire ignitions are automatically attributed to arson, though this classification is often revised when *ex post* analysis is conducted (Blandford, 2019^[36]).

Figure 4. The causes of wildfires in Greece between 1984 and 2009



Note: The chart relies on the latest data available, which might not precisely describe the situation as of 2024.
Source: Based on data from (GFMC, 2019^[81]).

3.2 Wildfire risk awareness and communication

Ensuring high levels of awareness among the population is a critical step to reduce the likelihood and negative impacts of extreme wildfires (OECD, 2023^[18]). In order to mainstream wildfire risk information and raise awareness of the good practices to adopt to prevent wildfire risk, the Ministry of Climate Crisis and Civil Protection has engaged in a number of awareness-raising campaigns, including through the use of posters, television ads, and radio spots. The General Secretariat of Civil Protection has also released self-protection guidelines that provide information to citizens on the recommended behaviours that can reduce wildfire risk and impacts in the event of a wildfire (Ministry of Climate Crisis and Civil Protection, 2022^[77]). In parallel, both the General Secretariat of Civil Protection and the Hellenic Fire Brigade have increasingly used social media to inform citizens on the appropriate measures and recommended behaviours to prepare and self-protect from a wildfire. The Ministry of Health also provides the population with guidelines on how to contain the health impacts resulting from wildfires and the resulting smoke (Hellenic National Public Health Organization, n.d.^[78]) (Climate ADAPT, 2022^[50]).

Ongoing EU projects, such as the LIFE-IP AdaptInGR (Box 1), also aim to enhance public awareness of climate risks such as wildfires through the development of an online information hub and other digital climate projection tools. In addition, a growing number of campaigns implemented by local authorities, as well as by the private sector – including insurance providers and non-governmental organisations – has also contributed to raise awareness of wildfire risk in the country (EPPF, 2022^[79]) (HAIC, n.d.^[80]).

Despite these efforts, there remains scope to improve the overall awareness of existing risk levels among citizens. Insufficient levels of risk awareness were identified as a key driver of the high socio-economic

cost of wildfires in the country, as well as a challenge to effective wildfire management. This is further exacerbated by the high number of seasonal residents and tourists that can be found in wildfire-prone areas during the wildfire season, who are often unaware of local wildfire risk levels and who can unknowingly contribute to increase wildfire risk with their behaviours (Ganteaume et al., 2021^[14]) (GFMC, 2019^[8]).

3.3 Physical and organisational prevention measures

Over the past decades, Greece has invested significant attention and resources in strengthening its wildfire suppression capacity. While these efforts have helped improve emergency preparedness and response throughout the national territory, they have not gone hand in hand with increased prevention efforts (Palaiologos et al., 2020^[81]). The imbalance between wildfire suppression and prevention efforts – which was further exacerbated by the breakdown of the Forest Service’s institutional structure in 1999 (see Section 2.2) (Hovardas, 2015^[82]) – has proven particularly problematic in recent years. Indeed, increasingly extreme wildfires in many countries have strained emergency response resources and limited their ability to contain impacts in the context of a changing climate (OECD, 2023^[18]). In Greece, this was most evident during the 2018 extreme fire season, when the outbreak of several simultaneous wildfires challenged the effective deployment of firefighting resources.

In the aftermath of the 2018 and 2021 extreme wildfires, such low levels of investment in wildfire prevention were identified as a key shortcoming of wildfire policy in Greece (GFMC, 2019^[8]). As a result, in recent years, Greece has started to step up its wildfire prevention efforts, with a view to building the resilience of communities and ecosystems to growing wildfire risk (Hellenic Republic, 2021^[12]). Thus, whereas today responsive measures still benefit from more institutional attention and funding than does prevention, a growing number of risk reduction measures has been introduced. These include new practices in fuel and ecosystem management as well as organisational measures such as land-use and building regulations.

3.3.1 Fuel and ecosystem management for wildfire prevention

Fuel and forest management are key to tackling wildfire risk and impacts, as they allow to reduce the quantity and flammability of vegetation available to burn in the landscape (OECD, 2023^[18]). In Greece, the centrality of fuel management for wildfire prevention is acknowledged in several legal documents, including the 2022 National Climate Law (Hellenic Republic, 2022^[54]), the National Forest Strategy (Ministry of Environment and Energy, 2018^[49]), the National Climate Adaptation Strategy (see Section 2.1), and the 2021 National Risk Assessment (see Section 3.1). The latter highlights the need to avoid excessive fuel accumulation as a top priority in wildfire management, especially in the context of continued rural depopulation in the northern mountainous areas (Hellenic Republic, 2021^[12]).

In wildland forested areas, fuel management is usually undertaken by the Forest Service and its subnational extensions (FIRE-RES, n.d.^[64]) (Morehouse et al., 2011^[3]). Overall, the Forest Service and its subsidiary bodies manage more than 60% of all forested land in Greece (Hellenic Republic, 2021^[12]) (Xanthopoulos, 2008^[33]), including both national and regional forests, on the basis of forest-specific ten-year management plans. Their interventions include fuel management practices such as vegetation thinning, vegetation clearing and fuel breaks,¹³ as well as other structural interventions such as the opening and maintenance of forest roads (Sapountzaki et al., 2011^[35]). At the local level, forest land is managed by the local Forest Service Offices, which are tasked to develop Forest Fire Protection Plans based on specifications set by the Ministry of Environment. The Ministry of Environment also oversees the

¹³ Fuel breaks consist of patches of non-flammable land cover used to reduce fuel continuity (OECD, 2023^[18]).

management plans for grassland areas, which include the possibility to use grazing to reduce fuel accumulation.

While in recent decades resources for wildfire prevention have been limited in Greece, fuel and forest management have recently benefitted from an increase in public funding, most notably through the AntiNero programme (Box 2). In the context of this programme, the use of fuel breaks is also gaining growing prominence in Greece. In addition, a 2023 law has established a new committee, composed by experts from the Ministry of Climate Crisis and Civil Protection and the Ministry of Environment, which is tasked to identify priority areas for wildfire prevention in the wildland-urban interface (Hellenic Republic, 2023^[60]). Going forward, increased investments in sustainable forest management, and particularly in the containment of fuel loads and continuity in forested areas, will be key to reduce the occurrence of extreme wildfires and to strengthen the resilience of forest stands.

Box 2. Strengthening wildfire prevention: the AntiNero programme

In 2022, Greece launched the AntiNero programme with the objective of enhancing forest and fuel management for wildfire risk prevention. The programme, carried out by the Ministry of Environment through its Forest Service and overseen jointly with the Ministry of Climate Crisis and Civil Protection, aims to enhance the management of fuel loads in priority areas identified as particularly wildfire-prone over a total area of 80 000 hectares. The programme, which will run until 2026, is funded through the EU Recovery Fund as well as through national funds (see Section 3.6).

In terms of fuel management, AntiNero entails vegetation removal in areas characterised by excessive fuel accumulation as well as preventive forest cleaning operations, including tree cutting and pruning and vegetation thinning. Under AntiNero, fuel management interventions mostly focus on the surroundings of urban areas (and are mostly concentrated in the risk-prone Attica region) as well as in the areas surrounding key archaeological sites. In the period 2024-2025, AntiNero will also introduce some fuel mosaic areas, i.e. strategic networks of fuel breaks alternating different land covers to reduce landscape flammability. In addition, AntiNero aims at opening or maintaining 12 000 kilometres of forest roads and 1 600 kilometres of buffer zones.

In parallel, the AntiNero programme also aims to advance wildfire prevention planning in Greece through the development of 39 forest fire protection plans. These plans, to be developed by the end of 2024, aim to inform and guide the wildfire risk prevention interventions in 39 forest ecosystems across the country considered particularly prone to wildfire risk.

Source: (Ministry of Environment and Energy, 2022^[83]) (OECD, 2023^[18]).

In recent years, fuel management efforts in Greece have been increasingly complemented by the use of buffer zones. In 2022, buffer zones gained growing attention through a new set of regulations that promote fuel management around human settlements throughout the country. These new regulations require all tenants and landowners to remove excess fuel (e.g. through the thinning of tree crowns and the removal of dry trees and grass, leaf litter, etc.) and any explosive materials from the area surrounding their properties by the start of each wildfire season. In the event of non-compliance, municipalities are entitled to undertake the required measures themselves and can demand the payment of a penalty (Hellenic Republic, 2022^[84]) – although the limited resources available to municipalities for implementation and monitoring often hamper this process. To strengthen the enforcement of existing fuel management requirements on private properties, the Ministry of Climate Crisis and Civil Protection has recently established a register of fuel management obligations applying to private owners, as well as a digital monitoring mechanism that relies on randomized checks to identify non-complying properties and an automatic fining system (Hellenic Republic, 2023^[60]) (Ministry of Internal Affairs, 2023^[85]).

Specific provisions are also in place to ensure fuel management – and in some cases the maintenance of buffer zones – in the surroundings of valuable assets, with responsibilities split between public and private actors. For example, the Ministry of Infrastructure and Transport is responsible for the maintenance of fuels around road networks, while the Hellenic Railways Organisation is responsible to manage vegetation along the country's railway lines (GFMC, 2019_[8]). Infrastructure owners or managers are also mandated to develop buffer zones and manage fuel accumulation around infrastructure assets (Blandford, 2019_[36]). For instance, the Hellenic Electricity Distribution Network Operator (HEDNO) and the Independent Power Transmission Operator (IPTO) are responsible for clearing excess vegetation around specific sites of the electricity distribution network that are deemed to be highly exposed to wildfire risk (GFMC, 2019_[8]). The Ministry of Culture also undertakes regular fuel management in the surroundings of selected archaeological sites. In most cases, such interventions are undertaken in co-ordination with the Forest Service and the national civil protection authorities.

Finally, while the active use of fire is allowed – under certain conditions – to dispose of agricultural residues (Tedim, Leone and Xanthopoulos, 2016_[66]) (Box 3), the use of prescribed fires to preventively reduce fuel accumulation in wildland areas is forbidden in Greece. In some instances, this ban has hampered the effective management of fuels in rural areas. To address this, policy discussions are currently ongoing and some pilot projects (e.g. on the island of Chios) have recently been developed to test the consequences of prescribed burning as a form of wildfire prevention (Athanasiou et al., 2022_[86]). In the meantime, the use of backfires – i.e. the active ignition of controlled fires to contain or control the spread of ongoing wildfires during the fire suppression phase – has recently been allowed in Greece. This represents a key step forward, as backfires represent an effective tool to contain the spread of wildfires.

Despite some advancements in recent years, effective fuel management in Greece is subject to several challenges. Rural land abandonment and the abandonment of traditional activities such as charcoal production and resin harvesting have left behind a large extent of unmanaged lands, facilitating vegetation encroachment and fuel build-up (Palaiologou et al., 2021_[87]). Abandoned or inadequately managed olive grove plantations have also shown to increase fuel accumulation and thus wildfire hazard in some areas (Morehouse et al., 2011_[3]) (Blandford, 2019_[36]) (Athanasiou, 2016_[88]). At the same time, the low value and high fragmentation of rural land in certain regions has limited the economic incentives to actively manage the landscape (Morehouse et al., 2011_[3]). This also hampers the development of a co-ordinated approach to fuel management, favouring the excessive accumulation of fuel. These challenges are only exacerbated by a complex institutional setup, characterised by a sometimes unclear distribution of roles and responsibilities for fuel management and limited co-ordination among sectors, agencies, and public and private stakeholders (Palaiologou et al., 2018_[48]) (Palaiologos et al., 2020_[81]) (see Section 2.2). Finally, the enforcement of existing forest law is also quite low in Greece, not least due to the longstanding lack of financial and human resources available for the Forest Service (see Section 3.6).

Box 3. Agricultural burning

Rural populations have long used fire to clear lands of weeds and agricultural waste. Besides serving agricultural purposes, these practices can help control fuel loads in agricultural areas, thus contributing to reduce extreme wildfire risk. However, if not managed correctly, agricultural fires can turn into wildfires (OECD, 2023^[18]). This has been common in northern Greece, where stubble burning and shepherd-lit fires (e.g. for pasture clearing) are common in the early autumn, when wildfire hazard is still relatively high. Overall, in Greece, wildfire ignitions caused by the burning of crop residues and pastures represent a high share of all ignitions for which the cause is known.

Recent regulatory reforms have helped to overcome this challenge. In recent years, Greek legislation has established rules and requirements to regulate agricultural burning, with a view to reducing wildfire risk in rural areas (Hellenic Republic, 2021^[12]). In case of non-compliance, the Ministry of Rural Development and Food can set out sanctions (GFMC, 2019^[8]). In addition, as a result of a data exchange reform, the EU subsidies database now automatically classifies burned forest areas as “under reforestation” for up to ten years after a wildfire, thus removing burned land from the land area available for grazing. Since EU subsidies to shepherds are proportionate to their lands’ carrying capacity, shepherds get less money if their land has been burned. This system disincentivizes shepherds from starting illegal fires and indeed, since its introduction, the number of wildfires associated with shepherd activity seems to have declined (Tedim, Leone and Xanthopoulos, 2016^[66]).

Source: (OECD, 2023^[18]) (Tedim, Leone and Xanthopoulos, 2016^[66]) (Hellenic Republic, 2021^[12]) (GFMC, 2019^[8]) (Karali et al., 2014^[4]) (Palaiologou et al., 2021^[87]).

3.3.2 Land-use planning and building regulations for wildfire prevention

Land-use regulations

Land-use planning and building regulations play a critical role in wildfire risk prevention, as they can directly affect the exposure and vulnerability of people and assets to wildfire risk (OECD, 2023^[18]). In Greece, urban development is forbidden in all those areas designated as “forests” or “forest areas”, as these are characterised by a special protected status that arises from the Greek constitution and the national forest law. This classification has significant implications on land-use rights. Indeed, once a land parcel is labelled as forested area, it is excluded from development rights, with only some exceptions based on documented public interest (Sapountzaki et al., 2011^[35]).

Nonetheless, the enforcement of forest regulations and development bans in rural areas has faced major challenges in recent decades, not least due to eroded capacity of the Forest Service and the absence of a completed national land cadastre and forest registry, which has hampered the identification of which areas should be preserved from development (Sapountzaki et al., 2011^[35]). This, combined with weak or inconsistent land-use regulations and spatial planning policies, has in some cases favoured the development of informal housing and the use of arson, with significant consequences on wildfire risk levels (Triantis, 2022^[15]) (GFMC, 2019^[8]) (Salvati and Ranalli, 2015^[1]). Informal development in WUI areas expanded substantially in the second half of the twentieth century, with an average of 31 000 informal buildings (i.e. one quarter of the total development occurred in the country) built illegally every year between 1991 and 2001. This phenomenon has been particularly acute in the Attica region, as well as in other areas subject to residential and tourism development pressures, such as WUI areas along the coast, where the value of land is particularly high (Triantis, 2022^[15]) (Blandford, 2019^[36]) (Sapountzaki et al.,

2011^[35]). Informal buildings and settlements tend to increase wildfire risk due to their non-compliance with the safety standards established by land zoning and building regulations (OECD, 2023^[18]). For example, the use of flammable building materials and the lack of escape routes were identified as two key causes of the high death toll of the Mati wildfire (Ganteaume et al., 2021^[14]) (Blandford, 2019^[36]) (Box 4). However, in spite of the observed negative impacts, in some cases informal buildings are granted development rights retrospectively after they have been built.

In recent years, Greece has undertaken significant efforts to address these challenges. Since 2021, the development and publication of forest maps for the entire national territory has facilitated the implementation of existing forest protection and environmental regulations. These maps – which have been developed for more than 95% of the country's territory, determine the areas in which forest legislation applies. This, combined with the strict legal restrictions and high fines aimed at protecting burned forest areas, has reduced incentives for arson. Arsonism, i.e. the act of igniting a wildfire – is punished by national criminal legislation. Investigations are usually undertaken by the Hellenic Fire Brigade, in some cases with the support of the Hellenic Police and subnational authorities. In addition, Greece is also currently working on the development of a national land cadastre, which will be pivotal to facilitate the implementation and enforcement of land-use regulations as well as of fuel management and other relevant requirements. In some cases, new regulatory plans have also been introduced (e.g. in Attica) to promote more compact urban development, with a view to containing sprawling development in the wildland-urban interface (Triantis, 2022^[15]).

Box 4. Unplanned development and wildfire risk: The Mati wildfire

The extreme wildfires that affected the Attica region in 2018 offer a clear example of the gaps underlying land-use and spatial planning regulations in Greece. Over the second half of the twentieth century, the Attica region experienced intense urban development. The absence of urban plans in many settlements and the lack of risk-based land zoning, combined with the local topography and the growing development of informal buildings, gave ground to unplanned and sprawling development in the WUI (Triantis, 2022^[15]). Such development patterns proved particularly problematic during the 2018 Mati wildfire. Indeed, a large share of the buildings burned in Mati were found to have no building permits (Blandford, 2019^[36]) or to be constructed using below-standard building materials (Hellenic Republic, 2021^[12]). At the same time, the narrow streets (often characterised by dead-ends) that characterised the area facilitated the spread of wildfires and reduced the access to escape routes (Triantis, 2022^[15]), while also hampering evacuation and emergency response efforts (Komac, 2020^[43]). As a result, several people died in traffic jams trying to escape (Ganteaume et al., 2021^[14]), while others were forced to flee towards the seashore, where they got trapped by the flames.

The importance of spatial planning and building standards can be best appreciated when comparing the impacts of the extreme 2018 wildfire in Mati with those experienced in the neighbouring village Neos Voutzas. While both settlements were affected by the wildfire and located in highly flammable Aleppo pine forests, Neos Voutzas benefitted from a planned urban structure and from being built out of mostly high-quality building materials. As a result, only a few houses collapsed and most properties were only partially damaged in Neos Voutzas, while in Mati 80% of constructions were completely destroyed (Hellenic Republic, 2021^[12]).

Source: (Triantis, 2022^[15]) (Blandford, 2019^[36]) (Hellenic Republic, 2021^[12]) (Komac, 2020^[43]) (Ganteaume et al., 2021^[14]).

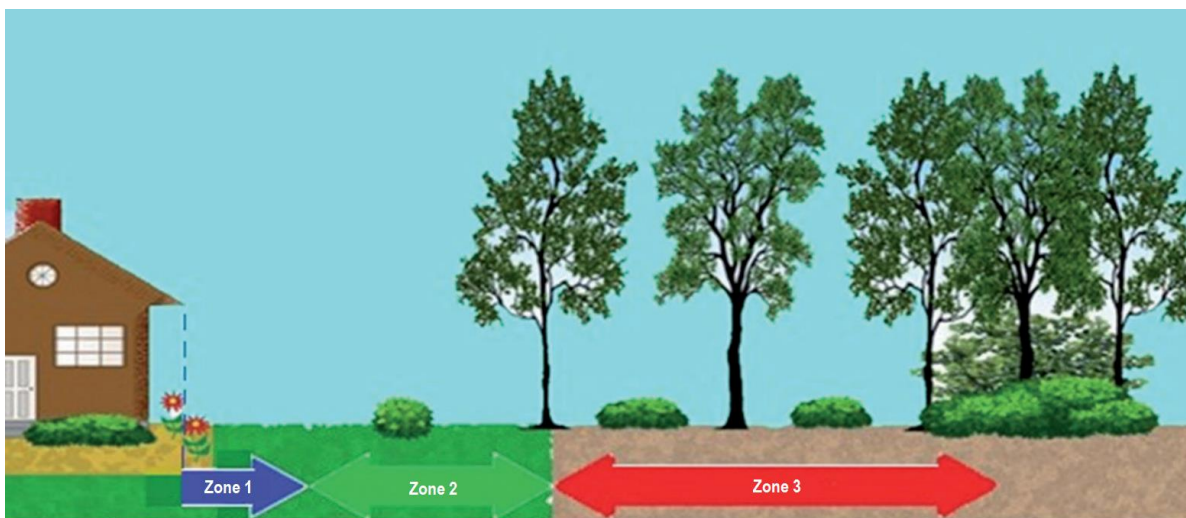
Building code regulations

In Greece, various requirements, building codes, and guidelines are in place to regulate the construction and retrofitting of housing and other built assets. In recent years, new building regulations addressing both new and existing assets have been released with the objective of containing fire spread within and across buildings and reducing wildfire impacts. These regulations, which are mandatory for properties located in or within 300 meters from forested areas, woodlands and grasslands as well as for properties located in urban and suburban green areas, define the minimum standards and requirements to enhance property safety in the event of a wildfire (Government of Greece, 2016^[89]) (Hellenic Republic, 1979^[90]).

Most notably, existing regulations mandate structural protection measures to be considered in building design and management. These include, for example, requirements on the use of non-flammable materials, including fire-resistant roofs and fences, as well as the use of construction elements that can protect escape routes and help avoid structural collapse in the case of a fire (Hellenic Republic, 2020^[91]) (Government of Greece, 2018^[92]). In addition, existing regulations also establish minimum safety requirements for the area immediately surrounding the building. Among others, these include the obligation to regularly clear yards, roofs and gutters from waste and vegetation residues as well as the requirement for access roads and evacuation routes to be sufficiently wide and free of obstacles or flammable materials. Existing regulations also establish a mandatory three-tier fire protection zone around houses, which regulates the use of different types of vegetation around properties (Figure 5) and prohibits the storage of flammable materials (such as furniture, firewood, etc.) in the vicinity of the property. In addition, these new regulations also provide recommendations on water supply and the installation of sprinkler systems around key assets to enhance risk reduction and facilitate emergency response. Compliance with these requirements is necessary for receiving building permits for new constructions, while for existing properties compliance is usually investigated by local civil protection offices (Hellenic Republic, 2019^[93]).

The infrastructure sector is also subject to some specific requirements to reduce wildfire risk, with measures such as tree pruning and vegetation management in the immediate surroundings of infrastructure assets being mandated by law. In most cases, however, prevention measures are adopted on a voluntary basis by infrastructure managers and operators. These include the mainstreaming of prevention in asset and network design, as well as regular maintenance interventions. Policy discussions on climate-proofing private assets and infrastructure in areas exposed to climate risks such as wildfires and floods are currently ongoing.

Figure 5. Three-tier buffer zone requirements around residential properties



Source: Adapted from (Hellenic Republic, 2019^[93]).

3.4 Emergency preparedness

Effective emergency preparedness measures can significantly reduce the human cost of wildfires, while also helping to contain asset damages and broader economic losses (OECD, 2023^[18]). In Greece, the Ministry of Climate Crisis and Civil Protection is the main body responsible for emergency preparedness. The ministry provides advisory services to agencies and public bodies at all levels of government, with a view to enhancing preparedness and strengthening resilience to disasters. This includes the provision and timely update of relevant information and warnings, the development of guidelines, and the organisation of civil protection exercises and emergency drills to train staff and assess the operational readiness of emergency response services. The National Co-ordination Centre for Operations and Crisis Management (ESKEDIK) is also critical in the management of wildfire emergencies, as it offers a valuable platform to gather all key stakeholders active in emergency preparedness and response at different levels of government (e.g. civil protection authorities, the Fire Service, the Armed Forces, the Hellenic Police, the Hellenic Coast Guard and the relevant health authorities) and facilitate their co-ordination and collaboration in operational matters. Since the establishment of the Ministry of Climate Crisis and Civil Protection in 2021, a series of regulatory reforms has also allowed to strengthen the capacity and effectiveness of civil protection authorities throughout the country.

During the wildfire season (i.e. from 1 May to 31 October every year), the General Secretariat for Civil Protection issues a daily fire danger map, which is published online and shared with the key public and private stakeholders involved in wildfire management (Ministry of Climate Crisis and Civil Protection, 2022^[94]) (Sapountzaki et al., 2011^[35]). The map – which builds on the Canadian Forest Fire Weather Index (FFWI) and on local wildfire history data – is updated daily using meteorological data combined with information on fuel conditions. The fire danger map is a critical tool used to inform the definition of alert levels, resource relocation, and wildfire management operations. For example, based on the danger level identified via the daily danger map, public authorities can issue warnings to the population, increase surveillance activities, and temporarily ban the access to forests and wildland areas. This information is also used by the Hellenic Fire Brigade for their daily operational planning. Since 2019, the enhanced co-operation between the Forest Service and the Hellenic Fire Brigade (see Section 2.2) has also enhanced the information base for emergency preparedness and response decisions.

The monitoring and forecasting of fire weather, as well as the monitoring of fuel moisture levels, are carried out on a daily basis by the National Meteorological Service. In addition, complementary information is also provided by various scientific initiatives developed by the National Observatory of Athens, including the DISARM service, the IRIS platform, and the ZEUS live lightning monitoring system. While these tools can help monitor, simulate, and forecast fire weather conditions (e.g. temperature, wind, relative humidity, lightnings, rainfall, etc.) (National Observatory of Athens, n.d.^[95]) (National Observatory of Athens, n.d.^[96]), only few of these are operational and officially adopted to inform policy and operations. The National Observatory of Athens also operates the SEVIRI fire monitoring system, which provides real-time satellite information on wildfire activity and burned area. Yet, to date, the monitoring of the outbreak and spread of wildfires in Greece primarily relies on patrolling activities on the ground, mostly operated by the Hellenic Fire Brigade, as well as by NECCA in protected areas. On-the-ground patrolling is usually complemented by air and drone surveillance, also operated by the Hellenic Fire Brigade and NECCA. To strengthen its patrolling capacity, Greece currently plans to increase the number of aerial vehicles and drones available for wildfire monitoring.

Regions and municipalities are required by law to develop special plans for the preventive evacuation¹⁴ of citizens (Hellenic Republic, 2020^[59]).¹⁵ The General Secretariat of Civil Protection has released dedicated guidelines to inform and support the preparation and implementation of municipal and regional evacuation plans. In the event of a wildfire, evacuation operations are managed by municipalities, under the responsibility of local mayors, who can count on the support of the Hellenic Fire Brigade, municipal and regional civil protection offices, and local police authorities. The Ministry of Climate Crisis and Civil Protection recommends that municipalities organise at least one emergency drill every year before the start of the wildfire season, though these exercises are not mandatory. Other emergency drills are usually organized by subnational civil protection offices.

In order to alert the population in a timely manner, the General Secretariat of Civil Protection has developed the emergency line “112”, which alerts people located in high-risk areas in the event of a wildfire. This system provides information on the potential or required evacuation of the area, as well as on recommended behaviours to reduce wildfire risk before and during a wildfire (e.g. closing windows and chimneys to avoid sparks and embers) (National and Kapodistrian University of Athens, 2021^[40]). This information is shared in Greek and English through a cell broadcast system. Citizens without smartphones can register for receiving alerts via text messages, emails, or voice messages. While in the past existing warning system mechanisms have not always managed to achieve the set objectives (Xanthopoulos and Athanasiou, 2019^[97]), their effectiveness has significantly improved in the last few years (Hellenic Republic, 2023^[60]). During the extreme wildfire that affected the island of Rhodes on 22 and 23 July 2023, the “112” emergency service effectively supported the organisation of the preventive evacuation in the area threatened by the wildfire. According to the Hellenic Police’s estimates, such precautionary evacuation involved approximately 19 000 people, becoming the largest operation of this kind ever carried out in Greece (Hellenic Fire Brigade, 2023^[98]).

3.5 Post-fire recovery and rehabilitation

The policy and management decisions taken in the aftermath of a wildfire can have significant impacts on future wildfire hazard, as well as on the exposure and vulnerability of communities and assets to future wildfire events (OECD, 2023^[18]). In Greece, post-fire recovery, rehabilitation and reconstruction are mostly addressed by the Ministry of Environment and Energy (through the Forest Service), the Ministry of Climate Crisis and Civil Protection, and the Ministry of Infrastructure, with the support of other relevant national and subnational authorities. Official data on burned areas are usually gathered by the Forest Service and complemented by data from NECCA and the National Observatory of Athens. In the occurrence of extreme wildfires, the General Secretariat for Civil Protection can also activate the Copernicus Emergency Management Service, which maps and provides complementary information on burned areas to all the relevant authorities.

In terms of ecosystem management in the aftermath of a wildfire, post-fire interventions in Greece focus both on emergency stabilisation and longer-term ecosystem restoration. In the immediate aftermath of each wildfire, land stabilisation measures are usually implemented to reduce or contain the occurrence of post-fire hazards such as flooding or land erosion. Land erosion control represents a key priority area, as set out in the National Climate Adaptation Strategy. Longer-term recovery efforts mostly focus on the restoration and rehabilitation of the wildland ecosystems affected by fire (Ministry of Environment and Energy, 2018^[49]). These interventions often consist in reforesting burned areas and recovering natural

¹⁴ The Greek legal framework refers to the preventive and temporary evacuation of citizens in the occurrence of a wildfire as “organised relocation”.

¹⁵ This requirement applies to all municipalities, except for large cities whose urban territory is directly surrounded by the urban territory of other municipalities.

biophysical processes at landscape level. Both emergency stabilisation and ecosystem restoration interventions are managed and co-ordinated by the Forest Service, with the support of NECCA and, when relevant, of the Fire Brigade's Special Forestry Operations Units.

The overall principles for post-fire reforestation are laid out in the National Reforestation Plan and in the National Biodiversity Strategy. For example, the National Reforestation Plan sets out specific interventions – such as the monitoring of soil layer recovery in severely burned areas – to be undertaken in the aftermath of a wildfire. These interventions are usually carried out under the supervision of the Forest Service, on the basis of area-specific reforestation studies. In parallel, the National Biodiversity Strategy differentiates between forest types where active reforestation is required or encouraged and forest types that have high potential for natural regeneration and thus do not need proactive interventions (Ministry of Environment and Energy, 2014^[51]). This distinction can be problematic in the context of climate change, as more frequent and extreme wildfires – combined with human activities that heavily alter the landscape, such as illegal land-use and overgrazing – can hamper the ability of ecosystems to recover after a wildfire. This challenge is well illustrated by the case of east Attica, where the extent of proactive reforestation has been low (with only 10% of the area burned between 1991 and 2004 being actively reforested) and natural forest regeneration has not picked up as expected (Sapountzaki et al., 2011^[35]).

In the aftermath of the 2021 Evia wildfire, Greece has also established the Greek Biodiversity Recovery Hub, with the goal of containing the negative impacts of extreme wildfires on biodiversity and ecosystems (National and Kapodistrian University of Athens, 2021^[40]). Most notably, the hub establishes a framework to support the recovery of affected biodiversity and ecosystems in burned areas, through expert support, improved impact monitoring, and cross-agency co-ordination (Biodiversity Recovery Hub, 2022^[26]). The hub is funded through EU funds and managed by the Aristotle University of Thessaloniki, with the support of the Ministry of Environment and Energy, the Ministry of Climate Crisis and Civil Protection, NECCA, and other key stakeholders.

The reconstruction of affected settlements and assets after a wildfire is managed by the Ministry of Climate Crisis and Civil Protection's Secretariat for Natural Disaster Recovery and State Support, which manages the reconstruction or restoration of buildings, as well as the compensation system for households and businesses (Government of Greece, 2023^[99]). The Ministry of Environment also plays a key role in this phase, as its Secretary General of Spatial Planning and Urban Environment is in charge of spatial and land-use planning decisions. In parallel, the Ministry of Infrastructure and Transport co-ordinates the recovery – and when necessary, the rebuilding – of infrastructure assets and networks. In some cases, private stakeholders, such as infrastructure owners and managers, also play a role in post-fire reconstruction, as well as in debris management and land erosion control.

While post-fire recovery plans formally recognise the importance of enhancing resilience through post-fire interventions, in some cases implemented measures have been found to maintain or even increase wildfire risk levels. This trend is most marked in WUI areas, where pressures to preserve informal settlements remain. For example, the Special Urban Plan developed to guide recovery efforts after the 2018 extreme wildfires in Attica revoked the legal status of “forested area” from some of the burned areas (most notably in the municipalities of Mati and Kokkino Limanaki), formally recognising them as agricultural lands and thus legitimising new and previously existing development (Triantis, 2022^[15]) (see Section 3.3). These decisions are often influenced by local pressure groups, such as associations representing developers and local property owners.

3.6. Financing wildfire risk reduction

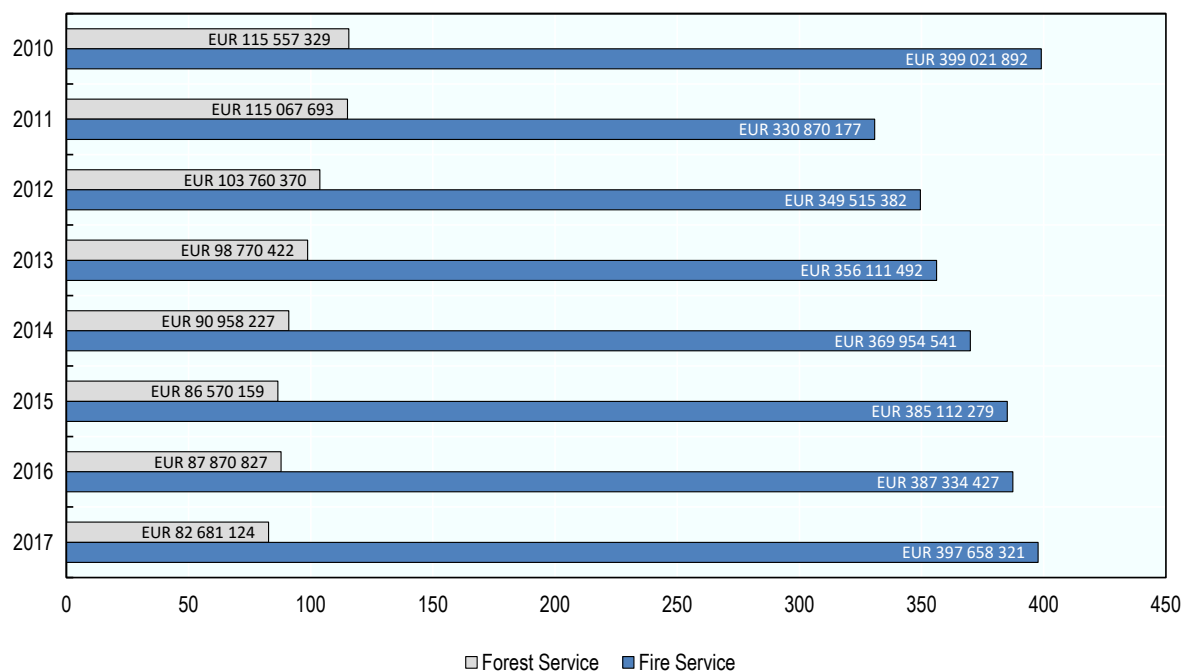
Public funding for managing wildfires in Greece is provided by the central government and is reflected in the budget allocated to the relevant ministries. For example, the Ministry of Environment, through its Green Fund, allocates revenues from environmental taxes and fines to support various activities in wildfire research, prevention, awareness-raising and post-fire recovery, including support for fuel and forest management (Climate ADAPT, 2022^[50]). Funding for the implementation of fuel management and wildfire prevention at the municipal level is provided by the Ministry of the Interior. Funds raised through public investments, such as those managed by the Hellenic Asset Development Fund, also contribute to wildfire prevention efforts, e.g. by supporting the creation of forest fire protection plans.

These resources are usually complemented by European funds. For example, EU funds have been critical in supporting Greece's Rural Development Programme, which entailed significant wildfire prevention and forest restoration interventions undertaken by the Forest Service Offices between 2007 and 2020. These interventions included, among others, fuel management, reforestation, and the creation of buffer zones. Overall, funding for wildfire prevention interventions under Greece's Rural Development Programme grew from EUR 15.4 million in the 2007-2013 period to EUR 19.3 million in the 2014-2020 period (Louka, Arabatzis and Kantartzis, 2022^[100]). In recent years, funds from the EU Rural Development Programme (RDP) have supported the enhancement of forest roads and fuel breaks as well as the renewal of wildfire monitoring and detection equipment, while the EU Recovery and Resilience Facility has significantly contributed to the implementation of the AntiNero programme (Box 2). In addition, several EU projects, such as those discussed in Box 1, have also contributed to strengthening wildfire management and prevention in Greece. In some cases, the private sector also provides additional funding in the form of voluntary contributions. However, there remains scope to increase the private sector's investments in wildfire prevention and management.

Following the institutional transformation of 1999 (see Section 2.2) and until recent years, public investments for wildfire management have increasingly focused on wildfire suppression at the detriment of prevention, with funding for the Hellenic Fire Brigade increasing and resources for the Forest Service steadily shrinking (Figure 6) (Morehouse et al., 2011^[3]) (GFMC, 2019^[8]). Overall, funding for wildfire suppression more than doubled between 1998 and 2008 (Xanthopoulos, 2008^[33]) (Fernandez-Anez et al., 2021^[31]), while funding for the Forest Service shrank by nearly 30% between 2010 and 2017. As a result, in 2017, funds allocated to the Forest Service amounted to one-fifth of those allocated to the Hellenic Fire Brigade (GFMC, 2019^[101]) (Figure 6). Municipalities and other public agencies involved in wildfire prevention have also faced similar challenges.

Figure 6. Public funding provided for the Hellenic Fire Brigade and the Forest Service, 2010-2017

Million EUR



Source: Based on data from (GFMC, 2019_[101]).

To address this imbalance, the Greek government has recently allocated more funding for wildfire prevention. Most notably, EUR 50 million of the EU Recovery and Resilience Facility have been allocated to the implementation of the AntiNero programme (Box 2). This was further complemented by EUR 22 million from the regular budget (Ministry of Environment and Energy, 2022_[83]). Despite these improvements, further efforts are needed to secure sufficient and stable financial support for wildfire prevention, as well as to ensure the effectiveness of existing resources, which are often under-utilized due to delays and bureaucratic bottlenecks. Indeed, lengthy and complex bureaucratic procedures have sometimes hampered the ability of public authorities to access or use the resources allocated to them by European and national funds. The allocation of stable resources to the public authorities in charge of wildfire prevention is also critical in order to allow the hiring and training of permanent human resources as well as to enable long-term strategic planning for prevention.

At the national level, funding is also available for post-disaster reconstruction as well as to provide financial assistance and compensations for the losses and damages suffered by the population. After a natural disaster such as an extreme wildfire, the national government usually identifies the affected area, quantifies the damages, and determines the extent to which (if at all) it will compensate the losses suffered by households, farmers, and businesses. Since 2023, as per Presidential Decree 77/2023, the compensation process is managed by the Ministry of Climate Crisis and Civil Protection. Despite various reforms in this area, the lengthiness of bureaucratic procedures has often hampered the effectiveness of this system, as it can take years for compensations to reach the affected citizens. In addition, the Ministry of the Interior provides financial support to municipalities for infrastructure reconstruction after disasters (World Bank, 2021_[102]). For example, after the Mati and Evia extreme wildfires, the Greek government provided compensation and emergency relief allowances to support the recovery and reconstruction of the affected buildings, businesses, and agricultural holdings (Climate ADAPT, 2022_[50]). After the Evia wildfire, green

bonds were also issued as an additional recovery measure (National and Kapodistrian University of Athens, 2021^[40]). National funds for disaster recovery are usually complemented by those made available by the EU Solidarity Fund (EUSF) (Climate ADAPT, 2022^[50]) (World Bank, 2021^[102]). Between 2002 and 2017, Greece received EUR 118 million from the EU Solidarity Fund to deal with wildfires, floods, and earthquakes (European Commission, 2019^[103]).

Finally, insurance represents an important financial tool to sustainably manage the costs associated with extreme wildfire risk in Greece (OECD, 2023^[18]). In light of growing wildfire risk, wildfires have been included as part of basic insurance packages for private property. Despite this significant change and the availability of generally affordable insurance premiums, property insurance coverage remains rather low throughout the country, with fewer than 15% of dwellings and about 230 000 commercial properties covered by insurance against wildfire risk (World Bank, 2021^[102]). This is likely due to the low awareness of existing wildfire risk combined with the availability of state compensation, which hinder the uptake of insurance coverage by property owners. Public infrastructure in Greece is also often not insured. Altogether, the insurance gap in Greece remains rather large, with only 9% of all wildfire losses in the country covered by insurance between 1990 and 2019 (OECD, 2021^[104]).

To address these challenges and close the insurance gap, policy discussions to reform insurance policy are ongoing, including on making insurance coverage for wildfire risk mandatory and on the promotion of insurance uptake via tax incentives. In some cases, private banks require wildfire insurance subscription as a condition for mortgages, which has helped to improve the coverage for new houses and businesses. In recent years, insurance coverage for wildfire risk has also become mandatory for private businesses in the agriculture sector (World Bank, 2021^[102]).

4 Conclusions

Wildfire risk is a major and growing challenge in Greece due to a combination of factors including the local climate, land cover and land management practices. Increasingly extreme wildfires in recent years have set new records in terms of area burned, the number of people affected, and the difficulties faced during wildfire suppression operations. Following the particularly severe blazes of 2018, 2021 and 2023, Greece has undertaken several efforts to strengthen wildfire management at all levels, dedicating increased attention to wildfire prevention efforts and climate change adaptation.

As a key step to enhance wildfire management, Greece has implemented a set of institutional reforms aimed at improving the country's enabling environment for wildfire management. Local and regional actors have gained a prominent role in wildfire management, while improvements in the co-ordination between the Forest Service and the Hellenic Fire Brigade and the establishment of the Ministry of Climate Crisis and Civil Protection have opened new channels for cross-agency co-operation and knowledge exchange, partially addressing the challenges posed by an otherwise rather fragmented institutional framework.

In recent years, Greece has also taken some important steps forward in mainstreaming wildfire prevention and climate change adaptation across sectoral policies and strategies. Several policy documents, including the National Adaptation Strategy, the National Biodiversity Strategy, and the National Forest Strategy, recognise the links between climate change and growing wildfire risk and highlight the pivotal role of preventive measures in containing wildfire risk and impacts throughout the territory. By promoting the systematic management of forest ecosystems, identifying priority areas for wildfire prevention and encouraging the development of forest maps, the National Forest Strategy is the central document currently guiding Greece's wildfire prevention efforts. A number of ongoing EU initiatives have also promoted an integrated approach to wildfire management. Yet, the lack of an overarching wildfire management strategy remains a major policy gap at the national level.

Wildfire management practices in Greece have also improved in the last few years. Achievements in wildfire risk assessment include the production of wildfire hazard projection and mapping efforts at the national and subnational level under different emission scenarios, as well as the in-depth assessment of exposure and vulnerability in selected areas. Greece has also taken some steps forward in improving public awareness of wildfire risk through the launch of various awareness-raising campaigns and guidelines. The LIFE AdaptinGR project promises to play a significant role in both wildfire risk assessment and awareness-raising going forward.

Whereas the mandate and capacity of wildfire prevention agencies – and most notably of the Forest Service – have increasingly eroded over the past three decades, wildfire prevention has gained some renewed attention in recent years. Key cornerstones include updated land-use regulations and building standards, as well as new requirements on fuel and ecosystem management. The AntiNero programme – which promotes the management of fuel loads, the creation of buffer zones and the development of wildfire protection plans for critical ecosystems – is a key initiative in this direction. New measures and protocols for wildfire monitoring, forecasting and early warning, as well as improved practices in the ecological recovery and rehabilitation of ecosystems in the aftermath of a wildfire, have also contributed to improving the fitness of Greece's wildfire management framework.

Overall, the extreme wildfires experienced in recent years have showed that emergency response measures alone are not sufficient to manage growing wildfire risk in the context of climate change. Yet,

while adaptation to growing wildfire risk has gained increased momentum in Greece, further steps are needed to strengthen, further co-ordinate, and complement the policies and measures already in place. Going forward, efforts could be directed towards strengthening wildfire risk prevention, assessment, and awareness-raising efforts and developing an enabling environment for effective wildfire prevention.

In terms of risk prevention, fuel and forest management policies and practices could be strengthened to reduce landscape flammability and increase forest resilience. Actions that could help in this direction include lifting the ban on the use of prescribed fires under regulated and monitored conditions, promoting the sustainable management of forest stands, and developing strategic fuel break networks (including through the strategic use of agricultural land) to build resilience at landscape level. Such actions, coupled with enhanced collaboration among stakeholders, could help reduce fuel loads and continuity and thus limit the spread and severity of wildfires. Promoting the active management of private lands also remains a priority. Initiatives that provide economic incentives to active land management and insurance uptake remain a central priority to address land ownership issues and encourage private investment in wildfire risk reduction. Mainstreaming climate adaptation throughout land-use and fuel management policies and practices would also contribute to contain the occurrence of extreme wildfires. Efforts to fight land abandonment could be strengthened through the development of comprehensive and collaborative strategies for rural development, which would help to increase the value and attractiveness of rural lands, thus addressing some structural issues that currently hamper effective wildfire risk reduction. Strengthening the monitoring and enforcement of existing land-use and zoning regulations would also be important, with a view to halting the development of informal buildings and containing unplanned or sprawling development in the wildland-urban interface. The finalisation of the national land cadastre and of the country's forest maps and the introduction of stricter rules on land development and environmental protection are key priority actions in this direction.

In terms of risk assessment, strengthening and accelerating current efforts on mapping fuel load and type for all wildland areas, updating the national wildfire hazard map, and developing high-resolution risk maps that account for changing hazard, exposure and vulnerability levels would be pivotal to better inform wildfire management decisions before, during and after a wildfire. The development of a detailed national risk assessment as well as of local risk assessments would also be pivotal to inform and prioritize prevention, preparedness, and response efforts throughout the territory. Existing efforts on raising risk awareness in rural areas could further be expanded through the development of targeted communication campaigns and the introduction of mandatory education programmes in schools.

Finally, from an enabling environment perspective, there is scope to further enhance co-ordination, collaboration, knowledge exchange and policy coherence across sectors and levels of government. To achieve this, the development of an overarching wildfire management strategy seems a critical cornerstone to define the country's policy objectives and targets and align wildfire policy and management across the territory. Developing a clear process chain defining institutional responsibilities and collaboration procedures to manage wildfires throughout the whole wildfire management cycle (including the prevention phase) would also be critical. Finally, the definition of a stronger and stable mandate for key wildfire prevention agencies and the allocation sufficient technical and financial resources for forest offices and local governments would also facilitate the implementation of wildfire prevention and preparedness measures across the national territory and increase the effectiveness of existing funding. In the context of growing extreme wildfires, closing the gap between wildfire suppression and prevention funding and securing appropriate and stable funding for preventive measures is critical to reduce the financial burden posed by wildfires and enhance Greece's resilience to extreme wildfires in the context of climate change.

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Taming wildfires in the context of climate change: The case of Greece

The frequency and severity of extreme wildfires are on the rise in Greece, causing unprecedented disruption and increasingly challenging the country's capacity to contain losses and damages. These challenges are set to keep growing in the context of climate change, highlighting the need to scale up wildfire prevention and climate change adaptation. This paper provides an overview of Greece's wildfire policies and practices and assesses the extent to which wildfire management in the country is evolving to adapt to growing wildfire risk under climate change.

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