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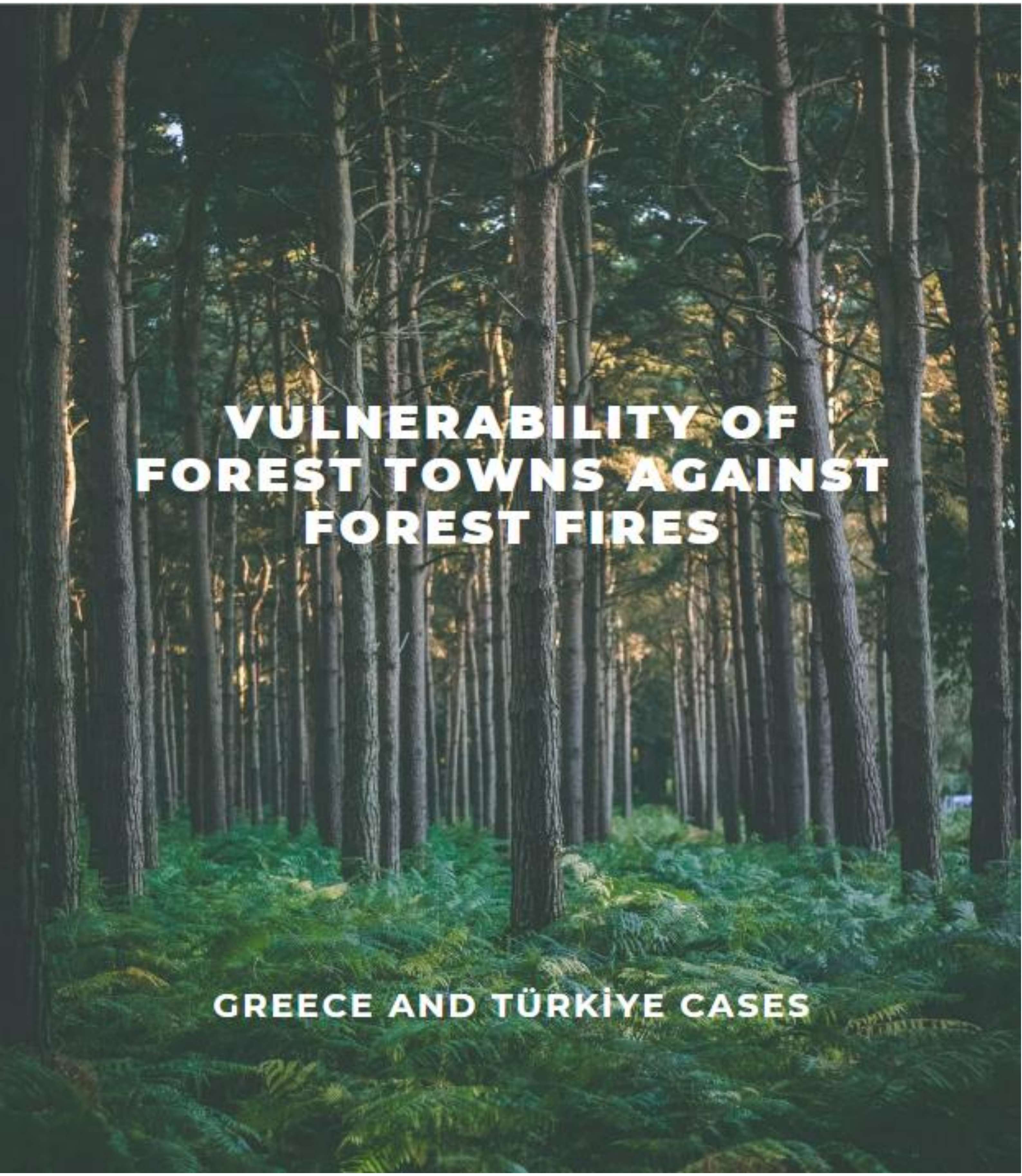

VULNERABILITY OF FOREST TOWNS AGAINST FOREST FIRES

GREECE AND TÜRKİYE CASES

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Introduction

Forest towns are settlements that attract attention with their natural beauty, biodiversity and ecological values. These towns are of great importance in terms of both protecting natural life and providing sustainable living spaces for people. Forests are one of the most valuable natural assets of countries due to their critical roles such as protection of climate and biodiversity, carbon storage functions, erosion and flood protection. Forest fires are events that destroy these unique assets and cause major ecological disasters.

Global climate change is exacerbating this vulnerability by causing forest fires to become more frequent and severe. Especially in the last century, greenhouse gases caused by activities such as industry, agriculture, animal husbandry and transport have been one of the main causes of climate change. Global warming leads to a rise in average temperatures and an increase in extreme weather events, increasing the frequency and rate of spread of forest fires.

Turkey and Greece are located in the Mediterranean climate zone, characterised by high temperatures and low humidity in summer. These conditions increase the risk of forest fires and the speed of their spread. In 2021, approximately 150,000 hectares of forested areas were affected by fires in Turkey, and similarly, large areas were burned in Greece, causing ecological and economic losses.

Human activities have an important place among the causes of forest fires. It has been determined that 90 per cent of forest fires in Turkey are human-caused. These fires are usually caused by negligence, accidents and deliberately. Similarly in Greece, a large proportion of forest fires are human-caused, and the economic crisis and budgetary constraints have led to a lack of firefighting equipment.

The ecological impacts of forest fires are not limited to the burnt areas. Fires cause serious damage to forest ecosystems, reduce biodiversity and increase soil erosion. In addition, forest fires reduce air quality, negatively affect human health and hinder tourism activities. For example, large fires in Turkey and Greece in 2021 severely affected both the lives of local people and the economy of the region. Fires in touristic areas have led to the loss of both natural beauty and tourism revenues.

The socio-economic impacts of forest fires are also extensive. Fires threaten the lives of people living in forested areas, destroy agricultural land and damage local economies. In addition, air pollution caused by fires increases respiratory diseases and adversely affects general public health. Rehabilitation works carried out after forest fires require large costs and may take many years.

The development of early warning systems and the effective use of technology in fire management are critical in the fight against fires. The use of advanced technologies such as unmanned aerial vehicles (UAVs) and satellite imaging systems enables early detection and rapid response to fires. In addition, the creation of fire risk maps and regular updating of fire management plans enable the development of effective strategies in the fight against forest fires.

Social awareness raising and education programmes also play an important role in combating forest fires. Local people should be made aware of fire risks and informed about the precautions to be taken before, during and after a fire. In this context, training programmes and awareness campaigns organised by local administrations and non-governmental organisations are important steps towards reducing the risk of fire.

This report has been specifically designed to support the project "Enhancing the Resilience of Local Authorities for Forest Protection and Forest Fires" involving the municipalities of Pozanti and Karaisali in Turkey and Rafina and Pikermi in Greece. It aims to investigate the vulnerability factors of forest towns in Turkey and Greece to fires and ways to cope with these factors. As these regions face the increasing threat of forest fires, the analyses presented here are intended to serve as a resource for local authorities. This report aims to contribute to policy and strategy development to reduce vulnerability to wildfires and ensure the sustainability of forest towns. This strategic approach promotes a resilient framework that supports sustainable development and improves the quality of life of all residents by ensuring that forest towns can prepare for and adapt to wildfires.

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Vulnerability Analysis

1. Climatic Conditions and Forest Fires

1.1 Turkey

Forest fires in Turkey usually intensify in the summer months, especially in July and August. During these periods, air temperatures usually rise above 30°C. These conditions cause vegetation to dry out rapidly and increase the risk of fire.

During the summer months, temperatures on the southern and western coasts of Turkey, especially in the Mediterranean and Aegean regions, can often reach 35°C and even exceed 40°C on some days. These high temperatures cause evaporation of moisture from the soil surface and drying of vegetation. Dried vegetation increases the amount of flammable material and creates a favourable environment for fires to start and spread rapidly.

The decrease in rainfall during this period is another important factor that increases the risk of fire. In the summer months, especially in July and August, rainfall is very low and this leads to a decrease in the water content of vegetation and makes it more easily combustible. Long periods without rainfall cause the soil to dry out and become more vulnerable to fires. Dry leaves, branches and other plant debris, especially the so-called forest understorey, provide a basis for the rapid spread of fire.

In regions of Turkey with a Mediterranean climate, the extremely hot and dry conditions of the summer months increase both the probability and the rate of spread of fires. Hot and dry summers and mild and rainy winters, which are characteristic features of the Mediterranean climate, are the main reasons why these regions are under fire risk. Heat and drought in summer create a favourable environment for fires to start and get out of control.

In addition, the fog winds, which are frequently observed in the southern and western coasts of Turkey during the summer months, are another important factor that increases the speed of the spread of fires. Blowing winds are dry air masses descending over the mountains and warming up. While these winds cause fires to spread rapidly, they also make extinguishing efforts difficult. Strong winds make it difficult to predict the direction and speed of the fire, making the work of the intervention teams even more difficult.

Heat waves in July and August increase the likelihood of fires. These heat waves can last from a few days to several weeks, during which time the moisture content of vegetation is severely reduced. During heat waves, water loss by plants accelerates and this creates a favourable environment for forest fires to start.

Understanding the spread dynamics of forest fires in Turkey is critical for developing effective strategies to combat these fires. Increasing temperatures, decreasing precipitation and more frequent heat waves with climate change are among the main factors that increase both the frequency and severity of forest fires. Therefore, pre-fire risk analyses, modernisation of firefighting equipment and raising public awareness on fire risks are essential for an effective fight against forest fires.

Effects of Climate Change

Climate change is a complex process that deeply affects many ecosystems and human life worldwide. Turkey is among the countries that are seriously affected by these changes. Climate change significantly increases the risk of occurrence and spread of forest fires, especially by increasing air temperatures and changing precipitation regimes. This situation poses a major threat to Turkey's forest ecosystems.

In recent years, severe droughts and extreme heat waves in Turkey have increased the frequency and spread of forest fires. Especially in the summer months, temperatures rise above normal and precipitation decreases, leading to the drying of vegetation in forested areas. Dried vegetation creates a favourable environment for fires to start and spread rapidly. In 2021, forest fires in Turkey occurred in July and August under the influence of severe heat waves and caused damage to approximately 150,000 hectares of forest areas.

Heat waves are associated with changes in atmospheric pressure systems and usually last from a few days to several weeks. During this period, temperatures can rise above 40°C. These extreme conditions severely reduce the moisture content of vegetation, increasing the likelihood of fires. In addition, high temperatures cause forest fires to spread faster and become more difficult to control.

Drought and Precipitation Decrease

One of the important effects of climate change is the change in precipitation regimes. Turkey has been experiencing serious fluctuations in precipitation amounts in recent years. The lack of expected precipitation, especially in the winter months, leads to periods of drought in the summer months, which increases the risk of forest fires. This situation causes forest ecosystems to enter water stress and become more vulnerable to fires.

During periods of drought, forests become more vulnerable to fires. The water content of plants decreases and the amount of flammable substances increases, making it easier for fires to start and spread rapidly. Drought leads to the degradation of not only vegetation, but also soil structure. As the moisture content of the soil decreases, organic matter dries out and becomes more susceptible to fire. Drought also increases post-fire soil erosion, which complicates the recovery process of ecosystems.

Drought and decreased rainfall lead to a decrease in water resources in Turkey and increase the fire risk of vegetation under water stress. For example, in the Mediterranean and Aegean regions, the decrease in precipitation in the summer months causes forests to have difficulty in meeting their water needs. Trees and plants under water stress become drier and more vulnerable to fires. Drought also leads to lower groundwater levels and reduced surface water resources, which makes firefighting more difficult.

During periods of drought, the probability of forest fires and the speed of their spread increase significantly. The drying vegetation increases the amount of flammable materials and prepares the ground for the rapid spread of fires over large areas. Drought also makes it difficult to control fires. Fire-fighting teams have difficulty in accessing adequate water supplies, making it difficult to extinguish fires. The efficiency of firefighting equipment is also reduced during periods of drought because water resources are limited and cannot be used effectively to fight fires.

Drought and reduced rainfall not only increase the risk of forest fires, but also complicate the recovery process of post-fire ecosystems. Post-fire problems such as soil erosion, decline in water quality and loss of biodiversity make it difficult for ecosystems to recover. Increasing temperature and drought due to climate change further complicate post-fire afforestation and rehabilitation efforts. Afforestation efforts during drought periods may fail due to insufficient water resources, which negatively affects the recovery process of ecosystems.

Severe droughts and reduced rainfall in various regions of Turkey increase vulnerability to forest fires. Comprehensive approaches such as water management, fire prevention strategies and emergency response plans should be adopted to protect forest ecosystems and reduce fire risk during drought periods. The impact of drought and reduced rainfall on forest fires should be at the centre of efforts to combat climate change and build an ecosystem resilient to forest fires.

Extension of Fire Season

Climate change also extends the fire season. Fires, traditionally concentrated in summer, are now more frequent in spring and autumn. This situation requires firefighting resources to be on high alert throughout the year. The lengthening of the fire season increases the pressure on firefighting teams and makes it difficult to utilise resources effectively. A longer fire season increases the likelihood of forest fires spreading more frequently and over larger areas.

The prolonged fire season creates various challenges in the fight against forest fires. The increased risk of fire also in spring and autumn months requires constant readiness of fire-fighting teams. This necessitates the active use of crews and equipment throughout the year and increases maintenance costs. In addition, the prolonged fire season may increase the workload of firefighting personnel, leading to problems such as fatigue and burnout.

The extended fire season also requires changes in fire management strategies. Fire prevention and response plans, traditionally focussed on the summer months, must now be revised to be relevant all year round. This includes updating fire risk maps, improving early warning systems and increasing firefighting capacity. The longer fire season also results in longer post-fire rehabilitation efforts. Reforestation of post-fire areas and recovery of ecosystems becomes a year-round process.

A prolonged fire season also has significant impacts on local communities and economic activities. Prolonged fire season can negatively affect agriculture, tourism and other economic activities. Agricultural areas under fire risk can lead to crop losses and economic damages. Prolonged fire season in tourism regions may cause disruption of touristic activities and damage to the regional economy. In addition, the fact that fires are more frequent in areas close to residential areas threatens the safety of local people and makes evacuation efforts difficult.

This also has serious impacts on ecosystems. More frequent and prolonged fires make it difficult for forest ecosystems to recover. Post-fire problems such as soil erosion, decline in water quality and loss of biodiversity make it difficult for ecosystems to recover. A prolonged fire season also causes post-fire rehabilitation works to be more extensive and costly.

Considering the impacts of climate change, it is of great importance to increase fire prevention, early warning and response capacities. Furthermore, effective planning and implementation of post-fire rehabilitation works are critical to accelerate the recovery process of ecosystems. The extended fire season should be at the centre of efforts to build a more resilient society and ecosystem to forest fires.

The Role of Wind

Winds are among the factors that significantly increase the speed and impact of forest fires. Especially in the Mediterranean and Aegean Regions of Turkey, the frequent blowing winds cause fires to spread over large areas in a short time. The winds are dry air masses that descend and warm up as they pass over the mountains. These winds cause forest areas to dry out rapidly and fires to spread over large areas. While blowing winds cause fires to spread over larger areas, they also contribute to the faster and more intense burning of the flames.

When wind speeds exceed 25 km/h, fires spread faster and firefighting efforts become more difficult. Strong and sudden winds make it difficult to predict the direction and speed of fires, which prevents firefighters from responding effectively. Winds can also cause fires to jump and create new fire foci.

Especially in the summer months, strong winds in the Mediterranean and Aegean regions can cause fires to spread rapidly from coastal areas to inland areas. Settlements and touristic areas in these regions can be directly affected by fires. Blowing winds can cause fires to spread over large areas within a few hours, causing great material damage and loss of life.

Winds also directly affect the effectiveness of firefighting operations. Firefighting aircraft and helicopters may find it difficult to drop water into targeted areas due to high winds. In addition, winds make it difficult for ground crews to establish fire lines and create the barriers necessary to prevent the spread of fire. This negatively affects the success of firefighting efforts and causes the fire to burn longer.

Blowing winds are particularly common in the Mediterranean and Aegean regions and cause fires to spread rapidly. These winds are known as hot and dry air masses and lead to the rapid drying of forested areas. Blowing winds contribute to the spread of fires over large areas and cause the flames to burn more intensely and quickly.

These effects of wind on forest fires increase the risk of fire and make it more difficult to control fires. Therefore, the effects of wind should be taken into account in fire risk management and strategic planning in fire fighting should be made by taking these factors into consideration.

Combating Climate Change and Preventive Strategies

In the context of combating climate change, Turkey needs to develop sustainable forest management strategies to create an ecosystem more resilient to forest fires. These strategies include pre-fire risk analyses, modernisation of firefighting equipment, raising public awareness on fire risks and use of advanced technology. In addition, it is of great importance to effectively plan and implement post-fire rehabilitation and afforestation works to reduce the ecological and economic impacts of forest fires.

Topographical and vegetation characteristics that determine the spread rate and impact of forest fires in Turkey are critical factors to be considered in fire risk management. Sloping areas, southern slopes and vegetation with high flammability characteristics cause fires to spread rapidly and make it difficult to extinguish fires in these areas. Therefore, pre-fire preparations and fire-fighting strategies should be developed by taking these characteristics into consideration.

In fire risk management, the combined effects of drought and wind should be taken into account and strategic planning for fire fighting should be made by taking these factors into account. Increasing fire prevention, early warning and response capacities is of great importance. In addition, effective planning and implementation of post-fire rehabilitation works are critical to accelerate the recovery process of ecosystems. The extended fire season should be at the centre of efforts to build a more resilient society and ecosystem against forest fires.

1.2. Greece

Greece is a country with a Mediterranean climate, characterised by hot and dry summers and mild and wet winters. This climate is an important factor that directly influences the frequency and severity of forest fires. The Mediterranean climate has a special place among the fire-prone regions of the world because hot, dry summers and mild winters cause the fire season to be long and intense.

Meteorological data and wildfire records collected over many years in Greece provide critical information for understanding the impact of climatic conditions on wildfires. Greece's mountainous geography and large forest areas cause climatic variability to increase the risk of fire. Rising temperatures and decreasing rainfall, especially in summer, lead to drying of vegetation and increase the risk of fire. This situation causes fires to spread to wider areas and become more difficult to control.

Temperature and Fires

The frequency and extent of forest fires in Greece are strongly correlated with increasing air temperatures, especially in summer. Average maximum and absolute maximum air temperatures are important factors that increase the risk of fire. Since the 1970s, a significant increase has been observed in temperature values and the number of forest fires. Heat waves, especially during the summer months, significantly increase the risk of fire outbreak and spread. The year 2007 was the hottest summer on record, according to the National Observatory of Athens, and was the period of the largest and most destructive forest fires in the history of Greece. Extreme temperatures cause vegetation to dry out, making it easier for fires to start and spread.

Average maximum and absolute maximum temperatures, as well as annual average temperature increases, increase the risk of fire. High temperatures cause vegetation to dry out and fuel to ignite more easily. Prolonged hot periods contribute to the rapid spread of fires, especially in dry and windy weather. This makes the work of fire-fighting teams more difficult and makes it more difficult to bring fires under control. In addition, high night temperatures prevent vegetation from gaining moisture and cause fires to continue. High night temperatures cause fires to remain active during the night and extinguishing operations become more difficult.

Precipitation and Fuel Moisture

Low rainfall during the fire season (May-October) is another critical factor that facilitates the spread of forest fires. Low rainfall during this period reduces the moisture content of vegetation, causing fires to spread faster and over a wider area. According to the data, reduced rainfall during the fire season increases the risk of fire by reducing fuel moisture. Especially in summer, low rainfall amounts cause vegetation to dry out completely, making it easier for fires to start.

Total area burnt shows a positive relationship with annual and summer rainfall with a two-year lag. This suggests that rainfall in previous years indirectly affects fire risk by increasing vegetation production and fuel accumulation. High rainfall years encourage vegetation growth, leading to more fuel accumulation, which in turn increases fire risk in subsequent years. Spring rainfall in particular favours vegetation growth, leading to more fuel accumulation during the fire season. The high amount of rainfall received in spring leads to an intensive growth of vegetation and thus more flammable material during the fire season. This combustible material dries out during the summer months, increasing the risk of fire.

Wind and Fire Spread

Wind plays a critical role in the spread of fires. Strong winds, which are common in Greece during the summer months, cause fires to spread rapidly over large areas. Wind direction and speed determine the direction and speed of fire spread. Strong winds complicate efforts to control fires and cause fires to spread over large areas. With the effect of wind, fires spread to large areas in a short time and cause great destruction. In addition, sparks carried by the wind can cause the fire to jump and start fires in new areas. This situation makes it difficult for fire-fighting teams to intervene and makes it difficult to bring fires under control.

Long-term Trends and Climate Change

Climate change scenarios predict that temperatures will continue to rise in Greece in the future and the risk of fire will increase further. Simulations show that air temperatures in the summer months will increase further and dry periods will become longer. These changes could result in a longer fire season and fires becoming more frequent and severe. Especially the extreme temperatures and fires experienced in the summer of 2007 are considered as an indicator of events that will be encountered more frequently in the future. Increasing temperatures and decreasing precipitation amounts due to climate change further increase the risk of fire and make it more difficult to protect forest ecosystems.

Understanding the relationship between climatic conditions and forest fires in Greece plays a fundamental role in the development and implementation of fire management strategies. Long-term meteorological data and fire records help to predict future fire risks and optimise fire fighting plans. Careful analysis of these data is vital for fire risk reduction and protection of forest ecosystems. Considering future climate change scenarios, temperatures are expected to continue to rise and precipitation patterns are expected to change. Therefore, continuous monitoring of climatic conditions and development of proactive fire management strategies based on these data is of great importance.

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2. Forest Structures and Vulnerability

2.1 Turkey

The forest structure in Turkey consists of easily combustible species such as maquis and pine forests suitable for Mediterranean vegetation. The maquis vegetation is especially common in regions where the Mediterranean climate prevails and consists of shrubs with hard leaves and short trees. These plant species are highly flammable due to their high oil content and can cause fires to spread rapidly. Scrub vegetation quickly ignites in case of fire and creates large flames, making it difficult to control fires.

Pine forests are also one of the important vegetation covers that increase fire risk in Turkey. Red pine (Pinus brutia) forests, which are widespread especially in the Mediterranean and Aegean regions of Turkey, are easily ignited due to their high resin content and cause fires to spread rapidly. The leaves and branches of pine trees burn rapidly during a fire, releasing a large amount of heat and energy, which paves the way for the fire to spread over large areas. Red pine forests act as a bridge between the flames during a fire and contribute to the spread of the fire to wider areas.

These forest structures are characterised by vegetation that dries out in summer and is flammable. High temperatures and low humidity in summer cause vegetation to dry out rapidly and increase the risk of fire. Drying vegetation provides a favourable environment for fires to start and spread rapidly. As the water content of plants decreases, the likelihood of fires starting and spreading increases. This situation causes fires to spread rapidly and become difficult to control.

The lack of adequate fire roads and gaps in and around forests makes it difficult to control fires. Forest roads and gaps play a critical role in preventing the spread of fires and enabling fire-fighting teams to respond quickly to fires. However, in Turkey, inadequate forest roads and poor maintenance of existing roads make it difficult to fight fires. The lack of fire roads delays fire-fighting teams from reaching fire areas and makes it difficult to control fires.

Forest structures in Turkey are characterised by dense and dense vegetation. This dense vegetation contributes to the rapid spread of fires. In addition, flammable materials accumulated in forests increase the severity of fires. Branches, leaves and dry grasses cause fires to grow rapidly and spread over large areas. This makes it difficult to bring fires under control and makes the work of fire-fighting teams more difficult.

One of the important factors determining the spread rate and impact of forest fires in Turkey is the topographical characteristics of the region. Mountainous and hilly terrains can cause fires to spread rapidly. Especially in sloping areas, fires spread faster with the effect of wind. Fires are fed with more oxygen as they climb upwards, which causes the fire to burn more violently. This makes firefighting efforts more difficult and makes it more difficult to bring the fire under control.

Southern slopes are areas with a higher risk of fire. These slopes receive more sunlight and are therefore hotter and drier. In these areas, vegetation dries out more quickly and fires can grow in a short time. In addition, fire fuelling factors such as wind and temperature are more intense on these slopes.

Turkey's forest structures have various natural characteristics that increase the risk of fire. For example, resinous tree species densely found in forests, especially red pine forests, cause fires to spread rapidly. Resin increases the severity of fires due to its high flammability and makes it difficult to control fires. In addition, the dense layer of shrubs and grasses in and around the forests causes fires to spread to wider areas.

Drought and heat waves are also important factors that increase the vulnerability of forest structures in Turkey to fires. Drought and heat waves, which occur frequently especially in summer, cause the vegetation in forests to dry out and become more susceptible to fire. Drying vegetation prepares the ground for fires to spread rapidly and cause large-scale destruction.

In addition, Turkey's forest structures are also vulnerable to post-fire recovery. Post-fire problems such as soil erosion, reduced water quality and biodiversity loss make it difficult for ecosystems to recover. Forest fires destroy organic matter in the upper soil layer, reducing soil fertility and making it more vulnerable to erosion.

Structural vulnerability of forests directly affects fire risk and post-fire recovery processes. Forest structures in Turkey are highly vulnerable to fires, resulting in frequent and extensive destruction by forest fires. Therefore, more comprehensive and effective strategies are needed to reduce the vulnerability of forest structures to fires and minimise the impacts of forest fires.

2.2 Greece

The forest structures of Greece are composed of various vegetation types and their vulnerability to fires varies depending on the characteristics of the plant species, their geographical distribution and climatic conditions. In order to understand their impact on forest fires, it is necessary to study in detail the effects of these different vegetation types on fire dynamics and how this is reflected in the vulnerability of forest towns.

The Mediterranean maquis formation, one of the vegetation types in Greece, is found in the hottest and driest parts of the country. It consists mainly of maquis plants such as mastic tree, wild olive and carob, and Aleppo pine and red pine forests. It is generally located in coastal areas and at low altitudes (up to 700 metres). This vegetation is adapted to hot and dry conditions, which increases the risk of fire. High temperatures and low humidity in summer cause the vegetation to dry out, creating favourable conditions for fires to start and spread. Mediterranean maquis formations are areas where fires are frequent and spread over large areas. Forest towns in these areas are at great risk due to the rapid spread of fires. Fires can be difficult to control because vegetation can burn quickly and fires can reach towns and cause serious damage. Examples of such towns are Gythio, Monemvasia (Peloponnese), Spetses and Hydra (Aegean Islands).

Although the plants in this maquis formation show fire-resistant characteristics, frequent fires negatively affect the ecosystem of this vegetation. Although species such as Aleppo pine and red pine have the ability to spread their seeds and grow new generations after fire, excessive and frequent fires can disrupt this process. While maquis plants in particular can regenerate quickly after fires, too frequent fires jeopardise the sustainability of these ecosystems. This also affects the wildlife around forest towns and prolongs the post-fire recovery process.

Another vegetation type, the oak forests formation, is found in more humid areas and is usually composed of species such as scrub oak and sandalwood. This formation is common in the low-altitude areas of Northern Greece, inland, in the humid areas of Northern Attica, Eastern Peloponnese and Western Greece. Oak forests have more humid conditions that reduce the risk of fire. However, dense vegetation can spread over large areas when fires occur. High biomass can cause fires to last longer and affect larger areas. Fires in oak forests can burn quickly and intensely due to the high fuel load, but humid conditions can prevent fires from starting to some extent. Towns located on the periphery of oak forests are at risk of fire due to this dense vegetation and there is a high risk of fires spreading to towns. Examples of such towns are Metsovo (Epirus), Zagori (Epirus) and Delphi (Central Greece).

Oak forests, although usually found in more humid environments, become vulnerable to fire during periods of drought in summer. Although the trees commonly found in these forests have thick, fire-resistant bark, the accumulation of leaf litter and dry branches underneath can cause a fire to spread rapidly. Oak forests have the ability to regrow after fire, but repeated fires make this process difficult and the balance of forest ecosystems can be disturbed. This situation also negatively affects the post-fire recovery processes of the surrounding towns.

The shrub formation is a vegetation type found in the cooler and more humid regions of Greece. It consists of species such as kermes oak, filaria and mountain maple and is generally found in the interior of Northern and Central Greece, on the plains of Thessaly and Macedonia and in the Central Peloponnese. This formation covers areas where the risk of fire is lower. However, when fires do occur, they can spread over large areas due to the dense and high biomass. In these areas, fires can be fast and difficult to control due to the high fuel load and dense vegetation. Also, cool and humid conditions can prevent fires from starting, but fuel accumulation can cause fires to burn for a long time. Towns in these areas may face immediate hazards depending on the rate at which fires spread. Examples of such towns are Trikala (Thessaly), Edessa (Macedonia) and Kalavryta (Peloponnese).

Although shrub formations are relatively resistant to fire, the dense vegetation in these areas can cause fires to spread over large areas. When fire breaks out in these formations, the underlying dry shrubs and leaf litter contribute to the rapid spread of fire. Although shrub plants have the ability to regenerate quickly after a fire, repeated fires can change the structure and composition of vegetation, which can disrupt the ecological balance of the region. These changes can threaten the sustainability of the natural environment around forest towns.

The deciduous forests formation consists of deciduous forests found in the mountainous regions of Greece, usually consisting of species such as sessile oak, sessile oak, Hungarian oak and chestnut. This vegetation is found at altitudes between 300 and 800 metres. This formation has humid conditions where the risk of fire is lower. However, when fires do occur, they can spread rapidly due to the dense and high biomass. Deciduous forests shed leaves in autumn and winter, causing fuel accumulation, which can lead to more severe fires. During the fire season, dry leaves, branches and other plant materials increase the risk of fire. Towns located near these forests are at high risk, especially during the fire season. Examples of such towns are Metsovo (Epirus), Karpenisi (Central Greece) and Naoussa (Macedonia).

Deciduous forests create high fuel accumulation during the fire season. Leaves, branches and other organic material that fall in autumn and winter dry out in summer, increasing the risk of fire. Although these forests are capable of post-fire recovery, repeated fires can inhibit the growth of young saplings and lead to changes in forest structure. During the post-fire recovery process, some species grow fast, while others may not be able to adapt to these conditions, which can affect biodiversity. This also affects the ecological balance around forest towns and makes post-fire recovery more difficult.

The mountainous areas formation includes forests at high altitudes (usually more than 700 metres), consisting of various conifer species. These include species such as larch, Scots pine, Macedonian fir and cypress. These forests at high altitudes cover areas where the risk of fire is relatively low. However, changes in fire regimes are observed in these regions due to climate change and fuel accumulation. Conifer forests can cause severe fires due to their high content of flammable materials. However, cool and humid conditions at high altitudes can prevent fires from starting. Towns in these regions may be safer due to low fire risk, but increased fire risk with climate change may threaten this safety. Examples of such towns are Arachova (Central Greece), Karpenisi (Central Greece) and Kalavryta (Peloponnese).

Conifer forests in mountainous regions are known as areas with low fire risk. However, increasing temperatures and decreasing rainfall with climate change may increase the risk of fire in these areas. Conifers are vulnerable to fire due to their high resin content. When a fire breaks out, these trees can burn rapidly and spread over large areas. In mountainous areas, the post-fire recovery period can be long and fires can severely affect ecosystems in these areas. This can also negatively affect the post-fire recovery processes of the surrounding towns.

Vegetation types in Greece are closely related to climatic conditions and topography. Climate variables play an important role in determining the structure of vegetation and fire risk. For example, vegetation types found in hot and dry regions, such as the Mediterranean maquis formation, represent areas of high fire risk, while vegetation types found in more humid and cooler regions, such as oak forests and shrub formations, represent areas of lower fire risk. The differences between these vegetation types are critical to understanding how fires start, spread and are controlled. Understanding the relationship between vegetation and fire plays an important role in the development and implementation of fire management strategies. To understand the dynamics and risks of forest fires in Greece, a detailed study of the effects of different vegetation types on fire behaviour is required. This information forms the basis for strategic planning for fire risk reduction and protection of forest ecosystems. Vegetation structure is a critical factor in determining how fires start and spread. Therefore, fire management strategies need to be adapted to regional vegetation types and their fire behaviour.

The vulnerability of forest towns to fires is directly related to the fire behaviour of these vegetation types. Towns located in regions such as the Mediterranean maquis formation are at high risk due to the rapid spread of fires. Towns located in regions such as oak forests and shrub formations are vulnerable to the risk of fire spread due to dense vegetation. Towns located around deciduous forests and coniferous forests in mountainous areas are located in areas with lower fire risk, but climate change and increased fire risk may threaten the safety of these towns.

Forest structures and vegetation types in Greece play an important role in determining the vulnerability of forest towns to fires. Therefore, in the development of fire management strategies, it is of great importance to take into account the structure of vegetation and fire risk around forest towns. Strategic planning for fire risk reduction and protection of forest towns requires measures adapted to the fire behaviour of regional vegetation types. In this way, it will be possible to make forest towns more resilient to fires and to accelerate post-fire recovery processes.

3. Infrastructure Deficiencies and Fire Fighting

3.1 Turkey

Forest fires are a major threat, especially in countries with a Mediterranean climate. Turkey is one of the regions with high fire risk and thousands of hectares of forest areas are destroyed by fires every year. It is critical to have a sound infrastructure to prevent and fight forest fires effectively. Infrastructure deficiencies make it difficult to control fires and delay post-fire recovery processes. In this context, it is important to examine the relationship between infrastructure deficiencies and forest fires in detail.

Inadequacy of Transport Facilities

The existence of adequate and fit-for-purpose roads is a critical factor for the teams and vehicles to reach the fire scene quickly and effectively. However, the insufficiency of forest roads in Turkey constitutes an important obstacle in the fight against fires. Inadequate maintenance of forest roads, narrow roads and roads full of obstacles delay firefighting teams from reaching fire zones and prolong the response time. The average forest road network in Turkey is around 15 m/ha. According to the Communiqué No. 285 of the General Directorate of Forestry, it is aimed to plan the road network within the forest to be 20 m/ha in fire prone forests. However, this target has not been achieved and the maintenance of existing roads has been neglected.

Among the most common problems encountered on forest roads are the difficulty in the passage of vehicles loaded with construction equipment or large water tankers due to the narrowness of the roads passing through settlements, the disruption of transportation by trees on the roadside and inadequate maintenance of the roads. In addition, prolonged routes due to the lack of exit points on motorways and highways and disruption of vehicle traffic due to non-standard roads are also important problems.

In 2021, in the forest fires in Turkey, inadequate transport infrastructure, especially in touristic regions such as Marmaris, Manavgat and Bodrum, had a negative impact on fire fighting. Delays in reaching the fire scene made it difficult to bring the fire under control and thousands of hectares of forest area were destroyed. Forest roads should be planned in accordance with fire fighting and their maintenance should be carried out regularly. Construction of new roads and widening of existing roads will facilitate fire response. The current average forest road network of 15 m/ha should be increased to the targeted 20 m/ha. In addition, a regular budget should be allocated for the maintenance and repair of roads and roads should be expanded.

Lack of Helipads and Airstrips

Helicopters and aeroplanes are used effectively in the fight against forest fires. However, the lack of suitable runways for landing and take-off of these aircraft causes serious problems in fire fighting. Trees or structures around helipads may adversely affect the operations of aircraft. In addition, the lack of facilities for night deployment and refuelling is also an important problem.

There are a total of 45 fire fighting helicopters in Turkey. This number is not sufficient for fire fighting. In addition, the number of helicopters rented to Turkey during the fire season is also insufficient. Ideally, at least 70 firefighting helicopters are needed for effective aerial intervention in fire fighting. In the summer of 2020, during the large forest fire in the Dalaman district of Muğla, due to insufficient helicopter and airstrips, aircraft could not be used effectively and the fire could not be prevented from spreading to a large area. This deficiency prolonged the extinguishing process of the fire and caused more areas to burn.

The number of runways where aircraft used in fire fighting can land and take off should be increased and these runways should be regularly maintained. Currently, there are 45 fire fighting helicopters in Turkey. This number should be increased to at least 70. In addition, sufficient number of helicopters should be rented during the fire season and the number of runways where these helicopters can land and take off should be increased.

Lack of Fire Prevention and Response Facilities

Inadequate fire prevention and response facilities are a major disadvantage in terms of preventing the spread of fire and facilitating fire response. Fire safety roads, fire safety lanes and fire resistant forest projects (YARDOP) can be considered in this context. However, the fact that these facilities are not sufficient in number and do not comply with the standards makes it difficult to control fires.

Fire safety roads are bare roads with no flammable material on them and their width varies between 6-15 metres. These roads are used as fire intervention points, counter fire application points and fire barriers. However, they may cause erosion when they are not properly constructed or neglected. Fire safety lanes are fire prevention green lanes created on the edges of existing or to be constructed roads. Their width is 25-50 metres and they are covered with green cover consisting of grass and meadow. If the maintenance of fire safety strips is neglected, the fine combustibles on them may accelerate the fire.

In 2019, during the forest fire in Hatay, the fire spread to large areas in a short time due to the inadequacy and poor maintenance of fire safety roads. The lack of fire safety lanes also made it difficult to bring the fire under control and caused the destruction of large forest areas. The number of fire safety roads and lanes should be increased and their maintenance should not be neglected. Fire resistant forest projects (YARDOP) should be popularised. The width of fire safety roads is between 6-15 metres and may cause erosion if not adequately maintained. Regular maintenance of these roads should be ensured.

In addition, the lack of fire water cylinders in Pozantı Municipality, which is foreseen to be the source of this report, makes the region vulnerable to fire. This deficiency makes it difficult to respond quickly and effectively in case of fire. In order to increase fire fighting capacity, the provision of water tanks would be of great benefit. Placing water reservoirs at strategic locations will ensure that the necessary water is quickly available in case of fire, making it possible to control fires and minimise damages. These infrastructure improvements will contribute to making Pozantı Municipality more resilient to fires and significantly reduce the fire risk in the region.

Inadequacy of Surveillance and Communication Facilities

The presence of surveillance and communication facilities is of great importance in order to detect forest fires as soon as possible and to intervene quickly. However, the insufficiency of these facilities in Turkey leads to late detection of fires and delays in intervention.

Some of the watchtowers, which provide surveillance of forests with human eyes or cameras, are old technology and cause delays in detecting fires. Currently, there are 776 fire watch towers throughout Turkey. However, this number is not sufficient. Ideally, at least 1000 watchtowers, modernised and equipped with camera systems, are needed.

Communication centres where fire-related information is collected and evaluated and coordination is ensured are also inadequate. Inadequate communication networks and lack of technological infrastructure create major problems in fire fighting. In 2018, during the large forest fire in Karabağlar district of Izmir, the fire was detected late and could not be responded quickly due to the inadequacy of watchtowers and deficiencies in communication infrastructure. This situation caused the fire to spread over large areas and made it difficult to bring it under control.

The number of watchtowers should be increased and existing towers should be modernised. There are currently 776 fire watch towers across Turkey. However, ideally this number should be increased to at least 1000 and modernised. Communication networks and centres should be strengthened to ensure rapid and efficient collection and evaluation of fire-related information.

Inadequacy of Water Resources

The presence of water resources is indispensable in fire fighting. However, in Turkey, the lack of sufficient water resources in fire zones makes it difficult to extinguish fires. Apart from natural water resources, the insufficiency of dams, ponds and pools used for water supply during fires is a significant disadvantage in fire fighting.

Dams and ponds where water is accumulated by compacting the soil are generally constructed by DSİ. However, there are not enough dams and ponds in many regions. This lack of water supply in case of fire makes it difficult to control fires. There are currently 1,500 water pools used for fire fighting across Turkey. However, this number is not sufficient for fire fighting. Ideally, at least 3,000 water pools are needed.

The low number of pools and water collection pits made of concrete or geotextile materials where water inlet and outlet can be controlled and the inadequate maintenance of the existing ones is an important deficiency in fire fighting. In 2020, during the large forest fire in Manavgat district of Antalya, the lack of sufficient water supply negatively affected the fire fighting efforts. Difficulties in water supply caused the fire to spread to large areas and caused great forest losses.

The number of water resources to be used in fire fighting should be increased. New dams, ponds and reservoirs should be built and existing structures should be regularly maintained. There are currently 1,500 water pools across Turkey. This number should be increased to at least 3,000.

Inadequacy of Accommodation and Logistics Facilities

Inadequate accommodation and logistics facilities for fire fighting teams and vehicles cause great difficulties in fire fighting. The inadequacy of fire brigade buildings means that brigades cannot be in suitable conditions for waiting, resting and resupplying. In addition, the lack of adequate accommodation for aircraft personnel, fuel depots and mobile fuel tankers are also among the major problems.

In 2017, during the large forest fire in Milas district of Muğla, the lack of facilities to meet the accommodation and logistics needs of the firefighting teams negatively affected the morale and motivation of the teams. This situation reduced the effectiveness of fire fighting and made it difficult to bring the fire under control. There are currently 50 fire fighting team buildings across Turkey. However, there is a need for at least 100 team buildings.

Facilities to meet the accommodation and logistic needs of fire-fighting teams should be built and the capacities of existing facilities should be increased. There are currently 50 fire fighting team buildings. However, this number should be increased to at least 100. All necessary equipment and materials for fire fighting should be available in these facilities.

These measures are of great importance for protecting forest assets, making settlements resistant to fire and minimising social and economic losses after fires. For a more effective fight against forest fires, infrastructure investments should be increased and existing infrastructures should be improved.

3.2 Greece

There are serious infrastructural deficiencies in the fight against forest fires in Greece. These deficiencies make it difficult to bring fires under control and cause large-scale destruction. The year 2023 was one of the most devastating years for forest fires in Greece. During the year, a total of 1,470 fires broke out and burnt approximately 190,200 hectares. These fires caused massive destruction in many parts of the country and exposed the deficiencies in fire fighting.

Economic Constraints

Economic problems in Greece make it difficult to provide the necessary equipment and personnel for fire fighting. The restriction of fire fighting budgets due to the economic crisis has led to a reduction in the number of fire fighting vehicles and personnel. This situation leads to the rapid spread of fires and makes it difficult to bring them under control. In 2023, Greece has pledged to spend 500 million euro to fight fires and these funds will be used for the leasing of firefighting aircraft and the modernisation of other firefighting equipment.

Fire Fighting Equipment and Personnel Deficiencies

In Greece, inadequate fire fighting equipment is one of the main factors that make it difficult to control fires. The limited number of firefighting aircraft and helicopters causes fires to grow rapidly. For example, in 2023, 450 foreign firefighters and firefighting aircraft and equipment from various countries were used to help fight fires. The inadequacy of this equipment and personnel made it difficult for an effective response, especially in large-scale fires.

During the fires on Rhodes Island, a total of 10 fire-fighting aircraft, 8 fire-fighting helicopters and 260 firefighters participated in the fight against the fires. However, the number of equipment and personnel was insufficient and great difficulties were experienced in bringing the fires under control. Old and poorly maintained firefighting equipment also prolonged the response time and accelerated the spread of fires.

Fire Roads and Access Problems

The inadequacy of emergency roads and transport infrastructure in Greece prevents firefighting teams from reaching fire areas quickly. The poorly maintained and inadequate roads, especially in forested and rural areas, cause fires to spread rapidly. In 2023, during the fires in the Alexandroupolis region, hospitals and many villages had to be evacuated, demonstrating the inadequacy of the transport infrastructure.

During fires, poorly maintained and narrow roads, which made it difficult for firefighting teams to reach the fire areas, prolonged the response time and caused fires to spread to wider areas. Especially in mountainous and forested areas, the lack of the necessary infrastructure for the effective movement of fire-fighting teams made it difficult to bring fires under control.

Communication Infrastructure

It is vital to have an effective communication network in fire fighting. However, the inadequate communication infrastructure in some regions in Greece makes the coordination of fire-fighting teams difficult. This situation delays the control of fires and jeopardises the safety of the teams. Especially in forest areas, communication interruptions have a negative impact on firefighting operations.

Inadequate communication infrastructure prevented firefighting teams from communicating effectively with each other and with central coordination centres, making it difficult to contain fires. Communication interruptions during fires reduced the efficiency of firefighting operations and caused fires to spread to wider areas.

Training and Preparation

Training and preparedness of fire fighting personnel is the key to success in fire fighting. In Greece, there are deficiencies in the regular training of fire fighting personnel and their preparedness against fires. This situation leads to an increase in the mistakes to be made in case of fire and causes fires to spread to wider areas.

Increasing the number of fire fighting personnel and implementing regular training programmes will ensure more successful results in fighting fires. Considering the increased risk of fire especially in summer months, it is of great importance that fire fighting personnel are adequate in number and trained.

These infrastructural deficiencies in the fight against forest fires in Greece contribute to the rapid spread of fires and make them difficult to control. Addressing these deficiencies will help to achieve more effective results in the fight against fires and reduce the vulnerability of forest towns to fires.

Conclusion and Recommendations

This report analyses the factors of vulnerability to forest fires in Turkey and Greece and ways to cope with these fires. Climate change and human activities are causing forest fires to become more frequent and severe. Especially in the Mediterranean climate zone, high temperatures and low humidity increase the risk of fire. The ecological, economic and socio-cultural impacts of fires are far-reaching, causing serious damage to forest ecosystems, reducing biodiversity, increasing soil erosion and reducing air quality. In addition, fires adversely affect human health, hinder tourism activities and cause economic losses.

In order to reduce the effects of forest fires and to combat these fires more effectively, the following strategic recommendations should be implemented.

Early Warning Systems and Use of Technology

Early detection and intervention play a vital role in controlling forest fires. The use of advanced technologies, such as unmanned aerial vehicles (UAVs) and satellite imaging systems, enables early detection and rapid response to prevent the spread of fires. Regular updating and integration of these systems is critical for fire management.

For example, UAVs can scan fire zones and provide real-time data, while satellite imaging systems can detect the direction and speed of fire spread. These technologies play an important role in the process of creating and updating fire risk maps. Fire risk maps help to identify high-risk areas and take preventive measures, thus enabling fire management plans to be prepared more effectively.

The installation of advanced fire management systems contributes to more effective coordination during a fire. These systems ensure fast and accurate information flow between fire management centres and teams in the field, enabling more effective interventions. Monitoring the location and movement of fire-fighting teams, predicting the direction of fire spread and utilising resources in the most efficient way can be achieved in this context.

In addition, regular fire training and drills are necessary to reduce fire risks and improve fire management. Continuous training of UAV operators, fire monitoring teams and firefighting personnel allows for fast and effective responses in fire situations. These strategies emphasise the effective use of technology in fire management and the need for continuous improvement.

Social Awareness and Education Programmes

Raising public awareness of fire risks and informing them about the precautions to be taken before, during and after a fire play a critical role in the fight against fire. For this purpose, training programmes and awareness campaigns organised by local administrations and non-governmental organisations are of great importance. These programmes are of vital importance for the prevention of fires and effective response during fires.

Training programmes should aim to provide knowledge and skills to reduce fire risks. These programmes should cover topics such as fire safety training, emergency response training and post-fire rehabilitation activities. In addition, special trainings should be organised for various segments of the society to raise awareness of fire risk.

Awareness campaigns should ensure that fire awareness is spread throughout the society, especially targeting school-age children and young people. Seminars, workshops and fire drills organised in schools should encourage young generations to be aware of fire risks. In addition, wider masses should be reached through media campaigns, social media activities and informative brochures.

Informing local people about the precautions to be taken before, during and after a fire is an important step to reduce the risk of fire and increase social resistance. Thanks to these information activities, the probability of fires can be reduced and the damage can be minimised by correct interventions in case of fire. Such strategic approaches emphasise the effective use of social awareness and training programmes in fire management.

Infrastructure Investments

Infrastructure investments are of great importance for the rapid and effective access of fire response teams. In this context, the number of forest roads should be increased and existing roads should be regularly maintained. The widening of forest roads should ensure that firefighting equipment can move easily over these roads. In addition, construction of new forest roads close to critical areas should be planned in order to shorten fire response times.

Increasing the number of helicopter and aeroplane runways will increase the capacity of aerial response to fire. Regular maintenance and repair of these runways will ensure their continuous availability throughout the fire season. Construction of new runways in strategic locations will further shorten fire response times.

It is essential to increase the number of water resources to be used in fire fighting and to regularly maintain existing water structures. The construction of new dams, ponds and reservoirs will prevent water supply problems in firefighting operations. The location of these water resources at strategic points will facilitate the supply of water to fire zones.

It is important to diversify water resources in order to overcome the difficulties in water supply. Especially in areas with high fire risk, portable water tanks, underground water tanks and emergency water sources should be established. Diversification of water resources will increase the effectiveness of firefighting operations and accelerate water supply processes.

In this context, infrastructure investments will play a critical role in fire fighting, enabling fire response teams to respond to fires faster and more effectively.

Strengthening Fire Prevention and Response Facilities

Increasing the number and regular maintenance of fire safety roads and lanes ensures that fire response teams can move quickly and safely. The width and standards of these roads are critical for the effective response of the teams. Construction of new roads should be planned especially in areas with high fire risk.

Increasing the number of watchtowers and modernising existing towers will make early detection and monitoring of fires more effective. Equipping these towers with advanced monitoring systems and regular maintenance will ensure that fire response teams are informed in a timely manner.

Communication centres where fire-related information is collected, evaluated and coordinated should be strengthened. Modern communication networks and centres should be designed and technologically supported to ensure fast and efficient information flow in fire fighting. These centres improve the coordination of teams in case of fire, increase the speed of response and ensure more efficient management of operations.

Modernisation of fire fighting equipment and facilities is also important. The renewal of firefighting vehicles improves the performance of firefighting teams. These investments increase the overall effectiveness of fire prevention and response processes, making it easier to control forest fires.

Economic and Financial Support

Sufficient budget should be allocated for fire fighting and rehabilitation works and effective utilisation of resources should be ensured. The lack of equipment caused by the economic crisis and budget constraints should be eliminated and the number of fire fighting teams should be increased.

Within the scope of international cooperation and aid programmes, equipment and personnel support needed in fire fighting should be provided. Especially by cooperating with the European Union and other international organisations, it should be aimed to increase fire fighting capacities. These collaborations can contribute in areas such as financial support, training programmes and technological assistance.

Furthermore, co-operation between the public and private sectors should be encouraged to ensure sustainable financing of fire prevention and response activities. Effective use of funds and proper management of resources will be the key to success in the fight against fire.

Combating Climate Change

Within the scope of combating climate change, sustainable forest management strategies should be developed. These strategies should include protection of forests, pre-fire risk analyses and post-fire rehabilitation works. For example, measures such as the establishment of fire early warning systems, training of fire monitoring and response teams, creation of fire protection strips and implementation of post-fire ecosystem restoration projects can be taken.

In addition, the use of carbon-free energy sources should be encouraged and greenhouse gas emissions should be reduced. Fossil fuel use should be reduced by investing in renewable energy sources, especially solar and wind energy. In addition, a more effective fight against climate change can be carried out by supporting projects to increase energy efficiency and carbon sequestration technologies.

Rehabilitation and Afforestation Works After Fire

Comprehensive rehabilitation works should be carried out to combat post-fire soil erosion and soil loss. These works will minimise the long-term effects of fire by increasing soil fertility and accelerating the return of ecosystems to their natural state. In the rehabilitation process, the use of local plant species can accelerate the restoration of ecosystems by increasing biodiversity. The selection of these species should be made taking into account regional ecological characteristics.

Rehabilitation projects should include reforestation of burnt areas and protection against erosion. Techniques such as vegetation cover, water harvesting systems and terracing should be used for soil stabilisation. In addition, the selection of fire-resistant plant species in post-fire afforestation works can reduce the risk of future fires.

Research and Development (R&D) Activities

Research and development of innovative technologies in fire fighting should be encouraged. Technologies such as fire extinguishing robots, advanced fire monitoring systems and fire resistant building materials can provide effective solutions in fire fighting. Universities, research institutions and the private sector should co-operate to develop and implement these technologies.

R&D activities should ensure the implementation of science-based projects in the fight against forest fires in order to reduce fire risk and accelerate post-fire recovery processes. These projects will improve fire management with an integrated approach by comprehensively addressing pre-fire preparation, response during fire and post-fire recovery processes.

Political and Legal Arrangements

In the fight against forest fires, legal frameworks need to be strengthened and existing laws need to be effectively enforced. Increasing deterrent penalties for fire setters and accelerating legal processes will contribute to the prevention of fires. It is important to develop fire fighting policies at national and regional level and to implement these policies in coordination with local administrations.

Legal regulations should regulate the allocation and utilisation of the necessary resources to reduce the risk of fire and support the post-fire recovery process. It should be aimed to prevent and control fires with an integrated approach by ensuring the active participation of all stakeholders in fire fighting. In this context, public institutions, non-governmental organisations, private sector and local communities should be encouraged to work in cooperation.

The effectiveness of fire fighting policies should be supported by regular inspections, training programmes and awareness raising campaigns. In addition, national and international funds should be utilised to provide equipment and technologies to be used in fire prevention and response activities. These strategic approaches will provide comprehensive and sustainable solutions for the prevention and mitigation of forest fires.

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