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Wildfire hazard and risk assessment at the instance of Gabala district

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Abstract

As one of the main natural resources for humans, protection of forest resources is one of the main ecological problems of the world. Forests are a source of oxygen, as well as they have some features that can ensure ecological balance. For example, forests are one of the major factors that prevent landslides, erosion processes, flood events, as well as protecting land resources, hydrological resources and optimization micro climatic condition. Decreasing of forest stock affects the fauna directly. There are some factors that impact decreasing of forest resources, for example, settlements, industry and forest supply and etcetera. Forest fires occurring in different parts of the world every year eradicated acres of forest stock. The formation of forest fires is influenced by factors such as climate, anthropogenic and topological effects. Research area is district of Gabala which is situated at south slopes of Greater Caucasus. Gabala is distinguished by the abundance of forest resources in the territory of Azerbaijan, which is poorly provided with forest reserves. XX hectares of this district are covered with forests. Taking into account that XX% of the fire incidents that occurred on the southern slope of the Greater Caucasus in 2021 and 2022 took place here, this place was taken as a research area. Wildfire hazard and risk assessment and fire risk zonation, anthropogenic and topological effects are considered in this article and mapping had been done. The resulting values were classified according to the risk group and the results were compared with the fire area data. As a result of the comparison, was not found fire process in the categories of no risk or low risk. 90% of fire incidents could be classified as medium risk, high risk and critic high risk categories. Consequently, this is an indicator of the validity of the selected parameters and the conducted assessment.

1. Introduction

Research area is located South slopes of Great Caucasus and Qanıx-Ayricay valley .Qabala is old district of azerbaijan. The region is located at an altitude of 68-4466 m. It covers an area of 1548600 ha. Forest area occupies 21% of the territory. Fauna and flora species included in the red book of Azerbaijan are spread in the area. Azerbaijan is a country with few forest resources. Forests covered 11% of the country's total area. The south slope of the Greater Caucasus stands out in the country for its percentage of forests (40% of the area). On the South slopes of Great Caucasus, which is well provided with forest resources, nature protection is considered one of the urgent issues. 45 percent of the territory is occupied by Specially Protected Nature Areas. There are a part of the Shahdag National Park, Gabala and Turyanchay nature reserves, 28 biological nature monuments and specially important forest areas taken under state control in the territory of Gabala region. Despite this, 40% of the fires that occurred on the south slopes of the Greater Caucasus in 2021 and 2022 fall on the territory of Gabala region. During the research period, 1826.3 ha of forest area was burned. This is 5.64% of the total forest area of the district. During the research period, 1826.3 ha of forest area was burned. This is 5.64% of the total forest area of the district. 2021 and 2022 were taken as research years. Wildfire hazard and risk assessment and fire risk zonation of Gabala district was carried out taking into account factors such as anthropogenic and effects of topography. In order to assessment the obtained result, it was compared with the fire data of recent years and the areas covered by the fire.

2. Method

Remote Sensing data programs and ArcGIS/ArcGIS map 10.8 Software were used for fire risk assessment in Gabala region during the research. Effects of topography (slope, elevation, aspect) and anthropogenic parameters were taken as criteria. when assessing the fire risk of

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the area, it is divided into 5 categories; no risk; low risk; medium risk; high risk; critical risk. Here, the slope, elevation, aspect and land use and land cover parameters were reclassified .Then overlay and map algebra operations were performed. Using this information, a fire risk assessment and risk zonation map was created. 30 m resolution SRTM DEM data provided by NASA, USGS were used to study Aspect, Slope and Elevation parameters. To investigate the land use and land cover parameters, the "Landsat 8" data provided by USGS Earth Explorer dated 17.07.2022 was used.

Data on wildfires and burned agricultural residues were obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS), a satellite-based sensor. Information about Forest and agricultural resides active fire location data was taken "NASA FIRMS" application which is uses different type of satellite-based sensor (Landsat, VIRS (S-NPP & NOAA 20), MODIS (Aqua & TERRA). Using in this data was created wildfire burned area and active wildfire location map and graphs. Also, using the existing stock literature materials, information on climate was investigated and certain results were obtained.

Table 1. Wildfire risk assessment criteries

Risk assess-ment	aspect	slope	Eleva-tion	Land use and land cover
No risk	0°-45°, 315°-360°	0-8°	3500-4466	Water bodies, bare earth, bare soil
Low risk	45°-90°, 270°315°	8-15°	3000-3500	Selitep areas
Moderate risk	90°-135°,	15-25°	68-500	Agriculture land
High risk	135°180°, 225°270°	25-35°	2000-3000	Pasture
Critic risk	180°-225°	35-68°	500-2000	Forest

3. Results

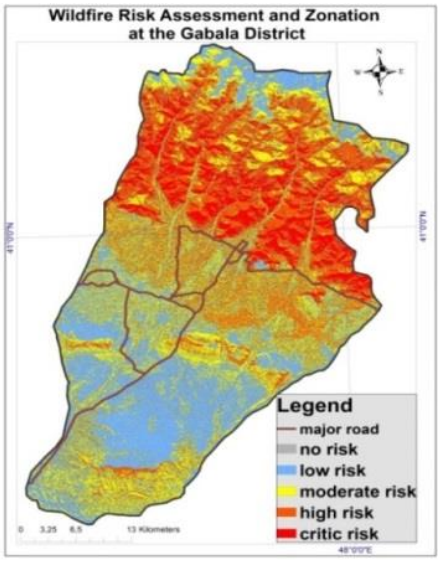

Figure 1. Wildfire risk assessment and zonation

Based on the effects of topography (slope, aspect, elevation) and Land use and Land cover parameters of the study area, fire risk classification was carried out.A fire risk assessment and a zonation map were drawn up according to the obtained categories. As a result, based on the obtained values, overlay and map algebra operations were performed, and the WildFire Assessment and Zonation map was drawn up and the area of the areas included in the risk categories was calculated (Figure 2).

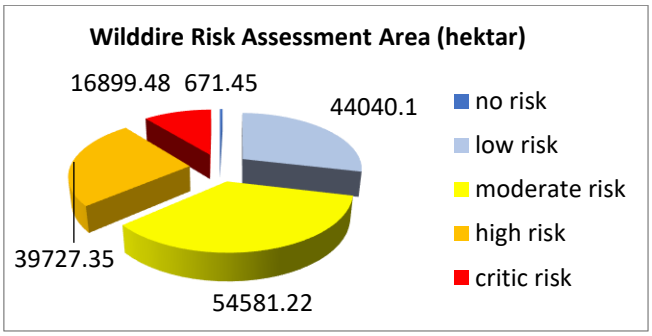

Figure 2. Wildfire risk assessment areas (hektar)

In general, 0.43% of the territory corresponds to no risk, 28.24% to low risk, 35.01% to moderate risk, 24.48% to high risk, and 10.84% to critical risk classification.

The resulting values were classified according to the risk group and the results were compared with the fire area data. In total, 108 fire incidents occurred in the area in 2021 and 11 in 2022 year. As a result of the comparison, no fire process was found in the non-risky area. There were 2 fire incidents in the low risk category, 10 in the moderate risk category and 107 in the high and critical risk categories. Thus, we can see that 90% of fire incidents correspond to the high risk and critical risk category (Figure 3-4)

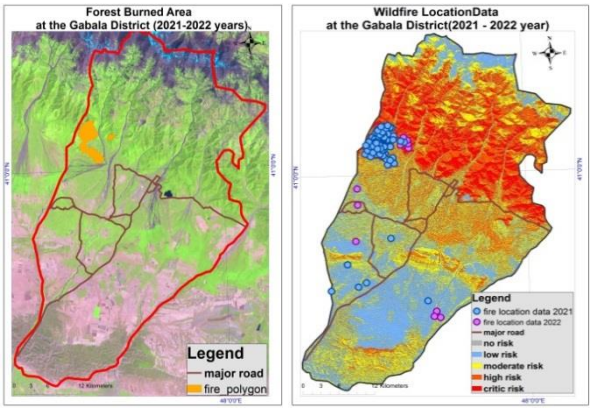

Figure 3-4. Forest burned area on the left and Wildfire location data on the left (2021-2022 year).

When the obtained results are compared with the fire area data, we can see that 100% of the area corresponds to the high risk and critical risk category. In general, during the study period, it was determined that 5.4% of the forest resources were destroyed based on the fire area data (Figure 2).

In these results, it is an indication that the selected parameters and the evaluation are reasonable.

4. Discussion

As one of the main natural resources for humans, protection of forest resources is one of the main ecological problems of the world. Forests are a source of oxygen, as well as they have some features that can ensure ecological balance. For example, forests are one of the major factors that prevent landslides, erosion processes, flood events, as well as protecting land resources, hydrological resources and optimization micro climatic condition. Decreasing of forest stock affects the fauna directly. There are some factors that impact decreasing of forest resources, for example, settlements, industry and forest supply and etcetera. Forest fires occurring in different parts of the world every year eradicated acres of forest stock.

The formation of forest fires is influenced by factors such as climate, anthropogenic and topological effects. Research area is district of Gabala which is situated at south slopes of Greater Caucasus. Gabala is distinguished by the abundance of forest resources in the territory of Azerbaijan, which is poorly provided with forest reserves. In the north of Gabala, alpine and subalpine meadows, mountain forests, bushy and sparsely wooded meadows in the central part, and wormwood and wormwood-saline semi-desert plants, xerophytic sparse forests occupy a large area. It is an area with high tourism potential. It has a dense river network system (Türyan, Demiraparan and their tributaries Tikanlıchay, Bum, Vandam, etc.).

When assessing the occurrence and spread of forest fires, it is important to consider parameters such as climate, anthropogenic and effects of topography. In this article, the classification was made mainly based on anthropogenic and relief factors. The following table lists the parameters of the classification and the results of research conducted based on these parameters in the area.

Table 1. Areas calculated based on wildfire risk assessment criteria.

Risk assess-ment	aspect	slope	Eleva-tion	Land use and land cover
No risk	34142,9	74666,7	2032,7	20802,2
Low risk	395550,7	19792,9	6413,82	32495,19
Moderate risk	15961,1	24991,2	58011,6	24395,95
High risk	47370,8	25011,1	12593,3	46371,68
Critic risk	28897,6	11459,8	42198,3	32405,15

Climate factor. The climate is mild-warm with dry winters in the lower part, and cold and humid in the highlands. Annual precipitation is 500-600 mm in the lower part, up to 1600 mm in the highlands. Average monthly temperature decreases with increasing altitude. While the average temperature in July is 24-27 C° in the plain part of the region, it drops to 20-15 C° in the middle highlands, and 10-5 C° in the highlands. While the average January temperature is 2 C° in the plains, it drops from -10-(-11) C° to even -14-(-15) C° in the high mountain peaks. Taking into account climate parameters (temperature and humidity), the risk of fire decreases with increasing altitude. The increase in temperature in the summer months and the partial decrease in precipitation increase the risk of fire. During the research period, according to the data we took from the "NASA FIRMS" platform, it can be seen that 93.27% of fire incidents happened in the summer months (August, early September). It should be noted that the fire events that occurred in September coincided with the first 5 days of the month.

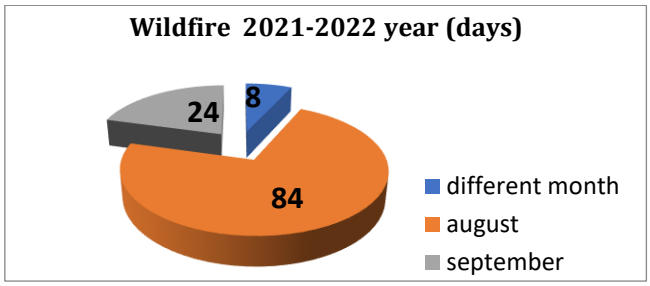

Figure 5. Wildfire events 2021-2022 year (days)

Anthropogenic factors are one of the main factors we should pay attention to when assessing fire risk. A number of anthropogenic effects, which we have listed below, cause forest fires.

- carelessness, negligence and intentional burning.
-making campfires in the forest without observing safety rules
-Throwing unextinguished cigarette butts and matches on the ground
- throwing glass and broken glass into the forest
- stubble burning
- intentional fires

The distance from residential areas and highways was taken into account when assessing the risk. Looking at the map of highways in Figure 3-4, it is clear that most of the fires classified as moderate risk occur in the buffer zone of 2000 m, which is defined as a risk area. (Figure 5).

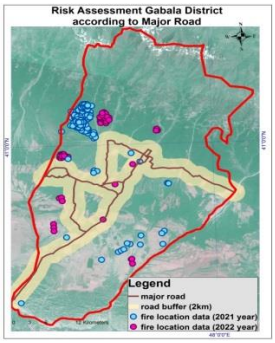

Figure 6. Risk Assessment according to major road.

The settlement factor was taken into account during the research. After the 2000s, the rapid development of tourism in the region has led to an increase in anthropogenic loads in the area. Resort-recreation centers created in the forest area increase the risk of forest fires of anthropogenic origin. As we can see in Map1, the central part of the area (200-800 m) is more densely populated. This corresponds to the lower

border of the forest. Settlements exist in the middle forest (800-1200 m) zone.

The map was prepared using arcgis 10.8 software from Landsat 8 data dated 17.07.2022 provided by USGS EarthExplorer. At this time, forest, agriculture land, urban areas, pastures, bare soil and earth land areas were classified using 1, 2, 3, 4, 5, 6, 7 band combinations and a land use and land cover map was drawn up. The resulting values were classified according to the risk group. The forest area of the total area is 20.71%. Settlement and appropriated areas cover 36.36%, summer and winter pastures cover 29.64%. In general, it is classified as water bodies, bare earth and soil land no risk, selteps low risk, agricultural area medium risk, pastures high risk, forest critical risk. In Figure 5, the Land use and Land cover map of the area was drawn up, then fire risk classification was made based on it.

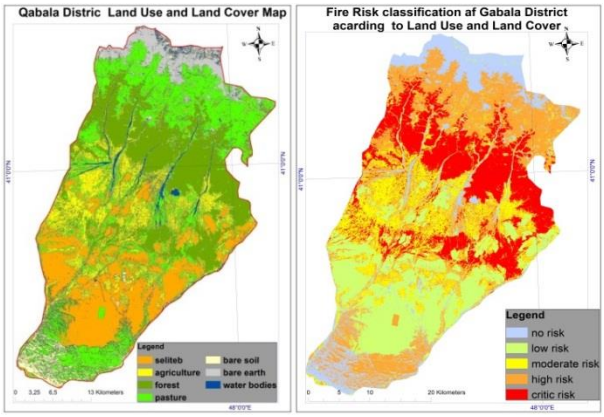

Figure 7-8. Land use and land cover on the left and fire risk classification acording to land use and land cover on the right

Elevation, slope and aspect parameters of the area are the main relief features that affect the risk of forest fires. It provides important information about the determination of the fire area, the speed and direction of its spread. Assuming other risk factors are constant, fire will move fastest on steep slopes. That said, increased inclination also increases the risk of fire.

The territory of Gabala district has an inclination interval of 7° - 68°. The inclination increases from south to north. 5 classifications were used when assessing forest fire risk based on slope inclination: 0-8° no risk, 8-15° low risk, 15-25° medium risk, 25-35° high risk and 35-68° critical risk areas. 47.9% of the total area of the territory is classified as no risk, and 23.4% as high and critical risk (Figure 6).

Fire conditions vary greatly depending on the aspect. In general, the south and southwest sides have good conditions for fire initiation and spread. These areas receive more sunlight. Increases the temperature of air and combustible material (Figure 7-8).

Elevation data is closely related to the distribution of vegetation. Vegetation in the study area is distributed along the vertical zonation of the mountainous area. Bushy and sparse meadows are spread in the central part, and semi-desert plants with wormwood and sorrel in the south, and arid type forests in the steppe plateau area. At altitudes of 600-2000 m, there are oak, beech and walnut forests. Subalpine (1700-2600 m) and alpine meadows (2500-3100 m) are common in the high mountain zone. At 3100-3500 m above sea level, subnival plants of the tundra type are found. Above 3500 m, the vegetation-free nival zone begins. Taking these into account, Elavatian classification was made again. Areas with an altitude of 500-2000 m are classified as critical risk zone, while areas higher than 3000 m are included in no-risk and low-risk categories (Figure 9-10-11).

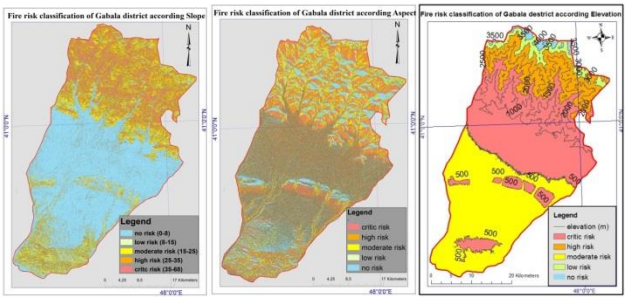

Figure 9-10-11. Fire risk classification according slope on the left , fire risk classification according aspect on the middle and fire risk classification acording elevation on the right.

5. Conclusion

Burned area data was used to verify the obtained data. The data is taken from the FIRMS database with 1000 m resolution from MODIS/MOD 14 sensors from the earth.data.nasa.gov application. Vectorized and area calculated using ArcGis 10.8 software. Data covers 2021 and 2022. The burnt forest area is 1826.3 ha, which is 5.4% of the forest area of Gabala district. 100 percent of the burned area corresponds to the high and critical risk classification zone. 2021 and 2022 data from MODIS (Aqua and Terra) sensors provided by NASA FIRMS are taken. In Gabala district, 11 fire incidents occurred in 2021 and 108 in 2022. 90% of recorded fire events correspond to the high and critical risk classification area, 8.4% to the moderate risk zone, and 1.6% to the low risk zone.

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