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APPLICATION OF GIS AND AHP IN THE ASSESSMENT OF FOREST FIRES VULNERABILITY IN THE PČINJA DISTIRCT

Abstract: Due to the increasing human impact on the planet's climate, most often negative, in response, major changes occur that require subsequent efforts to "rehabilitate". One of those problems, especially in the last quarter century, is problem of forest fires. Due to increasing temperatures, especially in the summer, forest fires have become a frequent occurrence, which is also the case in Serbia. Therefore, the application of GIS systems and Analytic Hierarchy Process (AHP) methods represent important tools for achieving the above-mentioned goals and combating the problems that surround us. The main goal in this study is to determine the main explanatory variables for forest fire occurrence using AHP model and GIS systems. They have their advantages and disadvantages, but here the emphasis is on the positive effect and the use of their advantages in presenting possible solutions to solvable problems. The final map can serve as a basis for showing potential hotspots for forest fires. The final fig. present model of vulnerability of making forest fires in Pčinja district. The area with the lowest vulnerability is around lake Vlasina in north-east part of district and represents 3.5% of the entire territory and the area with highest vulnerability is in south-west area with 6.1% coverage of area.

Keywords: wildfires, environment, AHP method, estimation, vulnerability level, multi-criteria analysis

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Introduction

Wildfires, a subset of wildfires that occur in wildland areas, including forests, grasslands, and scrublands, cause significant ecological consequences, including soil erosion, changes in hydrology, increased greenhouse gas emissions, and contributions to global warming. These effects destabilize ecosystems and threaten vital resources for human well-being (Durlević et al., 2025).

The territory of the Republic of Serbia is the most vulnerable by earthquakes, landslides, riverine and torrential floods, hailstorms, droughts, and forest fires, which are the most frequent and the most destructive natural disasters regarding huge material damage and loss of human lives. In the last few decades, upward trends in both the number of forest fire events and burned areas have been confirmed in Europe. In relation with climate changes, during the high-temperature summer months, the number of forest fires in Serbia has been increasing from year to year. Forest area in the Republic of Serbia covers 27,200 km^2, which is approximately 31.1% of the country area (Gigović et al., 2019).

In the recent past, examples of fires in protected natural areas in Serbia have not been so rare. According to the most accurate data, 7.66% or 677,950 ha of the total area of Serbia is under legal protection, in accordance with the nature protection law (Novkovic et al., 2021).

To minimize the harmful effects of forest fires, it is necessary to create an effective fire protection system. According to San Miguel-Ajanco, from Milanović et al., 2021 forest fire risk is defined as the probability of a fire occurring and its consequences. Therefore, any increase in the probability of a fire or its consequences directly results in an increase in fire risk. In their research is focused on mapping the probability of forest fires as an integral part of a future forest fire risk assessment system.

According to Xu et al. (2025) from Durlević et al., (2025) in contrast to climatological indices or multi-criteria methods with pre-defined weighted schemas, machine and deep learning models offer a more flexible and data-driven framework for wildfire prediction.

This paper presents the topic of processing quantitative and qualitative data to calculate the possibility of occurrence (and the area that would be affected) of forest fires in the territory of the Pčinja District. It will primarily present the geographical location of the district itself, along with accompanying basic geo-physical and socio-geographical information. Following this, the concepts of Geographic Information Systems (hereinafter referred to as GIS) and the application of the Analytic Hierarchy Process (hereinafter referred to as the AHP method) will be explained, along with their relevance to the topic of forest fires which are becoming increasingly frequent due to the growing number of tropical days (and nights) in this region as a result of rapid climate change over the past thirty years.

Analyzing the number of forest fires, Lukić and colleagues found that the number of forest fires in Serbia increased during the period from 2000 to 2012, but that this increase was not statistically significant. The highest number of fires (28,546) occurred in 2007 in Serbia, when the highest air temperature was recorded on July 24 at the Smederevska Palanka meteorological station (temperature of 44.9 °C) (Novkovic et al., 2021).

The paper presents the methodology, including the application of the AHP method to the district area, starting with the preparatory phase of selecting criteria, calculating the weighting coefficients for each criterion, and providing explanations related to each criterion in the context of the specific area. Finally, the process of producing the final evaluation Fig. will be described, followed by concluding remarks.

By presenting each criterion individually, the current state of all criteria will be presented, along with general information related to each topic. Advances in Earth observation technology and GIS tools have addressed many of the model's limitations, reducing subjectivity and enabling global application.

These improvements have enabled automated geospatial assessments, mapping of land loss, and predicting erosion rates under climate change scenarios. Modifications to the original methodology have also expanded its applicability to diverse geographic conditions (Durlević et al., 2025). The use of GIS is inevitable today when it comes to spatial research. This is of utmost importance in order to achieve an adequate understanding of the environment and the processes that take place in it (Novkovic et al., 2021).

Fire probability mapping is a fundamental tool in risk management and allows for the allocation of fire suppression resources during the fire season, from areas with lower risk to areas with higher threat. Also, in the long term, fire probability mapping is a very valuable tool in forest management planning, which improves the resilience of forests to fire by applying different types of preventive logging and silvicultural measures (Milanović et al., 2021).

The aim of the research is to demonstrate the potential and spatial distribution of forest fire vulnerability in the study area through the application of Geographic Information Systems (GIS) and the Analytic Hierarchy Process (AHP).
In conclusion, the paper will emphasize how cause-and-effect anthropogenic factors, when combined with natural hazards, significantly increase the likelihood of forest fire occurrence. In this paper, the main research objectives are: 1) Correct calculation and presentation of the Analytical Hierarchy Model and 2) Creation of cartographic representations of fire probability zones in the researched area.

Study area

The Pčinja District is located in the southern part of the Republic of Serbia. It borders the Jablanica District to the north and the Kosovo-Pomoravlje Administrative District to the west. The southern boundary of the district forms the border with the Republic of North Macedonia, while the eastern boundary borders the Republic of Bulgaria, as shown on Figure 1.

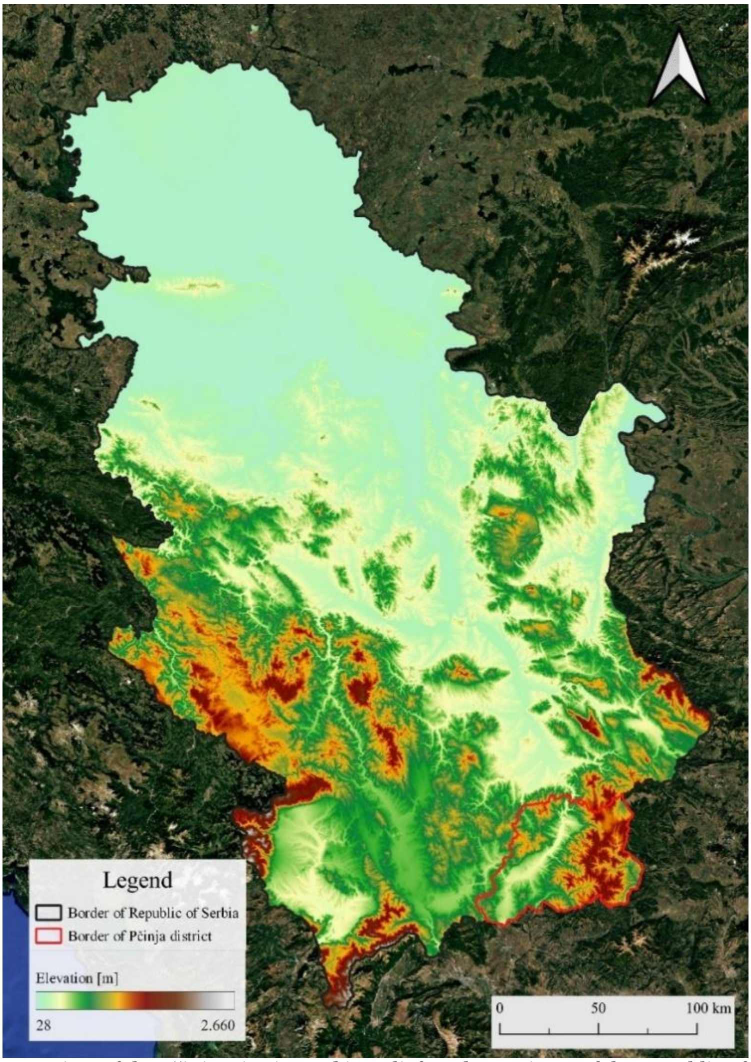

Fig. 1. Overview of the Pčinja District and its relief on the territory of the Republic of Serbia (Source: https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1?tab=download)

Methodology

The Analytic Hierarchy Process (AHP) is one of the most well-known and commonly used multi-criteria decision-making methods when the decision-making process i.e. the selection of one of the available alternatives is based on multiple criteria of different importance. One of the most broadly applied models for multi-criteria decision-making is the Analytic Hierarchy Process (AHP), which enables the ranking of alternatives or the selection of optimal alternatives based on a hierarchical structure of goals, criteria, and sub-criteria (Saaty, 1980).

From a methodological standpoint, AHP is a multi-criteria technique that relies on decomposing a complex problem into a simpler form. The goal is positioned at the top of the hierarchy, while the criteria, sub-criteria, and alternatives are placed at lower levels of the hierarchical structure.

The goal, which is part of the hierarchically structured model, is positioned at the top level and is not compared with any other element within the scheme. At Level 1, there are *n* criteria, which are compared in pairs, each with the others in relation to the parent element, i.e., the goal (Saaty, 1980).

The AHP consists of several previously existing but unconnected techniques that were unified and harmonized by Saaty to create a process whose overall power far exceeds the sum of its individual parts (Forman & Selly, 2001). It is a compensatory decision-making method, as alternatives that do not align with one or more goals can be compensated by their positive impact on the achievement of other goals.

This method provides flexibility in decision-making and helps decision-makers prioritize criteria based on their importance in order to reach a well-founded decision (Yang & Dense, 2012).

The method was developed by Thomas Saaty in the early 1970s and has since been a highly significant method for multi-criteria decision-making. Its application consists of four main phases:

1. Problem structuring;
2. Data collection;
3. Evaluation of relevant weights;
4. Determination of the solution to the problem (Hadi-Vencheh & Mohamadghasemi, 2012).

Its application enables the creation of a problem hierarchy, which serves as a preparation for decision-making, after which pairs of criteria and alternatives are compared, and finally, a synthesis of all comparisons is performed and the weighting coefficients of all elements of the hierarchy are determined

The sum of the weight coefficients at all hierarchical levels should be equal one, which allows decision-makers to rank all elements of the hierarchy by importance (Cambron & Evans, 1991).

The key in calculation is to find weight coefficient (WC). After obtaining WC, the consistency of the calculation should be checked using the following formulas:

$$CI \text{ (Consistency Index)} = (\lambda max - n) / (n - 1) \;||\; CR \text{ (Consistency Ratio)} = CI / RI \quad (1)$$

Finally, if the Consistency Ratio (CR) is less than 0.1, the calculation is considered consistent, and the process can proceed. In this example, the calculation is consistent, and therefore, further work can continue.

Criteria are most commonly defined numerically on a scale from 1 to 5, where the following scale is applied: 1 (equal influence); 2 (weak influence); 3 (moderate influence); 4 (strong influence); 5 (very strong influence).

The final ranking of the alternatives is determined through the synthesis of results obtained at all levels. The advantages of using the AHP method are as follows: (Gokmenoglu & Alaghemand, 2015).

- The AHP method incorporates both qualitative and quantitative parameters in the decision-making process. Prior to the introduction of AHP, qualitative data were not considered in decision-making.
- It is minimally sensitive to estimation errors.
- Decision-making using AHP enhances understanding of the problem and strongly and quickly impacts the motivation of the decision-maker.
- The application of this method enables faster problem-solving with reduced costs.
- When used in group decision-making, this method significantly improves communication among group members, as they must reach consensus for each criterion.
- The decision-making results of this method not only include the ranking of alternatives but also provide information on the weight coefficients of criteria in relation to the goal, as well as sub-criteria in relation to the criteria.
- A major advantage is the availability of quality software tools that support the AHP method, such as **Expert Choice**.

Some of the disadvantages of applying the AHP method include:

- When dealing with complex problems, there are a large number of pairs to compare.
- Achieving consistency is very difficult.
- Inability to use incomparable alternatives.

Research Results

The Analytic Hierarchy Process (AHP) model applied to the Pčinja District began with the identification (selection) of key criteria for which a specific calculation was later performed that will be used by the author when calculating values and later applied when processing digital spatial data in the QGIS software.

As a result, by the end of this work, all quantitative and qualitative data are presented in the form of digital Fig. format. The criteria taken into consideration during the calculations and Figure development are presented in the table below:

Table 1. Overview of Selected Criteria by Type

Type	Name	Source	Unit of measurement
Climatic	*Air Temperature*	*https://www.worldclim.org/data/monthlywth.html*	°C
	Percipitation	*https://www.worldclim.org/data/monthlywth.html*	mm
	Wind speed	https://globalwindatlas.info/en/	m/s
Geomorphological	*Terrain slope*	https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1?tab=download	°
	Terrain aspect	https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1?tab=download	Side of the world
	Elevation	https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1?tab=download	m
Ecological	*Land Use*	https://land.copernicus.eu/en/products/corine-land-cover/clc2018	-
Anthropogenic	*DFR*	https://www.putevi-srbije.rs/index.php/	m
	DFS	https://data.humdata.org	m

All criteria presented in Table 2 are assigned a value of 1 (one), as each criterion is considered equally important by itself. However, based on the author's discretion, the criteria are ranked in the following order, from the most to the "least" important:

1. Air temperature
2. Land use
3. Precipitation
4. Wind speed
5. Terrain slope
6. Terrain aspect
7. Elevation
8. Distance from roads
9. Distance from settlements

All the listed criteria represent a hierarchy of importance for the study area. As a first step, it is necessary to define the relationships between the importance of the criteria. Since it has already been emphasized that not all criteria are equally important, it is necessary to determine to what extent one criterion is more important than another.

This is best illustrated in Table 2, where all mutual relationships between the set criteria are presented. In the end, the sum of all criteria is calculated individually, as this data will be crucial for calculating the weight coefficient, hereinafter referred to as WC, which is actually the most important calculation for further work in the software, aimed at obtaining the final evaluation Fig.

The criterion "Temperature" is set as the most important among all seven criteria. Based on it, the values of the other criteria were arbitrarily determined. "Land use" and "Precipitation" are rated slightly lower, with a score of 2; "Wind speed," "Slope," and "Aspect" are rated with a score of 3; "Elevation" is rated 5; while the two lowest-rated criteria are "Distance from roads" and "Distance from settlements," with scores of 7 and 9, respectively.

Table 2. Overview of the Criteria Hierarchy with Represented Pairwise Relationships

	Temperature	Land Use	Percipitation	Wind speed	Terrain slope	Aspect	Elevation	DFR	DFS
Temperature	1	2	2	3	3	3	5	7	9
Land Use	0,50	1	2	3	3	3	5	7	9
Percipitation	0,50	0,50	1	2	3	3	5	7	7
Wind speed	0,33	0,33	0,50	1	2	3	3	5	5
Slope	0,33	0,33	0,33	0,50	1	2	3	5	5
Aspect	0,33	0,33	0,33	0,33	0,50	1	3	3	3
Elevation	0,20	0,20	0,20	0,33	0,33	0,33	1	3	3
DFR	0,14	0,14	0,14	0,33	0,20	0,33	0,33	1	3
DFS	0,11	0,11	0,11	0,20	0,20	0,33	0,33	0,33	1
Sum	**3,5**	**5,0**	**6,6**	**10,7**	**13,2**	**16,0**	**25,7**	**38,3**	**45,0**

Source: Author

After assigning the initial scores, the rest of the table needs to be filled in. All remaining cells are filled by calculating the reciprocal values for a given criterion, the first column is filled based on the values from the first row, the second column from the second row, and so on.

The next step is the normalization of values, which is used to obtain the weight coefficients (hereinafter referred to as WC), which will later be used for further calculations.

The obtained "Sums" of each criterion from Table 2 are then divided by the sum of its criterion, resulting in new values presented in Table 3.

Table 3. Overview of the Newly Calculated Criterion Results and Weight Coefficients

	Tem-pera-	Land Use	Per-cipita-	Wind speed	Ter-rain	Aspect	Eleva-tion	DFR	DFS	Sum	WC
Tempera-ture	0,29	0,40	0,30	0,28	0,23	0,19	0,19	0,18	0,20	2,27	0,25
Land Use	0,14	0,20	0,30	0,28	0,23	0,19	0,19	0,18	0,20	1,92	0,21
Percipitation	0,14	0,10	0,15	0,19	0,23	0,19	0,19	0,18	0,16	1,53	0,17
Wind speed	0,10	0,07	0,08	0,09	0,15	0,19	0,12	0,13	0,11	1,03	0,11
Slope	0,10	0,07	0,05	0,05	0,08	0,13	0,12	0,13	0,11	0,82	0,09
Aspect	0,10	0,07	0,05	0,03	0,04	0,06	0,12	0,08	0,07	0,61	0,07
Elevation	0,06	0,04	0,03	0,03	0,03	0,02	0,04	0,08	0,07	0,39	0,04
DFR	0,04	0,03	0,02	0,03	0,02	0,02	0,01	0,03	0,07	0,26	0,03
DFS	0,03	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,02	0,17	0,02

Source: Author

To calculate the WC, it is first necessary to calculate a new "Sum", this is done by adding the calculated values for each row. After that, the WC is obtained by dividing the new "Sum" by the total number of criteria used in this study, which in this case is 9 (nine). Next, the nominal value of all criteria is calculated by multiplying each value from Table 1 by its corresponding weight coefficient. The resulting values are presented in Table 4.

The simplest way to check whether all calculations so far have been done correctly is to sum up all the WC criteria. If the total is different from 1.00 (one), the calculation has not been done correctly. In order to apply the formulas, we now need to use our initial table and multiply each value by the corresponding weight coefficient for that criterion each column should be multiplied by its respective weight coefficient.

After obtaining WC, the consistency of the calculation should be checked using the following formulas:

$$\text{CI (Consistency Index)} = (\lambda max - n) / (n - 1) \;||\; \text{CR (Consistency Ratio)} = CI / RI \quad (2)$$

Finally, if the Consistency Ratio (CR) is less than 0.1, the calculation is considered consistent, and the process can proceed. In this example, the calculation is consistent, and therefore, further work can continue.

Table 4. Overview of the Calculated Nominal Values for Each Criterion and the Maximum Eigenvalue of the Comparison Matrix (shown in Table L)

	Tempera-ture	Land Use	Percipita-tion	Wind speed	Terrain slope	Aspect	Elevation	DFR	DFS	Sum	L
Tempera-ture	0,25	0,43	0,34	0,34	0,27	0,20	0,22	0,21	0,17	2,43	9,65
Land Use	0,13	0,21	0,34	0,34	0,27	0,20	0,22	0,21	0,17	2,09	9,80
Percipita-tion	0,13	0,11	0,17	0,23	0,27	0,20	0,22	0,21	0,13	1,66	9,77
Wind speed	0,08	0,07	0,09	0,11	0,18	0,20	0,13	0,15	0,09	1,11	9,70
Slope	0,08	0,07	0,06	0,06	0,09	0,13	0,13	0,15	0,09	0,87	9,51
Aspect	0,08	0,07	0,06	0,04	0,05	0,07	0,13	0,09	0,06	0,64	9,45
Elevation	0,05	0,04	0,03	0,04	0,03	0,02	0,04	0,09	0,06	0,41	9,39
DFR	0,04	0,03	0,02	0,04	0,02	0,02	0,01	0,03	0,06	0,27	9,19
DFS	0,03	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,02	0,18	9,39

Source: Author

CL = 0.100
CR = 0.068 – calculation is consistent.

After completing the calculations and obtaining the weight coefficients as well as the consistency check, the next steps involve working in the QGIS software, where the obtained parameters will be applied to digitize and display the calculations in the form of Figs. The criteria that will be used for designing the Figs are shown in Table 5.

Table 5. Overview of selected design criteria with their vulnerability levels

Criteria - name -	**Intensity of criteria – vulnerability level (fire occurrence)**				
	Very low [1]	**Low[2]**	**Moderate [3]**	**High [4]**	**Very High [5]**
	Separate criteria for each instance				
Air Tempereature	13 - 14	15 - 16	17 - 18	18 - 19	19 - 20
Land Use	Water bodies	Swamps	Built-up areas	Agricultural areas	Forest areas
Percipitation	56 - 60	52 - 56	48 - 52	44 - 48	40 - 44
Wind Speed	< 1,8	1,8 - 3,6	3,6 - 5,4	5,4 - 7	> 7
Terrain slope	< 5	5 - 10	10 - 20	20 - 30	> 30
Terrain aspect	without; N	NE;NW	E;W	SE;SW	S
Elevation	> 1600 m	1200 - 1600 m	800 - 1200 m	400 - 800 m	< 400 m
DFR	> 1500 m	1100 - 1500 m	700 - 1100 m	350 - 700 m	< 350 m
DFS	> 1500 m	1100 - 1500 m	700 - 1100 m	350 - 700 m	< 350 m

Source: Author

Evaluation of Results - Application to criteria

This section presents graphical representations for all previously listed criteria, using the aforementioned classification scale from "Very Low" [1] to "Very High" [5], as a gradation for displaying the probability of fire occurrence in the given areas.

Figs 2-11 refer to the previously established criteria, while Fig. 11 represents the final overview of all criteria. All overlays and graphical outputs were created using QGIS software. On the Fig. 11 shows that the eastern side of the district, especially around the lake Vlasina, is at the lowest vulnerability, while the western, especially southwestern parts are at the highest vulnerability of forest fire.

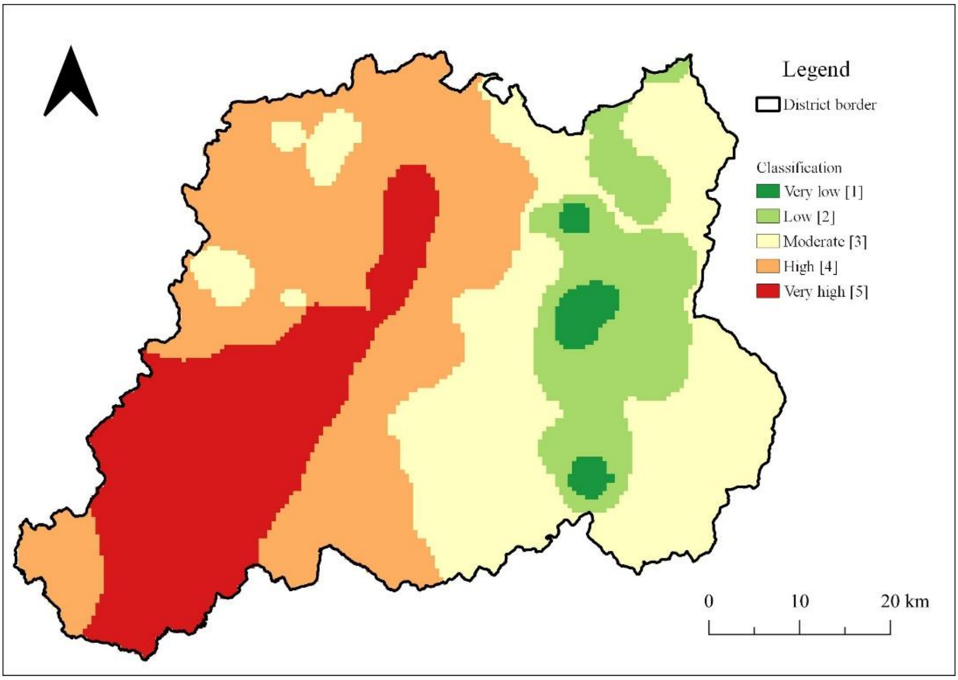

Fig. 2. Classification of the Air temperature

When processing data downloaded from the World Climate Organization website, raster layers for selected months (summer period) were inserted into the software itself and the data interpolation function (IDW Interpolation) was performed. The result is shown in Fig 2.

It's important to emphasize that the data was used exclusively for the period between June and September 2021 as an indicator of the highest chance of forest fires.

Given the enormous spread of forest cover and generally combustible material in the district, it is not surprising that the highest level of vulnerability is most prevalent in these areas, while it is least prevalent in water areas, as shown in Fig 3.

The classification, shown on Fig 4, shows that the highest vulnerability is related to the area of the southwestern part of the district, the stretch from Vranje to Preševo, while the lowest vulnerability is for the region of Čemernik and Vardenik, i.e. the western and northwestern parts of the district.

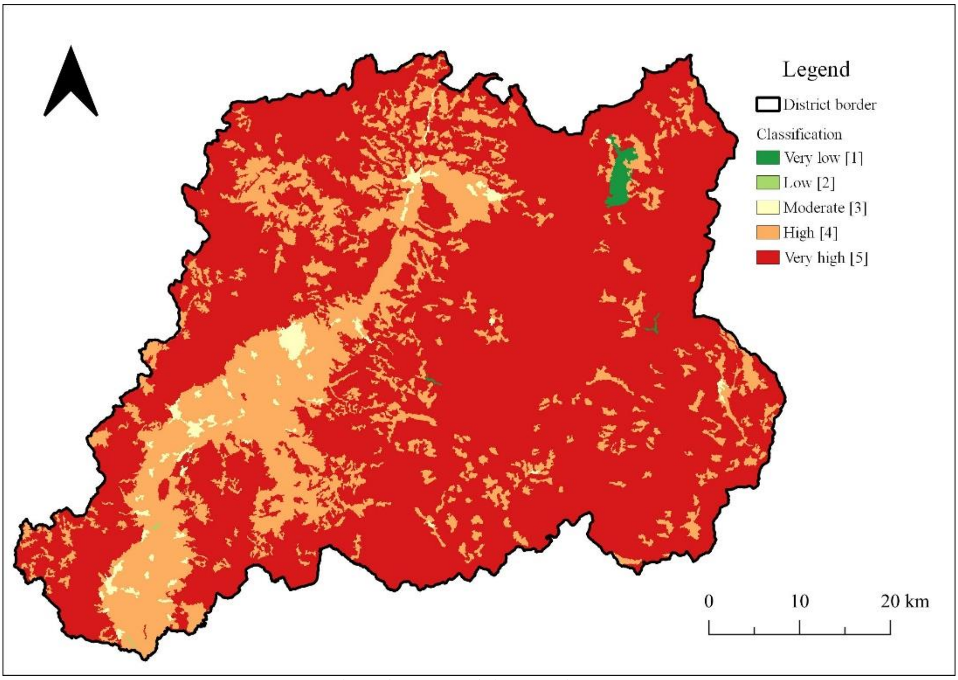

Fig. 3. Classification of the Land Use Criterion

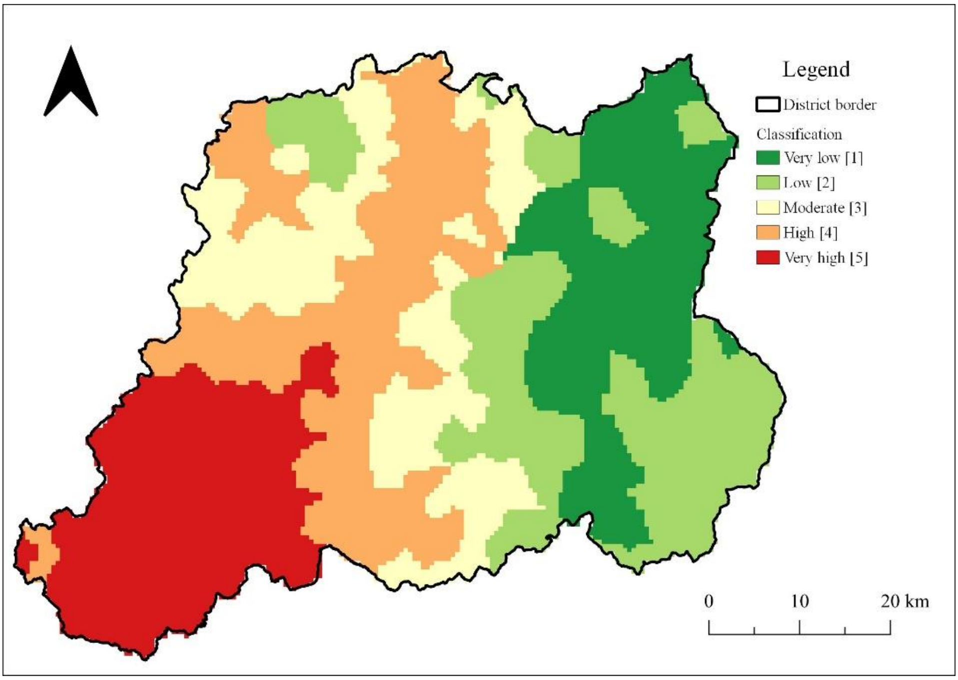

Fig. 4. Classification of the Precipitation Criterion (Period: June-August 2021)

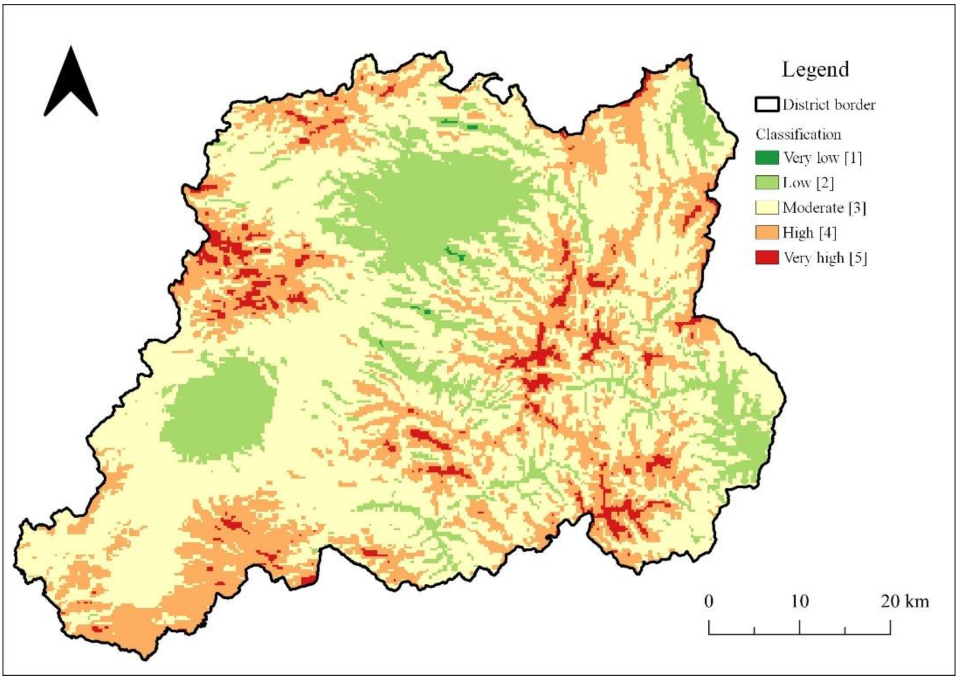

Fig. 5. Classification of the Wind Speed Criterion

The classification of the vulnerability level of wind impact is presented on Fig. 5. The highest vulnerability is in the hilly-mountainous massifs of Vardenik and Dukat, while the lowest vulnerability is shown through a pair of low-intensity "pockets" in the Vranje basin and the South Morava valley in general.

Wind direction and terrain slope are considered vector quantities, so slope can reduce the impact of wind on fire, but it can also increase it (Živković, 2018).

The classification presented in Fig 6. shows that the area of the aforementioned composite valley of the South Morava is the least vulnerability, while the slopes of Vardenik, not far from settlement Surdulica, are at the highest vulnerability for forest fires in the district.

On the sides that are more exposed to the Sun, fires occur more frequently, spread faster and have greater destructive power (Živković, 2018).

All categorized exposures have been reclassified and presented on Fig. 7. From the attached it can be seen that the southern exposures are the most endangered, which is about 11% in percentage terms, which also applies to the northern exposures, which with their 12% share in the total area are. The remaining exposures are arranged from low [2] to high [4]

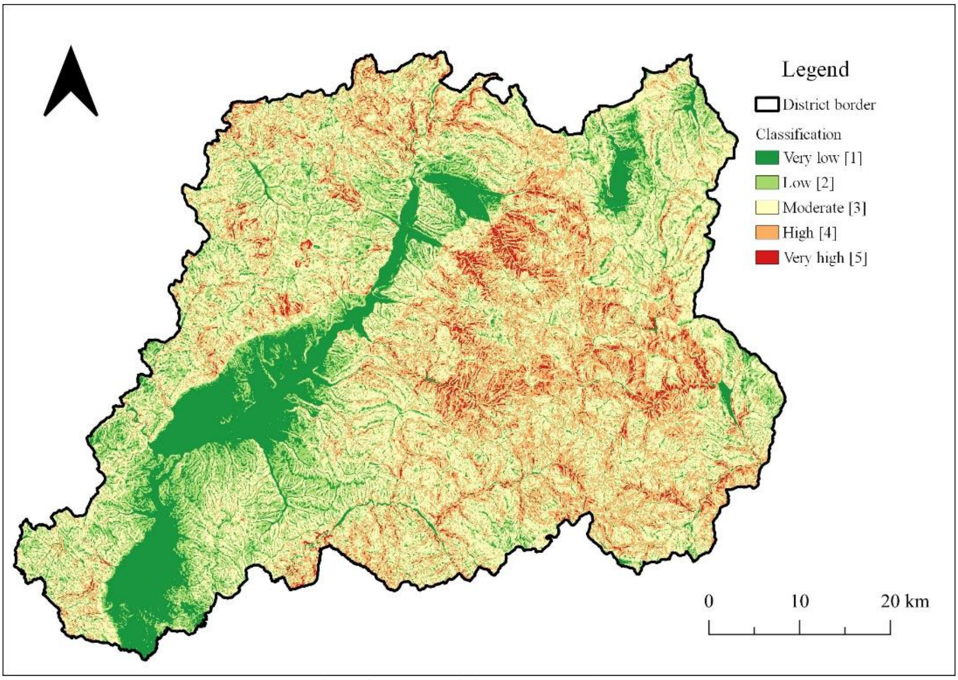

Fig. 6. Classification of the Terrain Slope Criterion

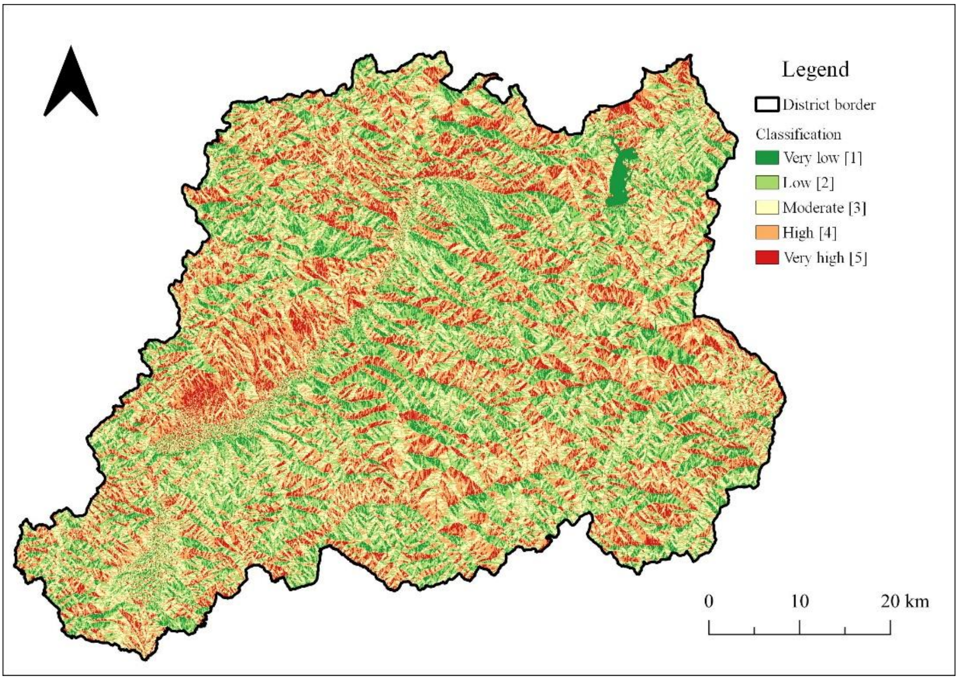

Fig. 7. Classification of the Terrain Aspect Criterion

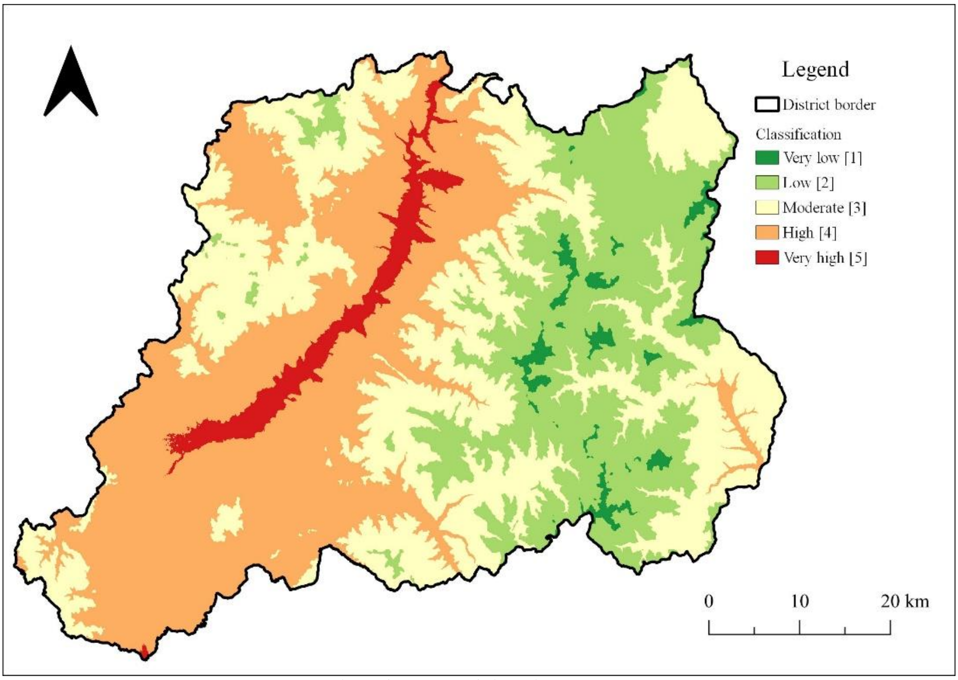

Fig. 8. Classification of the Elevation Criterion

In lower areas, especially in summer, the temperature is higher, so there is very little precipitation, which leads to drying out of fuel material and the possibility of its ignition (Videković, 2023).

Based on the Fig. 8, the greatest vulnerability is associated with the area of the South Morava valley, while the highest parts of the terrain stand out with very low possibilities of fire vulnerability in the area of the examined terrain. Distance from roads is another anthropogenic criterion used to calculate the possibility of fire occurrence. This criterion provides information on how important the spatial arrangement of primarily road infrastructure is in the entire process. Classification is represent in Fig. 9.

Distance from settlements is one of two anthropogenic criteria used to calculate the probability of wildfires. This criterion provides information on how much the spatial distribution of settlements in a given area increases or decreases the chances of wildfires in a given area. Classification and categorization, are therefore shown on Fig. 10, where the vulnerability scale is presented: Very low (1) – >1,500 meters; Low (2) – 1,100 – 1,000 meters; Moderate (3) – 700 – 1,100 meters; High (4) – 350 – 700 meters; Very high (5) – < 350 meters.

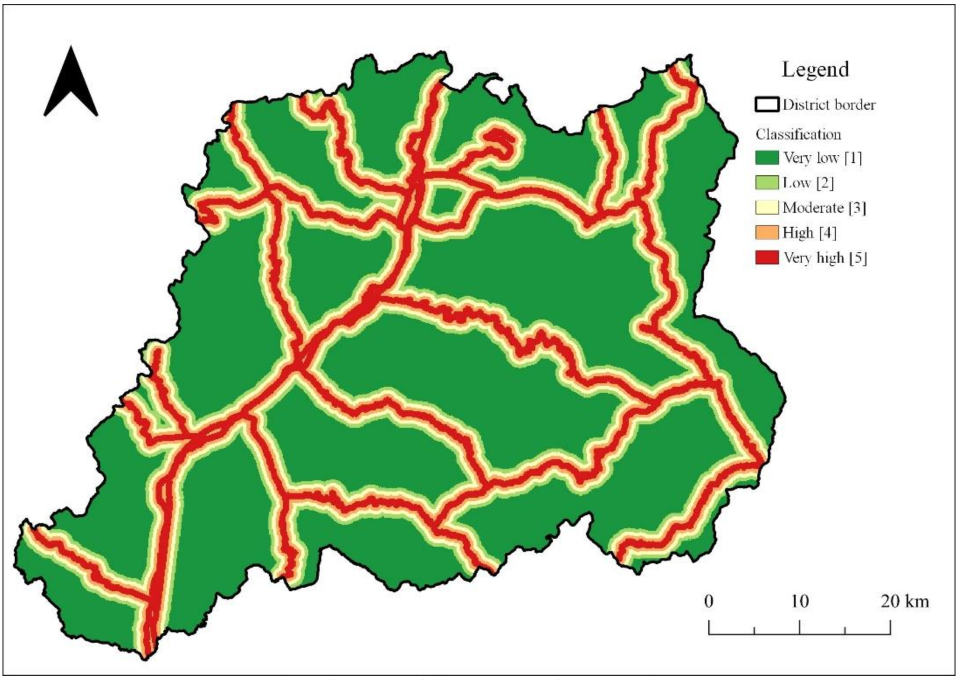

Fig. 9. Classification of the Distance from Roads Criterion

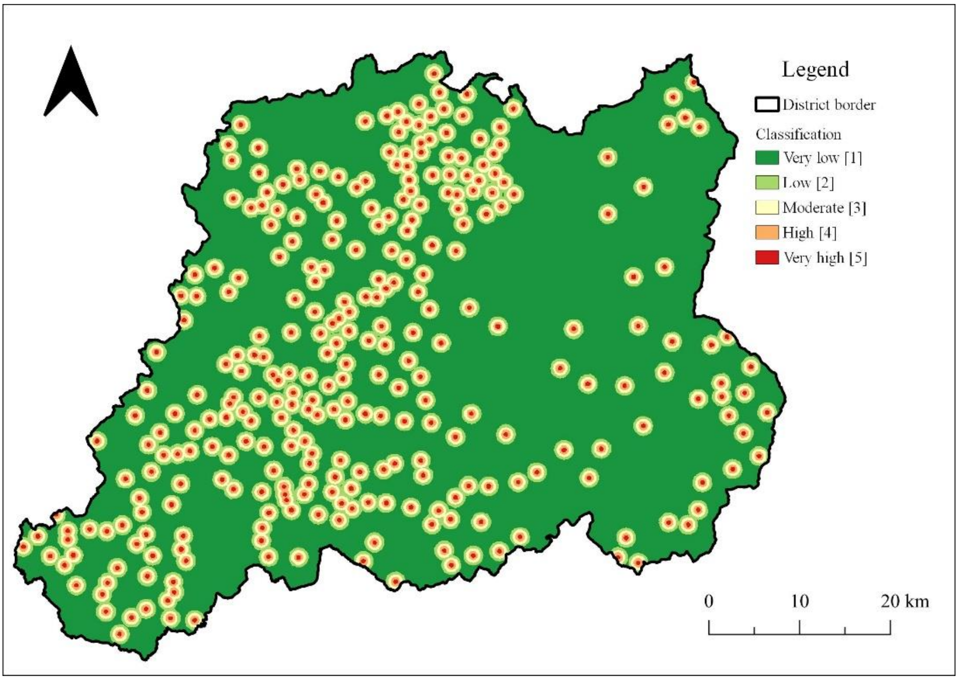

Fig. 10. Classification of the Distance from Settlements Criterion

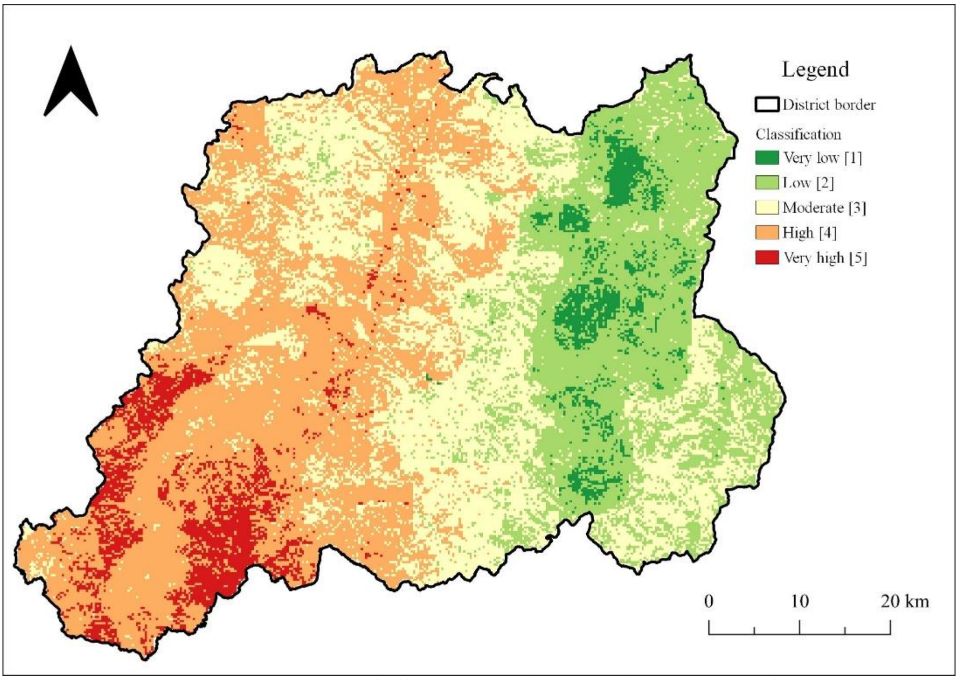

Fig. 11. Evaluation of All Criteria and Their Vulnerability Levels

After determining the vulnerability level for all nine [9] criteria, the last thing to do is to evaluate all the criteria. This is done in QGIS using the “raster calculator”.

All nine maps are loaded into the program, or rather the calculator, and multiplied by their weight coefficients, which are already presented in Table 3. The final product is present in Fig. 11 where is where 6.1% of the district's area is most vulnerable to fire and it’s in south-west side of district. The lowest percentage of vulnerability of the district is in the northeastern part and represents 3.5% of the entire territory. The rest falls under categories [2] [3] and [4].

Discussion

In Serbia, of the total number of fires in the analyzed period (2008 - 2012), 26.9% occurred in 2012. According to Tošić et al., (2019), 2012 was marked by the longest heat wave and the worst drought. In 2011, 2012 and 2017, conditions were extremely dry, causing a large number of forest fires and large burned areas, which is consistent with the data of this research. Although commonly present, drought causes numerous negative consequences throughout the world, in areas with very different climatic conditions. Drought is present throughout the territory of Serbia, but with varying intensity (Živanović et al., 2022).

Durlević et al., (2025) used dataset from the 16 geomorphological, climatological, hydrological, vegetational, and anthropogenic predictors and the wildfire inventory. All raster predictors were harmonized to the same coordinate reference system, spatial extent and cell size.

Jovanović et al., (2023) also used the AHP method in their work. Jovanović et al. (2023) Five out of nine indicators in this work were used in their work. The same is true in the work of Ćurić et al., (2022). where the forest fire susceptibility index was used where the indicators used were VT - vegetation type index, S - slope index, A - aspects index, DR - road distance index and DS - settlements and buildings distance index.

Until recently, there was a huge gap in forest fire vulnerability assessment in Serbia, with no system for assessing forest fire vulnerability at the national or even regional level (Gigović et al., 2019).

Živanović et al., (2024) used for their study several climate indices for national parks in central Serbia. Selected climate indices such as the De Martonne aridity index (IDM), Lang aridity index (AILang) and the Forestry Aridity Index (FAI) based on air temperature and precipitation data were used since these indices are the most suitable for analysis of climate conditions over the territory of the Republic of Serbia. To estimate results with the number of wildfires, they used Multiple linear regression (MLR) models to establish the relationship between the number of fires and climate variables and indices. The first step has been made on that course by producing maps with the forest fire occurrence probability using AHP method with several calculations in QGIS software.

Temperature greatly influences the occurrence of fires, by drying out vegetation and heating the soil, therefore higher temperatures increase the vulnerability of fires. Fuels previously heated in the sun burn faster than cold fuels. Also, based on Corina land cover, areas with a high vulnerability of fire can be easily identified based on the classification of land areas, for example, forest areas, maquis, agricultural areas, grasslands are very suitable for fire occurrence.

With high temperatures and low humidity, the vulnerability of vegetation, soil and air becoming dry increases, increasing the vulnerability of fires. Also, precipitation will quickly moisten the surface of the “fuel” (burning layer) to the point that fires cannot start, and forest fires will not occur. In lower areas, especially in summer, the temperature is higher, so there is very little precipitation, which leads to the drying out of combustible material and the possibility of its ignition (Videković, 2023).

The impact of wind on fire spread increases sharply with increasing wind speed, especially in areas with a small amount of fuel. The explanation is that the wind “pushes” the flame forward, allowing direct contact between the flame and new unburned vegetation, and also increases radiation to the combustible material it encounters and which receives thermal radiation. Wind direction and terrain slope are viewed as vector quantities, so slope can reduce the impact of wind on a fire, but it can also increase it. That also appeals with aspect. On sides that are more exposed to the Sun, fires occur more frequently, spread faster, and have greater destructive power (Živković, 2018).

After determining the vulnerability level for all nine [9] criteria, the last thing to do is to evaluate all the criteria. This is done in QGIS using the “raster calculator”. All nine maps are loaded into the program, or rather the calculator, and multiplied by their weight coefficients, which are already mentioned in Table 3. The final Fig. present model of vulnerability of making forest fires in Pčinja district. The area with the lowest vulnerability is around lake Vlasina in north-east part of district, and the area with higest vulnerability is in south-west area.

While the previous examples are based on methodology about subjective positioning criteria, Milenković et al., (2023) used Pearson's correlation coefficient (r) in the research of the connection between the fire data and the Atlantic Multidecadal Oscillation (AMO), the number of fires and the population.

While on the one hand, this method serves to simplify more complex problems by presenting them through an established hierarchy, on the other hand, that can also be a main disadvantage, as subjectivity itself dominates to such an extent that it cannot encompass the entire complexity of the problem, and also that there is no objective external method to justify set criteria.

Conclusion

Climate change, to which the anthropogenic factor has had the greatest impact, especially over the past half-century, has contributed to the fact that each subsequent year the average annual temperature is higher compared to the previous one. Every year, record measurements are repeatedly broken, even in areas that, until about thirty years ago, were considered moderate climate zones and are now shifting closer to the tropical segment. Serbia is no exception to this "rule." Unbearable heat during the summer period, reduced precipitation, and uncontrolled deforestation for the sake of the expansion of construction land are factors and behaviors that have culminated and will continue to do so thus creating the basis for raging wild forest fires.

Furthermore, human negligence within forest management areas, where owners and public enterprises do not take sufficient measures, only "fuel" the fire. We are witnessing significant changes in this segment. The development of studies and analyses for any area cannot hold weight unless they are respected or at least acknowledged by the citizens as credible legal documents. Based on everything presented in the previous chapters, it can be concluded that the problem of forest fires will become increasingly intense, not only in the Pčinja District but throughout the rest of the Republic of Serbia. The constant decline or at best, stagnation of the country's forest cover does not help the situation, even though Serbia, as a candidate for European Union membership, has set a goal for additional afforestation. So far, with little success.

By means of a specific methodology and by selecting the most crucial criteria along with presenting the theoretical framework, this work has approached the aforementioned issue with the aim of raising awareness on this topic and visually presenting the challenges of today's world through a series of Figs and various software tools.

We will leave time to show much this or other works, analyses, studies, or dissertations will contribute to development, or at least raise awareness among people. It is important to emphasize that, as people, through our dedication and patience, we hold some power to redirect this course, which is by no means favorable, and to try, by collaborating with experts, to reach a common solution that will benefit us in the present as well as future generations who, hopefully, will continue this way of thinking. GIS and the application of the AHP method represent important tools for achieving the above-mentioned goals and addressing the problems surrounding us. While they have their advantages (Systematic and transparent decision making; expert knowledge integration and integration in GIS systems) but also a disadvantages (Subjectivity of expert judgments; dependence on expert availability and quality), the focus here is on their positive effects and on utilizing their strengths to present possible solutions for solvable problems. This can be the basis for improving spatial planning in Serbia and help the local population.

Conflicts of Interest: The authors declare no conflict of interest.

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