STATISTICAL ANALYSIS OF ANGSTROM FIRE INDEX FOR KUTAISI, GEORGIA

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Abstract

The problem of fires, including forest fires, is actual for many countries of world. This problem is also important for Georgia, where forest fires are frequent. In recent years this problem is aggravated by the global and local climate warming which facilitates an increase in the fire hazard. In Georgia, the top 3 regions were responsible for 53% of all tree cover loss between 2001 and 2020. Samtskhe-Javakheti had the most tree cover loss at 3.24 kha, then Kakheti (1.24 kha) and Imereti (1.01 kha) [https://www.globalforestwatch.org/dashboards/country/GEO]. For evaluating the fire hazard in locality the set of indices is developed. One of the simple of these indices is the Swedish Angstrom Fire Index (AFI). Earlier, data on AFI for Tbilisi and Telavi were presented. In this work results of a statistical analysis of daily values of AFI for Kutaisi are presented. AFI = (R/20) + (27-T)/10, where R is the minimum relative humidity, T is the maximum air temperature. Data of the about daily values of T and R in the period 2011-2020 are used [http://www.pogodaiklimat.ru/archive.php?id=ru&region=07]. The gradations of the values of AFI are as follows: I. AFI ≥ 4.1 – Low, II. AFI = 4.0 ÷ 3.0 - Moderate, III. AFI = 2.9 ÷ 2.5 - High, IY. AFI = 2.4 ÷ 2.0 - Very High, Y. AFI = <2.0 - Extreme. In particular, it was found that an Extreme fire hazard in Kutaisi is observed on average within 59 days a year (16.0 % of cases), Very High – 46 days a year (12.7 % of cases), High - 64 days a year (17.6 % of cases), Moderate – 100 days a year (27.5 % of cases), Low – 96 days a year (26.2 % of cases). The highest repeatability of AFI values for its various gradations is as follows: Extreme – 33.3 % (September), Very High – 22.6 % (August), High – 30.3 % (July), Moderate – 37.3 % (November), Low 48.7 % (January). The values of AFI in Kutaisi are compared with their values in Tbilisi and Telavi. In particular, it was found that a repeatability of Extreme fire hazard in Kutaisi is lower, than in Tbilisi (19.1 % of cases) and Telavi (18.5 % of cases). This result is in good agreement with the data on loss of forest cover from fires in Kakheti and Imereti, indicated above.

Further, it is planned to expand work on this issue (using other more complex fire hazard indices, studying their trends in connection with climate change, determining these indices for other points in Georgia, etc.).

Keywords: city of Kutaisi, air temperature, air relative humidity, Angstrom Fire Index

Introduction

The problem of fires, including forest fires, is actual for many countries of world. The problem of the occurrence and spread of fires, including forest fires, largely depends on the meteorological conditions of the area (temperature and humidity, thunderstorms, precipitation, etc.). In particular, it is well known that high air temperature and low air humidity contribute to an increase in fire hazard. In recent years, this problem has been exacerbated by global [1] and local climate warming [2-5], which contributes to an increase in the number of fires [6,7]. This problem is also important for Georgia, where forest fires are frequent. In Georgia, the top 3 regions were responsible for 53% of all tree cover loss between 2001 and 2020. Samtskhe-Javakheti had the most tree cover loss at 3.24 kha, then Kakheti (1.24 kha) and Imereti (1.01 kha) [8]. In Imereti, from January 2, 2012 to December 27, 2021, 1618 fire alerts were registered.

In the indicated period of time, Imereti was in second place among the regions of Georgia in terms of the number of fire alerts, after Shida Kartli (2368 fire alerts), and before Kakheti (1550 fire alerts) [8].

Different countries of the world use different (including their own) forest fire danger indices [6, 7, 9-12]. These indices are mathematical formulas that formalize the influence of air temperature and humidity, precipitation, moisture content of forest fuels, lightning activity, etc. Simultaneously with the numerical values of these indices, the degree of fire danger is verbally determined using the appropriate scales. Together with climatological and operational information about forest fire hazard levels, their short-term and long-term forecasts are also carried out [9, 13]. One of the simple of these indices is the Swedish Angstrom Fire Index (AFI). In Georgia works on the forest fire hazard index study using the example of Tbilisi began in 2019 [14]. Similar studies were continued for the cities of Telavi and Nalchik [15, 16]. In these cases, the simple Swedish Angstrom index [6,7] with a four range scale [10] was used. Finally, the work [17] presented the results of a statistical analysis of the daily values of the Angstrom fire index (AFI) for Tbilisi (the capital of Georgia, a large city with a population of more than a million people) and Kislovodsk (Russian Federation, a resort city with about 130 thousand people) in the period 2011-2020 using a five-point scale [9]. This work is a continuation of previous studies. Results of a statistical analysis of daily values of AFI for Kutaisi (the main city of Imereti) are presented below.

Study region, Materials and Methods

Study region – Kutaisi (the main city of Imereti region of Georgia). In the work data on the daily maximum air temperature T and minimum relative humidity R in Kutaisi in the period 2011-2020 were used [18]. The Swedish Angstrom Fire Index AFI = (R/20) + (27-T)/10. The gradations of the values of AFI are as follows: I. AFI ≥ 4.1 – Low, II. AFI = 4.0 ÷ 3.0 - Moderate, III. AFI = 2.9 ÷ 2.5 - High, IY. AFI = 2.4 ÷ 2.0 - Very High, Y. AFI = <2.0 - Extreme. The standard statistical methods are used. The following designations will be used below: Min – minimal values; Max - maximal values; Mean – average values; St Dev - standard deviation; C_v - coefficient of variation (%); σ_m – standard error; 99%(+/-) - 99% upper and lower levels of the confidence interval of average.

Results and Discussions

Results in **Table 1, 2** and **Diagram 1-3** are presented.

In Table 1 and Diagram 1 the statistical characteristics of daily and mean monthly values of Angstrom Fire Index in Kutaisi for different months of year in 2011-2020 are presented.

In particular, as follows from Table 1 values of AFI changes from -0.3 (August, fire occurrence is Extreme) to 7.5 (January, December, fire occurrence is Low). The greatest variations in the values of AFI are observed during September (C_v = 46.4 %), smallest - in January (C_v = 31.1%).

The mean monthly values of Angstrom Fire Index (Table 1., Diagram 1.) changes from 2.3 (August, fire occurrence is Very High) to 4.4 (January, fire occurrence is Low).

Table 1.

Statistical characteristics of daily values of Angstrom Fire Index in different month of year in Kutaisi in 2011-2020.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	2.0	1.5	1.0	0.9	0.7	0.1	-0.1	-0.3	0.0	0.9	1.4	1.8
Max	7.5	7.4	7.4	6.5	6.1	5.0	5.4	5.0	5.9	6.0	7.2	7.5
Mean	4.4	4.2	3.9	3.1	3.0	2.6	2.7	2.3	2.5	3.1	3.8	4.2
St Dev	1.36	1.41	1.56	1.40	1.30	1.00	1.13	0.96	1.15	1.14	1.29	1.37
Cv,%	31.1	34.0	40.4	44.5	44.0	38.7	42.6	41.7	46.4	37.2	34.1	32.5
σm	0.08	0.08	0.09	0.08	0.07	0.06	0.06	0.05	0.07	0.06	0.07	0.08
99%(+/-)	0.20	0.22	0.23	0.21	0.19	0.15	0.16	0.14	0.17	0.17	0.19	0.20

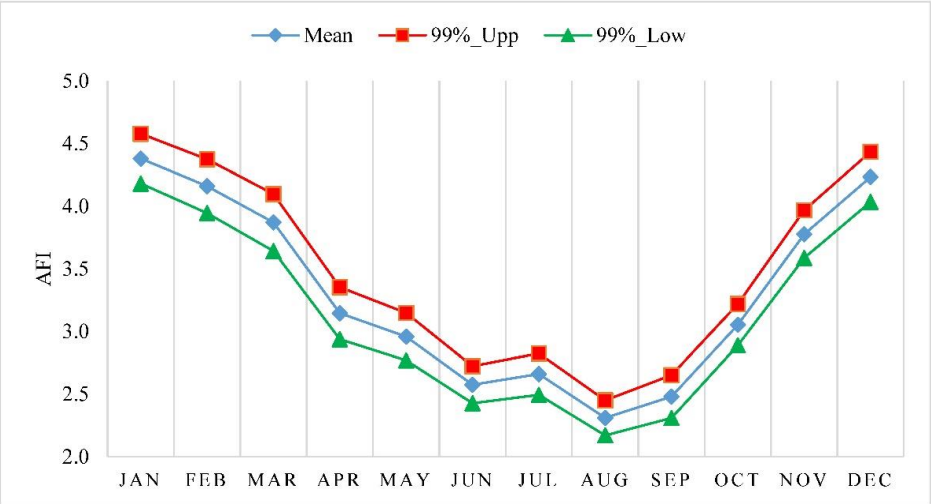

Diagram 1. The intraannual diatributions of mean monthly values of AFI in Kutaisi in 2011-2020.

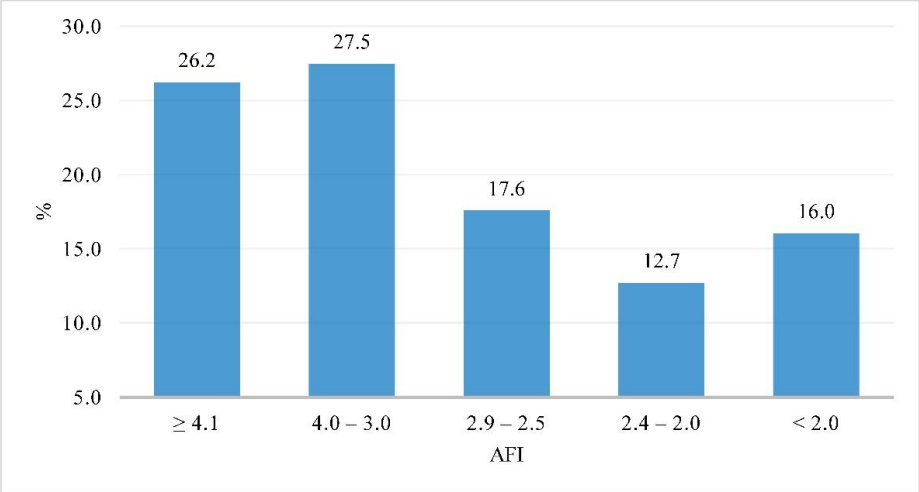

Diagram 2. Repetition of AFI with different its values in Kutaisi in 2011-2020.

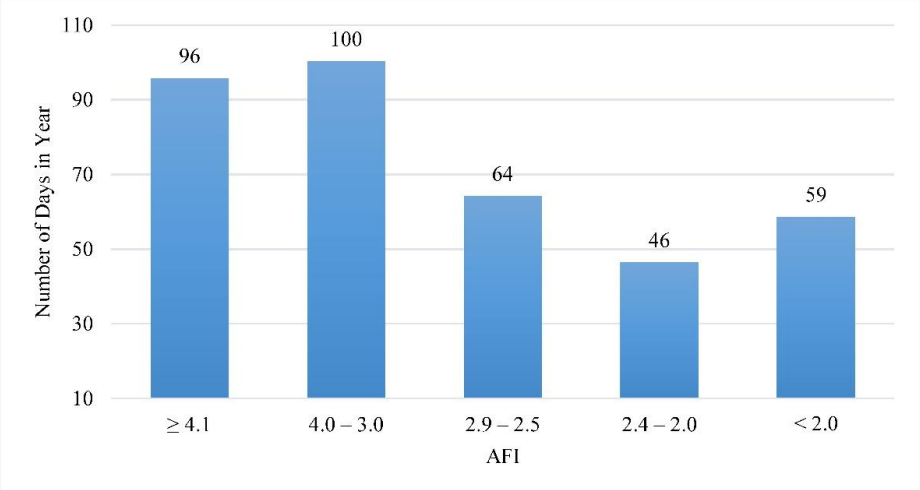

Diagram 3. Number of days in year with different values of AFI in Kutaisi in 2011-2020.

In Diagram 2. data about repetition of AFI with different its values and in Diagram 3 data about number of days in year with different values of AFI in Kutaisi in 2011-2020 are presented. As follows from these Diagrams an Extreme fire hazard in Kutaisi is observed on average within 59 days a year (16.0 % of cases), Very High – 46 days a year (12.7 % of cases), High - 64 days a year (17.6 % of cases), Moderate – 100 days a year (27.5 % of cases), Low – 96 days a year (26.2 % of cases).

In Table 2. data about repetition of AFI and number of days in month with different its values in Kutaisi in 2011-2020 are presented.

Table 2.

Repetition of AFI and number of days in month with different its values in Kutaisi in 2011-2020.

Location	%					Number of Days in Month				
AFI	**≥ 4.1**	**4.0 – 3.0**	**2.9 – 2.5**	**2.4 – 2.0**	**< 2.0**	**≥ 4.1**	**4.0 – 3.0**	**2.9 – 2.5**	**2.4 – 2.0**	**< 2.0**
Jan	48.7	37.1	11.6	2.6	0.0	15	12	4	1	0
Feb	46.6	31.8	11.7	7.1	2.8	13	9	3	2	1
Mar	40.3	24.8	16.5	10.3	8.1	13	8	5	3	3
Apr	25.0	21.7	13.7	16.7	23.0	8	7	4	5	7
May	22.9	23.5	11.6	16.8	25.2	7	7	4	5	8
Jun	8.7	24.3	24.3	17.0	25.7	3	7	7	5	8
Jul	10.3	27.7	30.3	10.0	21.6	3	9	9	3	7
Aug	3.5	18.7	25.2	22.6	30.0	1	6	8	7	9
Sep	11.0	17.7	20.3	17.7	33.3	3	5	6	5	10
Oct	18.7	29.4	18.4	17.4	16.1	6	9	6	5	5
Nov	34.0	37.3	15.3	7.7	5.7	10	11	5	2	2
Dec	45.8	35.5	11.6	6.5	0.6	14	11	4	2	0

The highest repeatability of AFI values for its various gradations is as follows: Extreme – 33.3 % (September, 10 days in month), Very High – 22.6 % (August, 7 days in month), High – 30.3 % (July, 9 days in month), Moderate – 37.3 % (November, 11 days in month), Low 48.7 % (January, 15 days in month).

Comparison of values of AFI in Kutaisi with their values in Tbilisi and Telavi [14-16] shown, that a repeatability of Extreme fire hazard in Kutaisi is lower, than in Tbilisi (19.1 % of cases) and Telavi (18.5 % of cases). This result is in good agreement with the data on loss of forest cover from fires in Kakheti and Imereti, indicated above.

Conclusions

Further, it is planned to expand work on this issue (using other more complex fire hazard indices, studying their trends in connection with climate change, determining these indices for other points in Georgia, comparison of the Angstrom Fire Index with the number of fire alerts, etc.).

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