International Baccalaureate

EXTENDED ESSAY

Environmental Systems and Societies

"Effects of the changes in climate and weather conditions on the Forest Fires in Türkiye: The case of Fires in Milas in 2021"

"How do the changes in weather conditions affect the outbreak and pattern of the forest fires in Muğla, Türkiye in 2021."

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1. INTRODUCTION

1.1 Forests in Türkiye

Being a habitat for millions of different species among the whole world, forests contribute to humans from different aspects. They play a significant role at the production of oxygen through their leaves pulling in carbon dioxide. They are the largest storehouses of carbon after the oceans, as they absorb greenhouse gases. Forests provide all the resources needed for the survival, offer home to various plants and animals. Forestry economy contributes to the livelihoods. Over 1.6 billion people depend on forests for food or fuel, and some 70 million people worldwide - including many Indigenous communities - call forests home. Forests help preventing erosion, enrich and conserve soil and reduce air pollution. Human health is inextricably linked to forests' health. Forests are also home to over 80% of terrestrial biodiversity[1]. They are important part of the eco-systems. Forests cover around one-third of world land area on Earth.[2]

According to the Global Forest Resources Assessment prepared by the FAO[3], Türkiye ranks as the seventh country in the world for an annual net gain of 114.000 hectares of forest area. By end of 2021, Türkiye has a forestry area of 23.1 million hectares[4]. Covering 29,5 % of the landmass, the forestry area is mostly located along the coastal lines of Mediterranean, Aegean, Marmara and Black Sea regions and extend up to 160 kilometres inland.

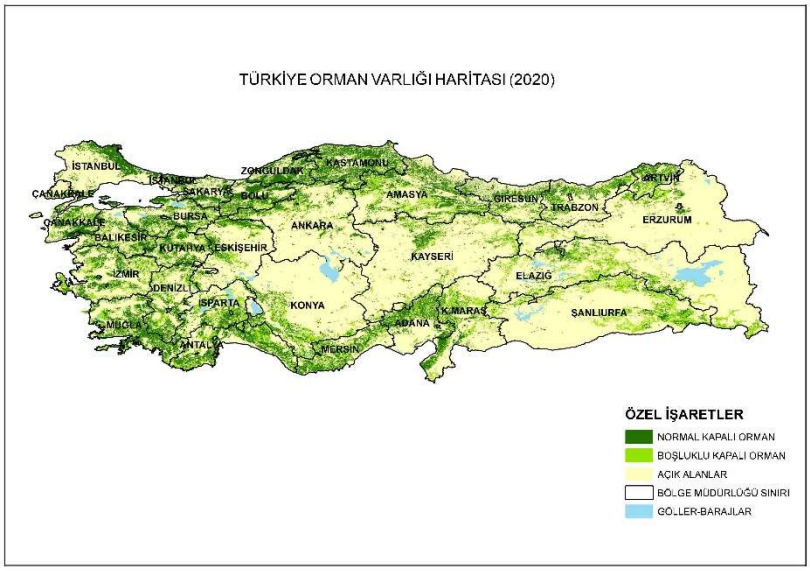


Figure 1: The map shows the distribution of trees in Türkiye
Source: General Directorate of Forestry

[1] Importance of Forests | WWF (panda.org)
[2] The State of the World's Forests 2020 (fao.org)
[3] ca9825en.pdf (fao.org)
[4] General Directorate of Forestry Statistics 2021

1.2 How do Wildfires Ignite?

Figure 2: The image shows an ignited forest fire in Türkiye.

"Wildfire" can be defined as "an unusual or extraordinary free-burning vegetation fire which may be started maliciously, accidently, or through natural means, that negatively influences social, economic, or environmental values. In contrast to wildfires, the landscape fires that we are more accustomed to are an integral part of our world, critical to the healthy functioning of many ecosystems and an important cultural and land management tool. Whether caused by humans or nature, when fires burn out of control, they can become wildfires[5].

There are 3 main factors that have a direct impact on wildfires: topography, fuel, and weather (meteorological parameters). The concurrence of the three factors accompanied with an ignition causes forest fires. The sources of the ignition are human factors (intentional, negligence) and natural event (lightening). Topography is the arrangement of the natural and artificial physical features of an area which are shaped by elevation, slope and aspect. It is the only fixed element among the variables causing fire. The elements affecting the role of fuel in wildfires is moisture, the type and condition of the vegetation, the organic content of the soil and amount of the vegetation. For instance, the more the trees have dead and dry branches, the higher the probability they must be prone to ignite an upcoming wildfire. An example for this type is the pine tree which is one of the most abundant type in Türkiye. The factor that is the most effective is the meteorological parameters which are air temperature, ratio of relative humidity, the speed and direction of the winds, rainfall and stability of solar radiation. There is an inverse proportion between the air temperature and the humidity. If temperature increases it will lead to a decrease in relative humidity, thus the air as well as vegetation will become drier and the warm weather can dry out the landscape rapidly which will cause the plants to catch fire in a faster way and burn for a longer period. Wind creating blow-dryer effect with a high speed has a positive relationship with wildfires.

[5] Spreading like Wildfire: The Rising Threat of Extraordinary Landscape Fires | UNEP - UN Environment Programme

When the temperature value exceeds 40°C and the percentage of relative humidity falls below 10%, the likelihood of wildfire propagation increases. In addition, when there is an atmospheric pressure gap between two regions (north and south), a wind occurs from high pressure area to the low one. If the winds come from north, the risk of wildfire increases. This happens especially when the speed of the wind exceeds 25 km/h as it fastens the process of the spread of fire sparks among trees. The nexus of these three extreme weather conditions accompanied with an ignition leads to wildfire.

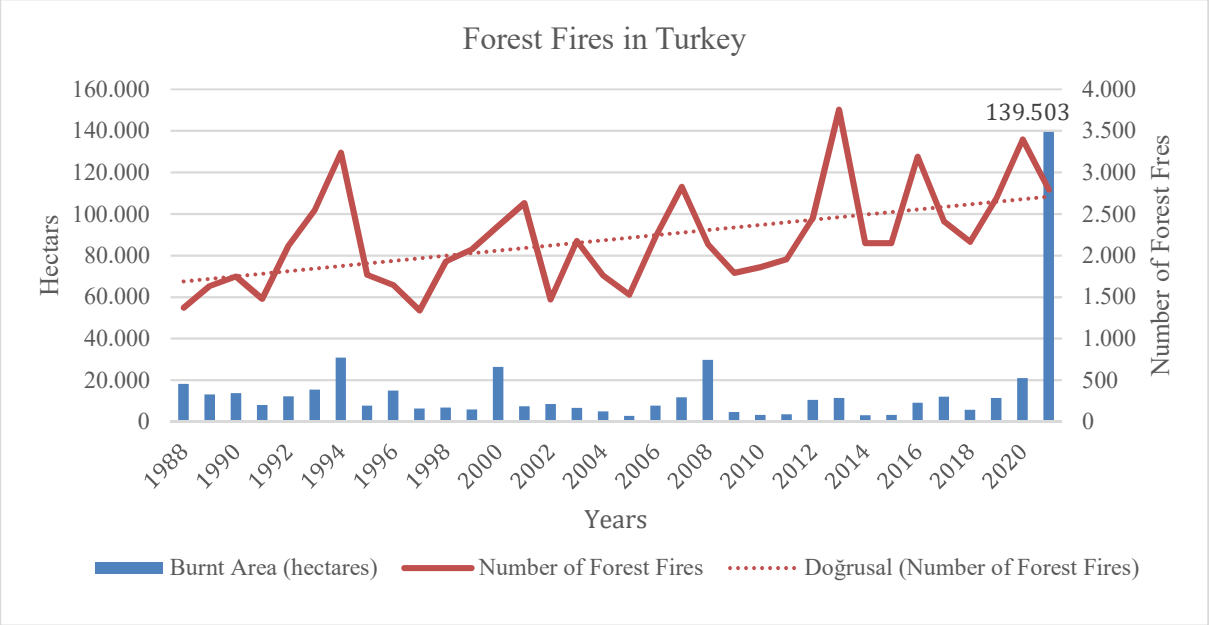
Subject to these extreme weather risks and having wet winters that leads to significant biomass growth and accumulation which then dries out and turns into combustible fuel during subsequent hot summers, the Mediterranean climate landscapes where Türkiye is in are among the most fire-prone locations.

1.3 Forest Fires in Türkiye

Out of 23,1 million hectares, more than half, approximately 12,5 million hectares of Türkiye's forests are under high risk of wildfire. The most vulnerable regions are on the Mediterranean and Aegean coasts.

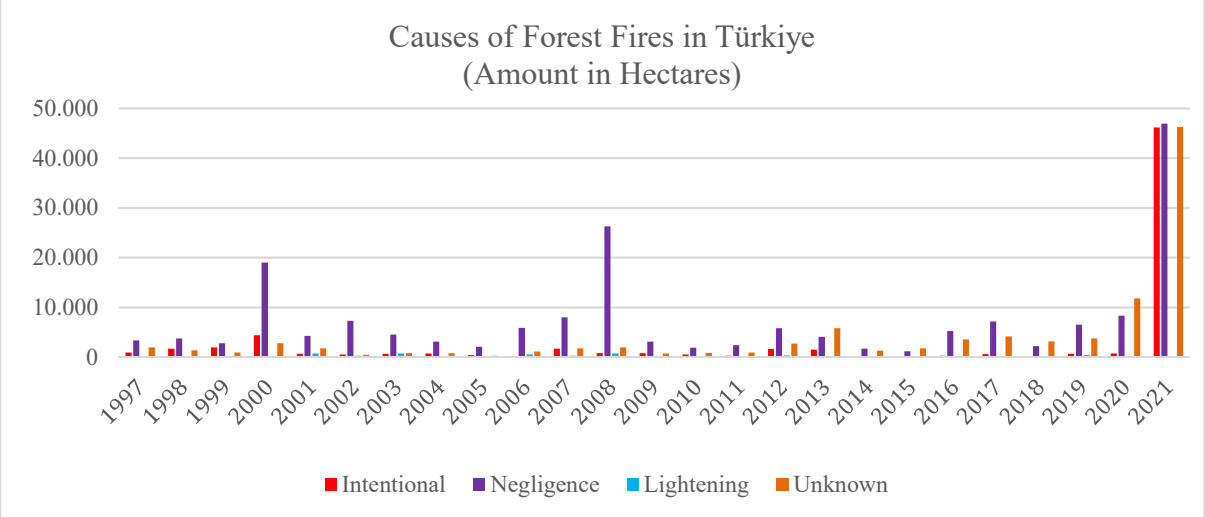
The underlying factors driving forests' vulnerability to wildfires include the presence of fire-prone species (sixty percent of Türkiye's forests contain species -mainly coniferous- that are sensitive to fires), long-lasting summer droughts that often exceed six months, low relative humidity levels (subject to the Mediterranean climate, Türkiye has hot and dry summers), drying winds, and unfavourable land conditions (80 percent of Türkiye's land is considered rugged). This creates a high possibility of the forest wildfires in Türkiye.

Indeed, the number of forest fires as well as the amount of burnt forestry areas are in an increasing trend in Türkiye. The number of forest fires increased to 2.793 in 2021 from 1.372 in 1998 whereas the forestry area burnt increased to 139.503 hectares in 2021 from 18.210 hectares in 1988 (Appendix I).



Graph 1: Number of forest fires and amount of forests burnt in Türkiye.

In Türkiye, more than half of the cause of forest fires are due to human activity made intentionally or by negligence. Causes due to negligence is higher than intentional ones. Almost 40-50% of the causes of fires in the last decade is unknown. Natural cause of the forest fires (an outburst of flame after a strike of lightning) is less than 10%. According to various publications of international organizations, almost 90% of the forest fires is attributable to human activity. In Türkiye, these human behaviours could be starting a picnic fire and forgetting to extinguish it or burning stubble to increase the efficiency of agricultural techniques (vegetation management). In the last years, there is remarkable increase in fires caused by electricity lines and waste management (all are under the category of negligence). Figures are in Appendix I.



Graph 2: Causes of forest fires in Türkiye.

1.4 Wildfires in July-August 2021 on the Mediterranean Coast of Türkiye

2021 was a special and exceptional year regarding the wildfires in Türkiye both in terms of amount burnt and the pattern of the wildfire. 139,503 hectares of forestry area was burnt in 2021 which is almost double times of the total area burnt in the preceding 10 years (2020-2011). This area is 8% of the burnt forestry since 1937, the year when the forest statistics started to be collected. 117.000 hectares of forestry area was burnt only between 28 July – 10 August[6] mostly in the 8 provinces (Antalya, Adana, Mersin, Muğla, Osmaniye, Uşak, Manisa, Isparta), majority of which were on the Mediterranean coast. The most remarkable one was in Antalya-Manavgat with burned area of 55.000 hectares making it biggest single wildfire in Türkiye's history. This is followed by Muğla-Milas almost on the same dates with burned area of 12.764 in this period. These wildfires triggered extensive evacuations, damaged urban, forestry areas and agricultural infrastructure, impacted 35 neighbourhoods and hundreds of households with nine people reported to have died[7], resulting in ecological and economic damage and loss, community, and business disruption. Thousands of animals died, and a significant amount of habitat has been lost. In addition to the direct effects of wildfires on forests in Türkiye, many sectors such as forest villagers, residential areas, the wood sector, tourism, hunting, mining, beekeeping, livestock, health, and food security were also affected.

Figure 3: Fires outbroke in July-August 2021 from Nasa

[6] 2021'de Orman Yangınları – Türkiye İnsani Çalışmalar Yıllığı (kizilayakademi.org.tr)
[7] https://reliefweb.int/report/turkey/information-bulletin-turkey-wildfires-10082021

During this period, many arguments have been made among public and on media about the causes of wildfires. There was a significant disinformation. According to the climate change survey conducted by Konda Research and Consultancy in cooperation with "iklimhaber.org", 36% of the society thought that the terrorist groups initiated the fires; 27% thought that the fires have been ignited deliberately to create land for construction and profit seeking; 20% thought that the reason is the lack of attention and negligence and only 3% thought that "climate change" caused these wildfires[8].

2. METHODOLGY

2.1 Research Question:

How do the changes in weather conditions affect the outbreak and pattern of the forest fires in Muğla in 2021?

2.2 Aim:

Throughout this investigation, my main goal is to understand the impact of the meteorological parameters affected by climate change on the outbreak and behaviour of forest fires in Muğla between end of July and beginning of August 2021. Furthermore, my other target is to analyse the correlation between the meteorological parameters and fires.

2.3 Method:

For this research, I collected data from the origin source i.e. the General Directorate of Meteorology under the Ministry of Environment, Urbanization and Climate Change and the General Directorate of Forestry under the Ministry of Agriculture and Forestry; these are the institutions producing the meteorological data and forestry data. I used graphs and statistical methods to make my analysis by using this data. In addition, I have gone through various articles and publications issued by universities, international organizations, and research institutions. Finally, I have had interviews with three experts from: (i) Fire Management Department under the General Directorate of Forestry; (ii) Fire Management Centre; (iii) General Directorate of Meteorology to get an insight from the officials who are directly involved in this topic and incident.

Hypothesis:

During the last week of July 2021, I was on vacation with my family in Yaliçiftlik/Bodrum/Milas/Muğla, which has a coast to the Mediterranean Sea – a beautiful forestry habitat. We have been going to the same place almost at the same time every year (end

[8] Türkiye'de orman yangınları geçen yıl neden rekor kırdı? – iklim gazetesi

of July-beginning of August). This time, I have observed two remarkable differences compared to past years: (i) The extremely hot weather – so hot that the sun was like biting my skin; (ii) The wind like a hair dryer – so strong that the moment I went outside my hair was drying in seconds. Unfortunately, soon, we watched the outbreak of forest fires in Manavgat/Antalya on TV which is followed by wildfires in Milas in our vicinity. First, we thought it will cease quickly but it did not. Finally, fire was very close to our place, and we, together with many people, evacuated the facility in panic. As a person who witnessed this horrific extreme weather conditions accompanied with wildfires, I thought that climate change have led to the extreme weather conditions which resulted in wildfires with a fast-spreading pattern. I also questioned whether this could have been prevented.

Figure 4: dated 31.07.2021 taken from the green are of the facility.

Figure 5: dated 31.07.2021 taken from the seaside of the facility.

Figure 6: dated 02.08.2021 – immediately after this, we evacuated.

3. Milas Wildfire in 2021

Based on the data obtained from the Fire Management Center of General Directorate of Forestry, Milas Wildfire started on 31 July 2021. The cause is registered as "electrical lines". At that moment, the weather temperature stood at 42 degrees, the relative humidity was 8% and the wind was from north with a velocity of 50 km/hour. The fire spread very fast, and the fire reached to a height of 150 meters. The fire first started in the neighbourhood of Karacahisar and spread to neighbourhoods of Mumcular, Yalı, Çökertme and Ören and damaged a forestry area of 12.764 hectares[9].

According to the first Forestry Expert I interviewed, temperature increasing above 40 degrees, relative humidity dropping below 10% and the velocity of the wind above 20 km/hour

[9] OGM Muğla Regional Directorate Report 2021

prepares the environment for a wildfire. The second Forestry Expert -who took an active role at combatting the forest fires in 2021- said that once start wildfires create their own climate and quickly spreads. This means that as fires release extreme heat waves, they create a pressure difference with the surrounding areas. As the gases move from high pressure to lower pressure, the burning region creates a strong wind which expedites the fire propagation.

Indeed, the chain of causes of these wildfire series began in 2020 said the Expert from the General Directorate of Meteorology during the interview. The drought which started in 2020 on the Aegean and Mediterranean Coast continued in 2021. This long-lasting drought have led the dead vegetation to dry and reduced the content of water of trees. The vegetation on the forest turned to "fuel". In the meantime, Basra low pressure penetrated the region and strengthened leading to further drought. The temperatures in Antalya, Muğla, Adana and Mersin rose to 45 degrees. In the meantime, wind coming from north-east which can be regarded as "Foehn Winds" reduced the relative humidity. All the preconditions for the outbreak and fast expanding of wildfires were present.

Figure 7: Map showing the location of the wildfire I witnessed.

3.1 The link between weather conditions and spread of wildfires.

The correlation coefficient (r) is a statistic that tells the strength and direction of the relationship between the variables. In this essay I have calculated "r" to analyse the link between the temperature, relative humidity, and velocity of the wind with the total amount of burned area (in hectares) in Muğla in 2018-2021.

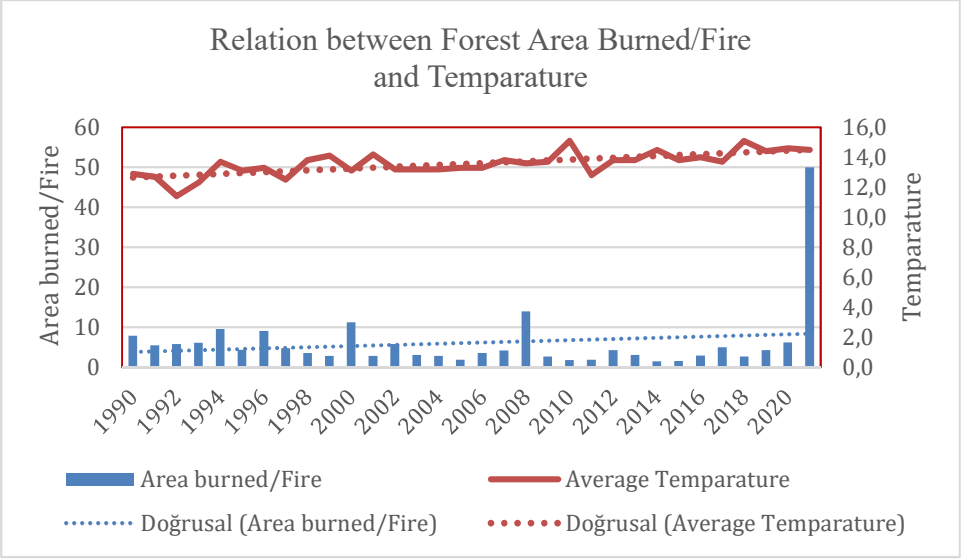
The coefficient of correlation for 3 meteorological parameters

Temperature	Relative Humidity	Velocity of the wind
0.1142	**-0.1667**	**0.2974**

For the calculation above, data about all the fires occurred in Muğla between 2018-2021 and for each fire the data about the then-prevailing meteorological conditions specially requested from the General Directorate of Forestry has been used. According to the coefficient of correlation calculated for each value, as the r is smaller than 0.1, there is a low relationship between the weather parameters with the burnt area in hectares. From this calculation, it can be concluded that for a fire to occur and to reach to concerning levels, extreme meteorological parameters are not sufficient.

However, the results led to the questioning of the sufficiency of the data sample to reach a conclusion. Thus, the individual relationship of the forestry area burned (hectares) with each meteorological parameter is investigated by using Türkiye's average data and based on graphical analysis. Data related to the graphs presented in Appendix 2

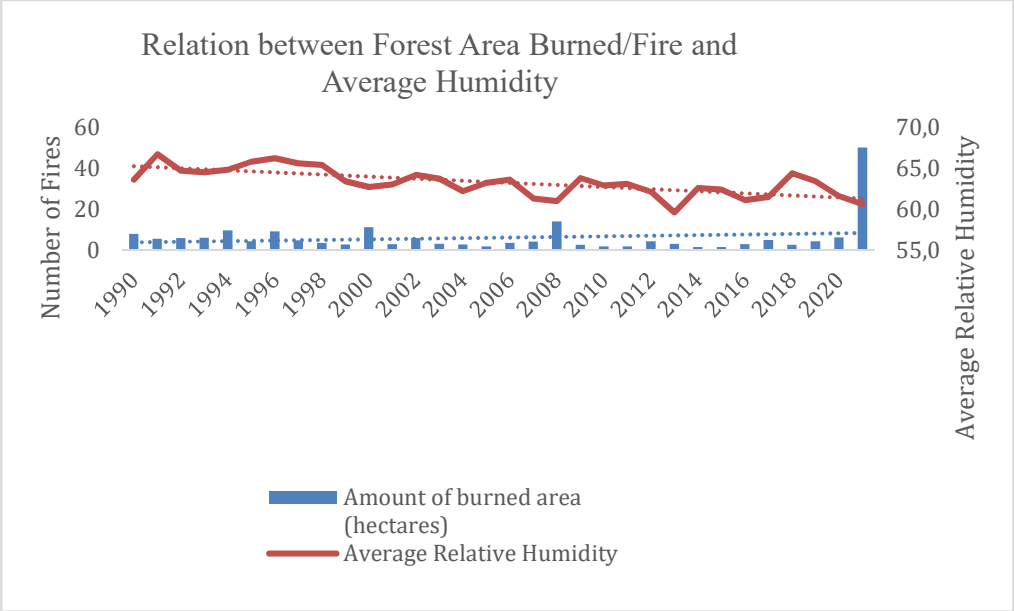
Temperature: The relationship between burned forestry area/fire and the temperature is positive, almost close to 1.



Graph 3: Relation between Forest Area/Burned and Temparature

The study on "A Mediterranean basin without a Mediterranean climate"[10] found out that the temperature in the Mediterranean basin has climbed 1.4 degrees, and the increase is projected to continue to exceed global rates, rising approximately 0.5 degree by 2030 and 1.5 degrees by 2050. Climate projections indicate that the number of days with a maximum temperature above 37 degrees will increase everywhere in the Mediterranean region, with especially large rises in northern Africa, the Middle East, southern Spain, and Türkiye.

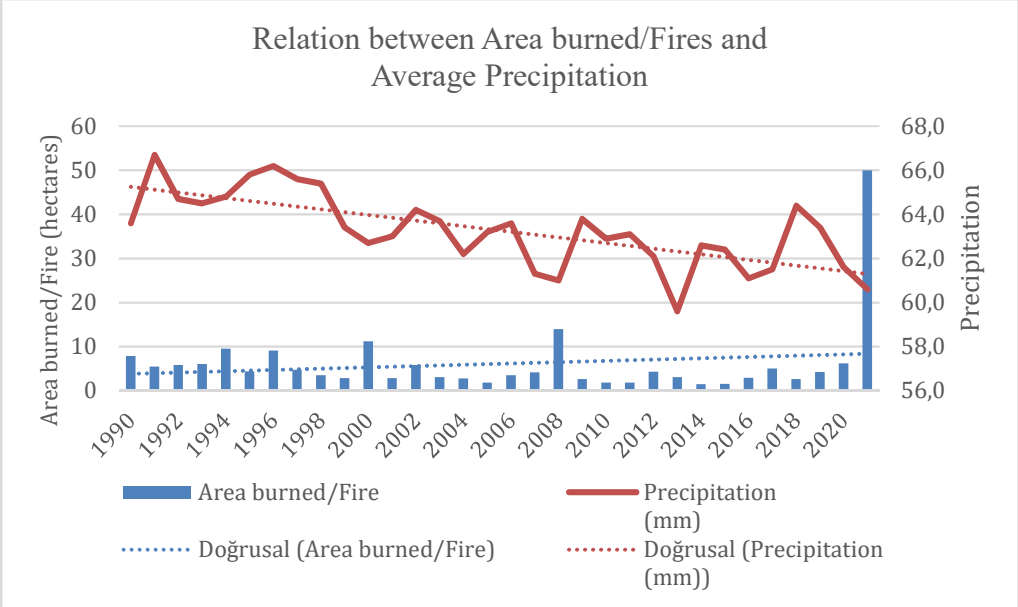
Humidity: The relationship between burned forest area/fire and average relative humidity is negative; the decrease in humidity is significantly higher than the increase in burned forest area/fire.



Graph 4: Relation between Forest Area/Burned and Humidity

Precipitation: The relationship between burned forest area/fire and average precipitation is negative; the decrease in precipitation is significantly higher than the increase in burned forest area/fire.

[10] mgi-a-mediterranean-basin-without-a-mediterranean-climate_casestudy.pdf



Graph 5: Relation between Forest Area/Burned and Precipitation

According to the above-referred study, in Türkiye, rainfall during the warm, dry season of April through September is projected to decrease by as much as 10 percent by 2030 and as much as 20 percent by 2050. By 2050, drought conditions could prevail for at least six months out of every year in these areas.

In 2017, according to IPCC (Intergovernmental Panel on Climate Change), it was predicted that there will be a sharp increase at the temperature value and a decrease at the percentage of relative humidity which will result with a rise at the number and severity of future forest fires especially in the Mediterranean region.

3.2 Analysis of the Ignitions in Milas Wildfires

Apart from the combination of these 3 major meteorological factors (heat, humidity, wind), the rapid rise of Milas' population and the human activities in the region strongly influenced the outbreak of wildfires in Milas in 2021.

Bodrum/Milas covering the neighbourhoods where the fire spread is one of the most attractive touristic coastal towns of Türkiye. Throughout the summer, the number of people accommodating in Bodrum grows exponentially. Bodrum's population increased to 181.541 by 1.78% in 2020 and to 187.284 by 2.06% in 2021. The main reason of this rise was the outbreak of Covid-19 pandemic in March 2021 which led to influx of people to coastal areas. In summer, Bodrum's population approaches to 1 million. There are continuous constructions on the formerly vegetated landscapes in the town and the settlements are scattered within the

forestry area causing serious risk for fire ignition. Due to the sudden increase of the population in summer, the existing infrastructure including water and electricity network, waste disposal facilities and roads are not meeting the needs. In an interview, the Mayor of Bodrum said that they are opening new roads but still cannot reduce traffic congestion[11]. However, openings created by humans (through construction of roads and buildings, logging activities, etc.) in formerly vegetated landscapes increase the availability of fine dry fuels for both anthropogenic and natural ignitions. These openings created by humans are more flammable than natural forest vegetation[12]. Hence, Bodrum/Milas is vulnerable to wildfires.

According to the Muğla Regional Directorate of Ministry of Agriculture and Forestry, the number of fires as well as the amount of the forestry area burned have increased significantly in Muğla in the recent years. The Muğla Directorate draws attention to fires caused by energy transmission lines. Although the share of fires caused by energy transmission lines and transformer stations is only 4%, the share of forestry area burnt is 25% of the total area burned in Turkey meaning that fires stemming from energy transmission lines burns larger forestry area. These forest fires occur in windy days due to the clash of wires or in the extremely hot days due to the over capacity use of the transmission lines and transformer stations. Therefore, these two weather conditions are critical for the outbreak of the fires[13].

Indeed, we have had all these conditions described above on 17-31 July of 2021 in Bodrum/Milas/Muğla. In the summer of 2021, due to the bairam, the Government announced the entire week of 17-25 July as holiday. Majority of the people extended their holiday until end of July. On 17th of July, people started fluxing to Bodrum. This stretched out the already insufficient infrastructure including the electricity lines and transformer stations severely. Due to the fire ignited via electricity lines and accompanied with the extreme weather conditions mentioned above, wildfires occurred on 31 July 2021 and spread fast. If the weather conditions were not severe, few ignitions were unlikely to cause a wildfire, but in case of the situation where weather thresholds (heat, humidity, wind) are simultaneously exceeded, the likelihood of any ignition causing wildfire increases. In such case, the height, size and duration of a fire will

Figure 8: from news on 17.07.2021 showing the entering cars to Bodrum.

[11] Bodrum'un 'tam kapanma göçü' sonrası nüfusu açıklandı (cumhuriyet.com.tr)
[12] Wildfires and global change - Pausas - 2021 - Frontiers in Ecology and the Environment - Wiley Online Library
[13] OGM Muğla Regional Directorate Report of 2021

largely depend on how long the extreme weather lasts and how big is the area containing fuel material suitable for fire. Indeed, 81% of the fires occurred between 10:00-20:00 when the weather was hot and relative humidity was low in Milas at that time[14]. In the neighbourhoods of Mazı, Yalı, Çökertme, Ören of Bodrum/Milas, the size of the fire was very small when started and could have been extinguished by a bucket, but the first intervention was late due to the lack of equipment and water. The only sprinkler was engaged in another neighbourhood of Bodrum, Kumbahçe, and the fire spread with power of wind and damaged a very big area in Mazı-Çökertme-Ören.

Figure 9: The maps compare the severity of the outbreak of forest fire in 2021 before July 31 and after in Mazıköy- Çökertme, Bodrum Milas.

All factors acted in concert to produce spreading wildfires in Milas in 2021.

3.3 Predicting weather conditions for fire management

To take the appropriate precautions for a possible fire outbreak, a system has been developed by the General Directorate of Meteorology which is called MEUS (Meteorological Early Warning System). The system hourly prepares a map for the coming next 3 days in order to inform the General Directorate of Forestry for possible fire outbreaks for every city of Türkiye by taking into consideration the data on meteorological parameters as well as the aspect of the land and applying these on the forest map. The Expert from the Forestry Fire Management Centre informed that there are many parameters to be considered, for instance fire pattern of each vegetation is different and now they are improving their Forestry Information System by developing a more comprehensive

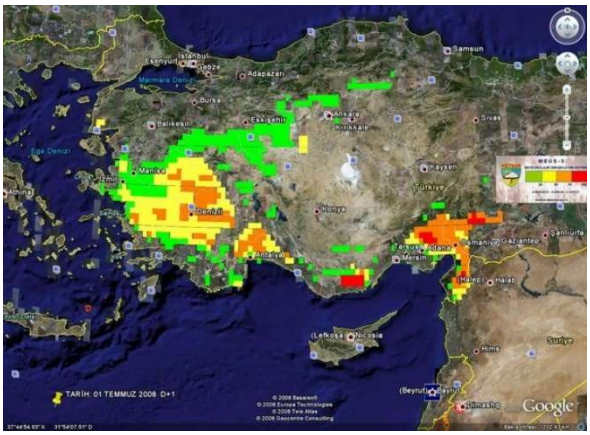


Figure 10: The MEUS demonstrating regions with a possible wildfire.

[14] OGM Muğla Regional Directorate Report of 2021

software program which includes almost 70 parameters to calculate the fire risk. This will enable them to work at the micro level.

4. Conclusion and Recommendations

In this research, the statistical method concluded low relationship between the weather conditions and forestry area burned but the applied method had drawbacks. In this analysis, only data with respect to Milas fires between 2018-2021 has been used. It was important to take the data for temperature, humidity, wind velocity and direction of the wind at that specific location at the time of the outbreak of the fire. However, although the data has been obtained directly by the data management division of the General Directorate of Forestry, data for all parameters were available only for 2018-2021. 4-year period may not be a sufficient data base.

Then the link between the meteorological factors and wildfires was analysed based on Turkey's average numbers on forest fires and weather conditions rather than specifically for Milas. For this, either the number of fires or the area burned must have been taken into consideration. Therefore, the link between the average forest area burned per fire has been analysed with graphics. This showed a strong correlation between weather conditions and the forest fires. However, using average numbers may cause loss of important information. In addition, it is not entirely reflecting conditions of Milas.

In addition to data analysis, studies and research showed that meteorological factors are not the only cause of fires because the sociological, economic and human factors are detrimental for the outbreak of the wildfires.

The analysis of a specific wildfire case, "2021 Milas Wildfires", enabled to make a conclusion by addressing qualitative issues which have not taken into consideration in the statistical and graphical analysis. "2021 Milas wildfires" is a very good example showing how both human and meteorological factors coming together can lead to wildfires. The research concluded that the meteorological conditions have significant impact on the outbreak, severity, pattern and duration of the wildfires while human behaviour is creating the enabling environment for wildfires and triggering them.

Increase of population, settlements close to forests, human activities, openings for constructions, infrastructure that do not consider peak times are increasing the forest fire risks. When meteorological thresholds have been exceeded at the same time, fires can quickly spread in significant heights.

To conclude, only climate-related factors affecting weather conditions do not fully explain the outbreak of fires. Climate change is increasing the frequency and severity of weather conducive to wildfire outbreaks and influence the likelihood, pattern, duration, extent, and finally impact of the fire.

This conclusion has been backed by the academic research. Various studies remarked that global warming lengthens the fire season in ecosystems that are prone to fires and increases the frequency of fire-prone years in ecosystems.

Through interviews, it has been understood that predicting the weather conditions is crucial to prevent wildfires but not sufficient. Models including more parameters such as the type of the vegetation, land-use changes, fuel fragmentation, demographic changes, etc. are necessary. In addition, Milas wildfires case showed that to be properly equipped is crucial to combat with wildfires.

Eliminating the risk of wildfires is not possible, but much can be done to manage and reduce risks. Preparedness can be increased by measures such as restriction of activities that might lead to accidental fire ignitions; management of vegetation and vegetation debris (wildfire fuel) to decrease fire hazard prior to wildfires occurring; creating buffer zones, building access roads; increasing institutional capacity, providing proper equipment, improving information systems capacity, closely monitoring, increasing awareness, conducting trainings; incorporating forest fire risk in city planning and in migration management.

How can the risk of outbreak of wildfires be incorporated into the city plannings?

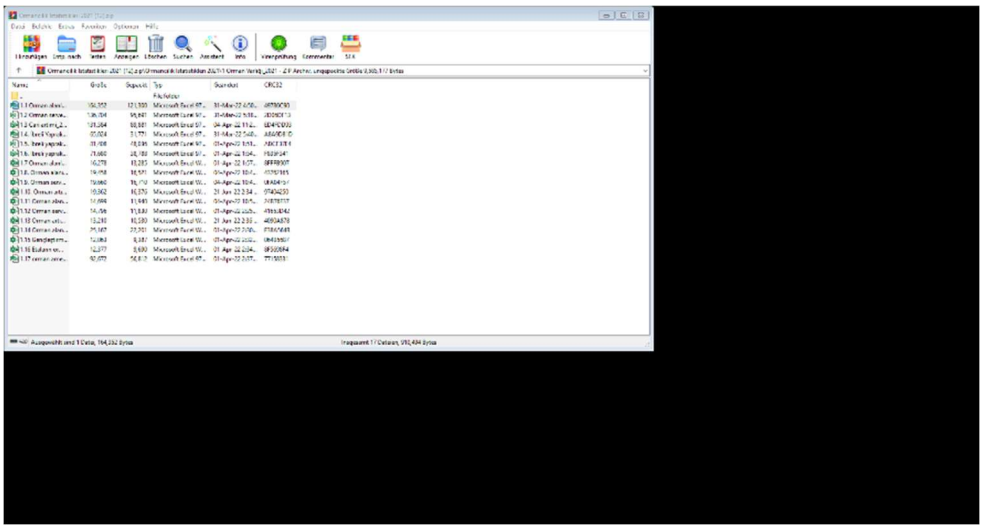
Appendix 1: Forest Fires in Turkey 1988-2021

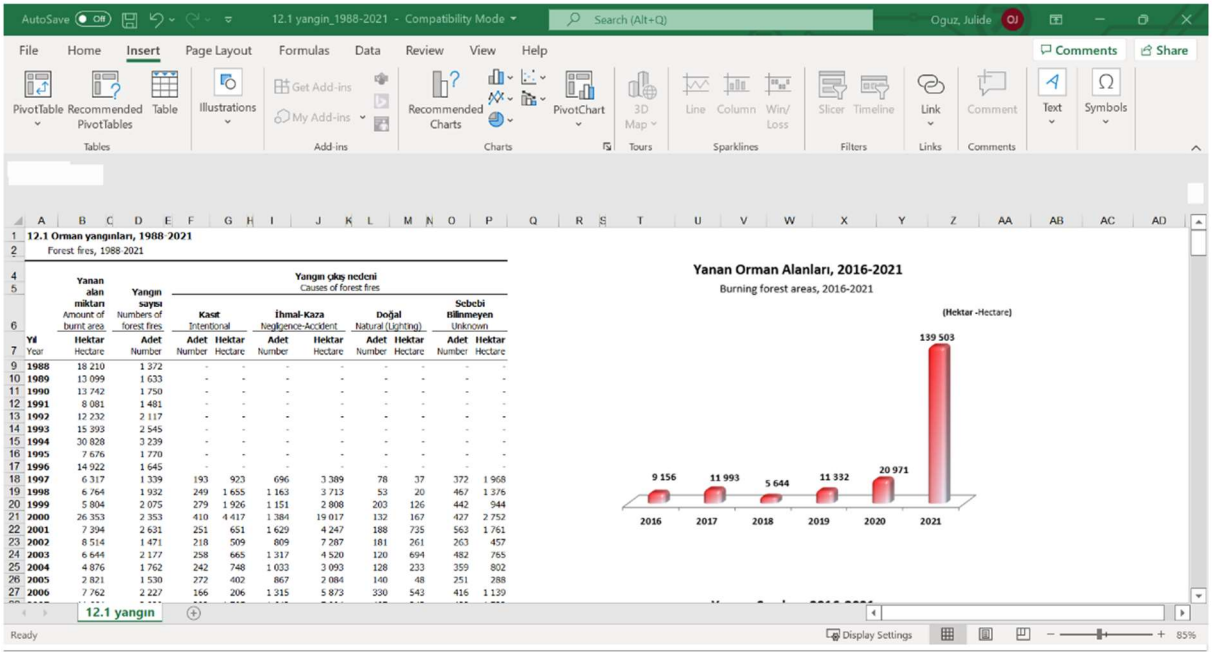
Source: General Directorate of Forestry, Ministry of Agriculture and Forestry

Forest Fires in Turkey										
			Intentional (Kasıt)		Negligence		Natural		Unknown	
Years	Amount of burned area (hectares)	Numbers of forest fires	Number	Amount (Hectar)	Number	Amount (Hectar)	Number	Amount (Hectar)	Number	Amount (Hectar)
1988	18,210	1,372								
1989	13,099	1,633								
1990	13,742	1,750								
1991	8,081	1,481								
1992	12,232	2,117								
1993	15,393	2,545								
1994	30,828	3,239								
1995	7,676	1,770								
1996	14,922	1,645								
1997	6,317	1,339	193	923	696	3,389	78	37	372	1,968
1998	6,764	1,932	249	1,655	1,163	3,713	53	20	467	1,376
1999	5,804	2,075	279	1,926	1,151	2,808	203	126	442	944
2000	26,353	2,353	410	4,417	1,384	19,017	132	167	427	2,752
2001	7,394	2,631	251	651	1,629	4,247	188	735	563	1,761
2002	8,514	1,471	218	509	809	7,287	181	261	263	457
2003	6,644	2,177	258	665	1,317	4,520	120	694	482	765
2004	4,876	1,762	242	748	1,033	3,093	128	233	359	802
2005	2,821	1,530	272	402	867	2,084	140	48	251	288
2006	7,762	2,227	166	206	1,315	5,873	330	543	416	1,139
2007	11,664	2,829	292	1,705	1,642	7,994	407	243	488	1,722
2008	29,749	2,135	377	797	1,018	26,283	330	699	410	1,970
2009	4,679	1,793	231	792	884	3,082	333	105	345	700
2010	3,317	1,861	146	526	861	1,851	281	69	573	871
2011	3,612	1,954	153	283	1,067	2,368	130	39	604	922
2012	10,454	2,450	197	1,615	936	5,780	373	334	944	2,725
2013	11,456	3,755	260	1,478	1,419	4,051	258	138	1,818	5,789
2014	3,117	2,149	127	85	801	1,682	328	77	893	1,273
2015	3,219	2,150	138	167	794	1,198	257	95	961	1,759
2016	9,156	3,188	157	240	990	5,222	310	170	1,731	3,524
2017	11,993	2,411	151	619	721	7,146	259	84	1,280	4,144
2018	5,644	2,167	92	148	693	2,216	413	141	969	3,139
2019	11,332	2,688	124	686	883	6,529	372	373	1,309	3,744
2020	20,971	3,399	72	718	1,156	8,285	312	197	1,859	11,771
2021	139,503	2,793	110	46,147	1,001	46,879	353	208	1,329	46,269

Source: General Directorate of Forestry, Ministry of Agriculture and Forestry

Raw Data Tables

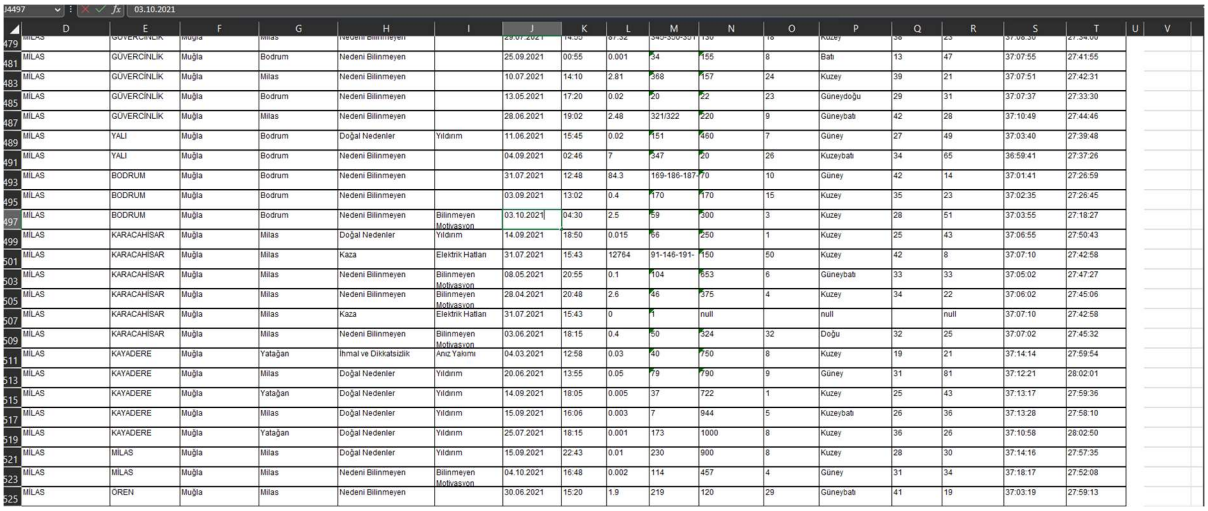




12.1 Orman yangınları, 1988-2021

Forest fires, 1988-2021

Yıl Year	Yanan alan miktarı Amount of burnt area (Hektar Hectare)	Yangın sayısı Numbers of forest fires (Adet Number)	Yangın çıkış nedeni Causes of forest fires: Kasıt Intentional (Adet Number)	Kasıt Intentional (Hektar Hectare)	İhmal-Kaza Negligence-Accident (Adet Number)	İhmal-Kaza Negligence-Accident (Hektar Hectare)	Doğal Natural (Lighting) (Adet Number)	Doğal Natural (Lighting) (Hektar Hectare)	Sebebi Bilinmeyen Unknown (Adet Number)	Sebebi Bilinmeyen Unknown (Hektar Hectare)
1988	18 210	1 372	-	-	-	-	-	-	-	-
1989	13 099	1 633	-	-	-	-	-	-	-	-
1990	13 742	1 750	-	-	-	-	-	-	-	-
1991	8 081	1 481	-	-	-	-	-	-	-	-
1992	12 232	2 117	-	-	-	-	-	-	-	-
1993	15 393	2 545	-	-	-	-	-	-	-	-
1994	30 828	3 239	-	-	-	-	-	-	-	-
1995	7 676	1 770	-	-	-	-	-	-	-	-
1996	14 922	1 645	-	-	-	-	-	-	-	-
1997	6 317	1 339	193	923	696	3 389	78	37	372	1 968
1998	6 764	1 932	249	1 655	1 163	3 713	53	20	467	1 376
1999	5 804	2 075	279	1 926	1 151	2 808	203	126	442	944
2000	26 353	2 353	410	4 417	1 384	19 017	132	167	427	2 752
2001	7 394	2 631	251	651	1 629	4 247	188	725	563	1 761
2002	8 514	1 471	218	509	809	7 287	181	261	263	457
2003	6 644	2 177	258	665	1 317	4 520	120	694	482	755
2004	4 876	1 762	242	748	1 033	3 093	128	233	359	802
2005	2 821	1 530	272	402	867	2 084	140	48	251	288
2006	7 762	2 227	166	206	1 315	5 873	330	543	416	1 139



MILAS	GÜVERCİNLİK	Muğla	Bodrum	Nedeni Bilinmeyen		25.09.2021	00:55	0.001	54	155	8	Batı	13	47	37:07:55	27:41:55
MILAS	GÜVERCİNLİK	Muğla	Milas	Nedeni Bilinmeyen		10.07.2021	14:10	2.81	388	157	24	Kuzey	39	21	37:07:51	27:42:31
MILAS	GÜVERCİNLİK	Muğla	Bodrum	Nedeni Bilinmeyen		13.05.2021	17:20	0.02	20	22	23	Güneydoğu	29	31	37:07:37	27:33:30
MILAS	GÜVERCİNLİK	Muğla	Milas	Nedeni Bilinmeyen		28.06.2021	19:02	2.48	321/322	220	9	Güneybatı	42	28	37:10:49	27:44:46
MILAS	YALI	Muğla	Bodrum	Doğal Nedenler	Yıldırım	11.06.2021	15:45	0.02	151	460	7	Güney	27	49	37:03:40	27:39:48
MILAS	YALI	Muğla	Bodrum	Nedeni Bilinmeyen		04.09.2021	02:46	7	347	20	26	Kuzeybatı	34	65	36:59:41	27:37:26
MILAS	BODRUM	Muğla	Bodrum	Nedeni Bilinmeyen		31.07.2021	12:48	84.3	169-186-187	70	10	Güney	42	14	37:01:41	27:26:59
MILAS	BODRUM	Muğla	Bodrum	Nedeni Bilinmeyen		03.09.2021	13:02	0.4	170	170	15	Kuzey	35	23	37:02:35	27:26:45
MILAS	BODRUM	Muğla	Bodrum	Nedeni Bilinmeyen	Bilinmeyen Motivasyon	03.10.2021	04:30	2.5	59	500	3	Kuzey	28	51	37:03:55	27:18:27
MILAS	KARACAHİSAR	Muğla	Milas	Doğal Nedenler	Yıldırım	14.09.2021	18:50	0.015	66	250	1	Kuzey	25	43	37:06:55	27:50:43
MILAS	KARACAHİSAR	Muğla	Milas	Kaza	Elektrik Hattları	31.07.2021	15:43	12764	91-146-191-	150	50	Kuzey	42	8	37:07:10	27:42:58
MILAS	KARACAHİSAR	Muğla	Milas	Nedeni Bilinmeyen	Bilinmeyen Motivasyon	08.05.2021	20:55	0.1	104	653	6	Güneybatı	33	33	37:05:02	27:47:27
MILAS	KARACAHİSAR	Muğla	Milas	Nedeni Bilinmeyen	Bilinmeyen Motivasyon	28.04.2021	20:48	2.6	46	375	4	Kuzey	34	22	37:06:02	27:45:06
MILAS	KARACAHİSAR	Muğla	Milas	Kaza	Elektrik Hattları	31.07.2021	15:43	0	1	null		null		null	37:07:10	27:42:58
MILAS	KARACAHİSAR	Muğla	Milas	Nedeni Bilinmeyen	Bilinmeyen Motivasyon	03.06.2021	18:15	0.4	50	524	32	Doğu	32	25	37:07:02	27:45:32
MILAS	KAYADERE	Muğla	Yatağan	İhmal ve Dikkatsizlik	Anız Yakımı	04.03.2021	12:58	0.03	49	750	8	Kuzey	19	21	37:14:14	27:59:54
MILAS	KAYADERE	Muğla	Milas	Doğal Nedenler	Yıldırım	20.06.2021	13:55	0.05	79	790	9	Güney	31	81	37:12:21	28:02:01
MILAS	KAYADERE	Muğla	Yatağan	Doğal Nedenler	Yıldırım	14.09.2021	18:05	0.005	37	722	1	Kuzey	25	43	37:13:17	27:59:36
MILAS	KAYADERE	Muğla	Milas	Doğal Nedenler	Yıldırım	15.09.2021	16:06	0.003	7	944	5	Kuzeybatı	26	36	37:13:28	27:58:10
MILAS	KAYADERE	Muğla	Yatağan	Doğal Nedenler	Yıldırım	25.07.2021	18:15	0.001	173	1000	8	Kuzey	36	26	37:10:58	28:02:50
MILAS	MILAS	Muğla	Milas	Doğal Nedenler	Yıldırım	15.09.2021	22:43	0.01	230	900	8	Kuzey	28	30	37:14:16	27:57:35
MILAS	MILAS	Muğla	Milas	Nedeni Bilinmeyen	Bilinmeyen Motivasyon	04.10.2021	16:48	0.002	114	457	4	Güney	31	34	37:18:17	27:52:08
MILAS	ÖREN	Muğla	Milas	Nedeni Bilinmeyen		30.06.2021	15:20	1.9	219	120	29	Güneybatı	41	19	37:03:19	27:59:13

Appendix 2: Data on Forest Fires, Average Temperature, Relative Humidity, Precipitation

Year	Burned Area	Number of Fires	Area burned/Fire	Average Temperature	Average Relative Humidity	Precipitation
1990	13,742	1,750	8	12.9	63.6	63.6
1991	8,081	1,481	5	12.7	66.7	66.7
1992	12,232	2,117	6	11.4	64.7	64.7
1993	15,393	2,545	6	12.3	64.5	64.5
1994	30,828	3,239	10	13.7	64.8	64.8
1995	7,676	1,770	4	13.1	65.8	65.8
1996	14,922	1,645	9	13.3	66.2	66.2
1997	6,317	1,339	5	12.5	65.6	65.6
1998	6,764	1,932	4	13.8	65.4	65.4
1999	5,804	2,075	3	14.1	63.4	63.4
2000	26,353	2,353	11	13.1	62.7	62.7
2001	7,394	2,631	3	14.2	63.0	63.0
2002	8,514	1,471	6	13.2	64.2	64.2
2003	6,644	2,177	3	13.2	63.7	63.7
2004	4,876	1,762	3	13.2	62.2	62.2
2005	2,821	1,530	2	13.3	63.2	63.2
2006	7,762	2,227	3	13.3	63.6	63.6
2007	11,664	2,829	4	13.8	61.3	61.3
2008	29,749	2,135	14	13.6	61.0	61.0
2009	4,679	1,793	3	13.7	63.8	63.8
2010	3,317	1,861	2	15.1	62.9	62.9
2011	3,612	1,954	2	12.8	63.1	63.1
2012	10,454	2,450	4	13.8	62.1	62.1
2013	11,456	3,755	3	13.8	59.6	59.6
2014	3,117	2,149	1	14.5	62.6	62.6
2015	3,219	2,150	1	13.8	62.4	62.4
2016	9,156	3,188	3	14.0	61.1	61.1
2017	11,993	2,411	5	13.7	61.5	61.5
2018	5,644	2,167	3	15.1	64.4	64.4
2019	11,332	2,688	4	14.4	63.4	63.4
2020	20,971	3,399	6	14.6	61.6	61.6
2021	139,503	2,793	50	14.5	60.6	60.6

Source: General Directorate of Meteorology, Ministry of Environment, Urbanization and Climate Change

Appendix 3: Calculations of coefficient of Correlation for each meteorological parameter

Temperature

$$\bar{x} = \frac{33+27+\cdots+12+32}{232} = 28.7026$$

$$\bar{y} = \frac{2+0.01+\cdots+1.52+0.87}{233} = 59.199$$

$$\Sigma(x_i - \bar{x})^2 = (33-28.7)^2+(27-28.7)^2+\cdots+(12-28.7)^2+(32-28.7)^2 = 14304.4784$$

$$\Sigma(y_i - \bar{y})^2 = (2-59.2)^2+(0.01-59.2)^2+\cdots+(0.1-59.2)^2+(1.52-59.2)^2 = 162183376.1$$

$$\Sigma(x_i - \bar{x})(y_i - \bar{y}) = (33-28.7)*(2-59.2)+(27-28.7)*(0.01-59.2)+\cdots+(12-28.7)*(0.1-59.2)+(32-28.7)*(1.52-59.2) = 173962.0219$$

$$S_{XY} = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{n - 1}$$

$$S_{XY} = \frac{173962.0219}{232 - 1} = 751.4655$$

$$r = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{(\Sigma(x_i - \bar{x})^2\Sigma(y_i - \bar{y})^2)}}$$

$$r = \frac{173962.0219}{\sqrt{(14304.4784*162183376.1)}} = \mathbf{0.1142}$$

Velocity of the wind

$$\bar{x} = \frac{35+9+\cdots+3+23}{221} = 10.6652$$

$$\bar{y} = \frac{2+0.01+\cdots+0.01+0.6}{222} = 62.0899$$

$$\Sigma(x_i - \bar{x})^2 = (35-10.67)^2+(9-10.67)^2+\cdots+(3-10.67)^2+(23-10.67)^2 = 17783.2217$$

$$\Sigma(y_i - \bar{y})^2 = (2-62.09)^2+(0.01-62.09)^2+\cdots+(0.001-62.09)^2+(0.01-62.09)^2 = 162143686$$

$$\Sigma(x_i - \bar{x})(y_i - \bar{y}) = (35-10.67)*(2-62.09)+(9-10.67)*(0.01-62.09)+\cdots+(3-10.67)*(0.001-62.09)+(23-10.67)*(0.01-62.09) = 504924.5501$$

$$S_{XY} = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{n - 1}$$

$$S_{XY} = \frac{504924.5501}{221 - 1} = 2289.9398$$

$$r = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{}$$

$$r = \frac{\sqrt{(\Sigma(x_i - \bar{x})^2 \Sigma(y_i - \bar{y})^2)}}{504924.5501} = \frac{}{\sqrt{(17783.2217*162143686)}} = \mathbf{0.2974}$$

Humidity

$$\bar{x} = \frac{11+43+ \cdots +8+33}{102} = 37.8725$$

$$\bar{y} = \frac{2+0.005+ \cdots +0.01+0.002}{102} = 129.5563$$

$$\Sigma(x_i - \bar{x})^2 = (11-37.87)^2+(43-37.87)^2+ \cdots +(8-37.87)^2+(33-37.87)^2 = 33037.3431$$

$$\Sigma(y_i - \bar{y})^2 = (2-129.56)^2+(0.005-129.56)^2+ \cdots +(0.01-129.56)^2+(0.002-129.56)^2 = 161249631.3$$

$$\Sigma(x_i - \bar{x})(y_i - \bar{y}) = (11-37.87)*(2-129.56)+(43-37.87)*(0.005-129.56)+ \cdots +(8-37.87)*(0.01-129.56)+(33-37.87)*(0.002-129.56) = -384708.7934$$

$$S_{XY} = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{n - 1}$$

$$S_{XY} = \frac{-384708.7934}{102 - 1} = -3808.998$$

$$r = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{(\Sigma(x_i - \bar{x})^2 \Sigma(y_i - \bar{y})^2)}}$$

$$r = \frac{-384708.7934}{\sqrt{(33037.3431*161249631.3)}} = \mathbf{-0.1667}$$