REPUBLIC OF AZERBAIJAN

On the rights of the manuscript

ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ASSESSMENT OF THE IMPACT OF REGIONAL CLIMATE CHANGE ON ECOLOGICAL SYSTEMS AND HABITAT (ON THE EXAMPLE OF THE NORTH-EASTERN SLOPE OF THE LESSER CAUCASUS)

Speciality: 5411.01 - Meteorology

Field of science: Geography

Applicant: **Rovshan Hasan Ramazanov**

Baku – 2022

The work was performed at the Space Research Institute of Natural Resources of the National Aerospace Agency of the Ministry of Defense Industry.

Scientific supervisor: Doctor of Technical Sciences, Professor
Tofig Ibrahim Suleymanov

Official opponents: Doctor of Geographical Sciences, Professor
Farda Ali Imanov
Doctor of Philosophy in Geography, Docent
Farhad Bayram Eminov
Doctor of Philosophy in Geography
Mirzaxan Rzaxan Mansimov

Dissertation Council BFD 1.23 of the Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at the Institute of Geography named after academician H.A. Aliyev of the Azerbaijan National Academy of Sciences of Azerbaijan

Chairman of the
Dissertation Council: Doctor of Geographical Sciences, Professor
Askar Samad Mammadov

Scientific Secretary of the
Dissertation Council: Doctor of Philosophy in Geography, Docent
Zaur Tahir Imrani

Chairman of the
scientific seminar: Doctor of Geographical Sciences, Docent
Surkhay Hasan Safarov

GENERAL CHARACTERISTICS OF WORK

Relevance and processing degree of the topic. Climate changes observed in our time are manifested both globally and regionally as an integral part of natural processes. This process, accompanied by global warming, is no longer in doubt in the world community and in scientific circles.

As in different regions and countries of the world, in Azerbaijan the effect of global climate change on the environment and various sectors of the economy, including separate ecosystems, is also observed. Among them, the most affected ecological systems and their components include-forest areas, hydrological regime, drought of territories, decrease in biodiversity, increase in extreme living conditions, etc.

Forest ecosystems, being part of the biosphere, play an important role in its protection, development and self-regulation, in the formation of the habitat, in the production of various products, and in the prevention of environmental pollution.

Climate warming also increases the likelihood of forest fires. Regular forest fires in various regions of the world, along with serious economic losses, are considered as an important factor in the local, regional and global dynamics of the environment. At the same time, forest fires are one of the main events affecting the environment. In all natural regions of Azerbaijan, as a result of anthropogenic influences, vegetation zones are being replaced in large areas, highly productive forest cover is being replaced by weakly soil-protective and less productive plant groups. As a result, soil erosion intensified in mountainous areas, and adverse trends intensified in such areas and rivers.

One of the processes occurring in natural ecosystems in the context of increasing extreme climate change is the drought. It has been established that this phenomenon can be observed in any region of the planet, and in some cases, in areas close to the coast of the ocean, characterized by humid climate. For example, more than 20% of all natural disasters are attributed to the drought-related processes. The already observed climate changes will undoubtedly have an impact on the increase of climate extremes, including the intensification of drought events.

In the modern era, significant changes in the living conditions and health of the population are directly related to climate change. This result is due to an increase in the frequency of relapses of abnormally high and low temperatures, floods, storms, hurricanes and so on and an exacerbation of their direct or indirect impact on environmental and socio-economic systems. The climatic factor intensively affects people's lives and in some cases can create significant risks. For example, every year, according to estimates of the World Health Organization, 1-10% of deaths among people are related to climate change. In addition, the economic damage caused by climate change is around $ 6–88 billion per year[1]. The main risks associated with climate change are considered: high temperature, atmospheric pressure, extreme weather events, spread of infectious diseases, malnutrition and so on.

According to the above analysis, we can say that this kind of research was not carried out for the territory of our republic or was carried out in a limited number. Assessment of possible changes in the background of climate change, development of adaptation measures against negative consequences is one of the most important tasks for Azerbaijani climatologists. Taking this into account, on the north-eastern slope of the Lesser Caucasus, one of the strategic regions of the republic, an assessment of possible change trends in the climatic conditions of this region in the background of global climate change and the parameters characterizing its extremeness, the likelihood of a recurrence of “fire hazard” in forests that are part of the natural ecosystem, drought intensity in the region, oxygen density, which is an important factor in the human environment, moderate and extreme temperatures, relative humidity, wind speed, precipitation and pressure, cloudiness, repetition rate of relevant

[1]State of health of the population in connection with the state of the environment and living conditions of the population / Evaluation of risk and exposure to climatic changes affecting the level of morbidity and mortality in groups of the population at increased risk // Methodical recommendations MR 2.1.10.0057-12, Official edition, Moscow - 2012, - 53 p.

indicators that can affect the health of people are actual problems to be solved in this dissertation.

Thus, integrated study of the nature of global and regional climate changes and their impact on ecosystems and habitats, identifying relevant diagnostic and prognostic relationships, development of recommendations and suggestions, and fundamental and applied research in the field of bioclimatic and environmental processes, are an object of researchers and specialists from many countries.

Purpose and objectives of research. The main goal of the dissertation is to assess the current state of climate change, meteorological aspects of hazardous environmental phenomena and the characteristics of meteorological conditions affecting the habitat on the example of the northeastern slope of the Lesser Caucasus.

For the implementation of the thesis, the following tasks were formed and solved:

1. Creation of a meteorological database based on observational data from hydro meteorological stations located on the north-eastern slope of the Lesser Caucasus.

2. Assessment of the potential impact of global climate change on various fields of the regional climate and improvement of calculation methods based on selected criteria.

3. Identification of climatic factors such as average maximum and minimum monthly temperatures, wind speed, total cloud cover on the north-eastern slope of the Lesser Caucasus and trends of biological indicators of regional climate change.

4. Identification of the trends of extreme climate change indicators, the recurrence of forest fire risks and droughts, as meteorological aspects of environmental processes.

5. Assessment of changes of such factors as oxygen density, equivalent effective temperatures, climate comfort and the index of cold stress, waves of heated air depending on meteorological conditions in the context of regional climate changes.

Research methods. For research, graphical, statistical, analytical and geographical generalization methods, an algorithmic programming language, and computer technology capabilities were widely used. The reliability of the results was checked by the generally accepted correlation relationships, density, and by the criterion of statistical significance of the used ranges.

Main clauses put forward for defense:

1. A systematic presentation of the key factors that form the possible links between global and regional climate change.
2. Spatial and temporal indicators of long-term changes in average monthly maximum and minimum temperatures.
3. Methods of statistical assessment of the tendency of long-term changes in wind speed, cloudiness as factors that have a significant impact on the environment.
4. Statistical indicators of long-term changes of important biological indicators of climate change, including oxygen density, comfort conditions and pathogenicity degree.
5. Methods for assessing the frequency of forest fires of different intensity and frequency of recurrence of meteorological drought.
6. Linear trend correlations in a long-term series of regional features of hot air waves.

The scientific novelty of research.

1. For the first time in the context of global climate change with a single methodology on the north-eastern slope of the Lesser Caucasus, regional climate changes ,their impact on the fire risks in forest ecosystems, the recurrence of drought, the temporal and spatial patterns of bioclimatic indicators of the living environment were identified, a geographical generalization of vertical and horizontal distribution of climatic factors was carried out, an assessment of their characteristics and quantitative changes was made.
2. The spatial characteristics of change tendency of regional indicators of climate change, wind speed and total cloud amount was estimated.
3. The characteristics of the spatial and temporal variability of recurrence of drought events and forest fire risks was evaluated, and drought guides was compiled in the respective territories.
4. The tendency of variability of the daily precipitation intensity index was estimated, during which period of time the maximum and minimum values of absolute temperatures which are indicators of

extreme weather conditions was found and the number of days when the maximum temperature exceeds 30 ° C was identified.

5. The temporally spatial characteristics of the dependence of oxygen density, equivalent effective temperatures, cold stress index, degrees of comfort and pathogenicity of the living environment on climatic factors are estimated.

6. The regional characteristics of the hot air waves based on tropical nights, the hottest days and other environmental factors were estimated.

Theoretical and practical significance of the research. The methodological approaches and research methods used in the thesis can be used to assess the impact of global climate change on environmental factors in other regions of the Azerbaijan Republic. The results obtained to assess the meteorological conditions in the work are relevant for the diagnosis and prediction of the danger of forest fires, droughts, biological indicators on the north-eastern slope of the Lesser Caucasus, as well as in planning the development of the tourist and recreational sphere, allow a more accurate consideration of the effects of meteotropic diseases, which can be spread among the population and play an important role in the preparation of daily bioclimatic forecasts.

Approbation and application. The main clauses of the dissertation were presented at meetings of the Scientific and Technical Council of Space Research Institute of Natural Resources and the National Aerospace Agency, as well as at the following scientific conferences and forums: VIII International Scientific Conference dedicated to the “Year of Industry” on the theme “Ecology and the Protection of Life” Sumgait, 2014; III International scientific conference of young scientists dedicated to the 92nd anniversary of the national leader of the Azerbaijani people Heydar Aliyev. Baku, 2015; Republican Scientific Conference “Geography, Theory, Practice and Innovations” Baku, 2015;International scientific conference "Problems of hydrometeorological support of economic activity in a changing climate", Minsk, 2015; Republican scientific-practical conference on the topic "Geographical problems of the regions of Azerbaijan." Baku, 2016.

The dissertation was successfully applied at Gadabay Central District Hospital named after academician Z.Aliyeva of the Ministry of Health, Institute of Soil Science and Agrochemistry of ANAS and Scientific-Research Aerospace Informatics Institute of the National Aerospace Agency. 21 articles on the topic of the dissertation were published.

The name of the organization in which the dissertation work was carried out.

The dissertation work was carried out at the Institute of Space Research of Natural Resources of the National Aerospace Agency of the Ministry of Defense Industry of the Republic of Azerbaijan.

The total volume of the dissertation with symbols, noting the volume of the structural units of the dissertation separately.

The dissertation consists of an introduction, 4 chapters, main results, a list of 150 references. Volume of work 21 pictures, 31 graphs, structural sections from 69 tables - chapter I - 24 pages, chapter II - 42 pages, chapter III - 47 pages, chapter IV consists of 41 pages, 230353 characters in total.

SUMMARY OF THE WORK

The introduction substantiates the relevance of the topic, defines the goals and objectives of the study, explains the novelty of the obtained scientific results, the practical significance and implementation of the results.

The chapter "**Current state of the impact of climate change on regional ecosystems**" describes the characteristics of global climate change and its regional manifestations, the most affected forests, hydrology and droughts in different areas against the background of climate change. It has been established that in almost all forest ecosystems, drought causes deterioration of forest vegetation, increases the frequency and intensity of forest fires, accelerates soil degradation and reduces biodiversity. Climate change, which is also important for the territory of Azerbaijan, is associated with the recurrence of air temperature, extreme meteorological events, events in severe natural ecosystems, and in this process, mainly anthropogenic factors have a major advantage.

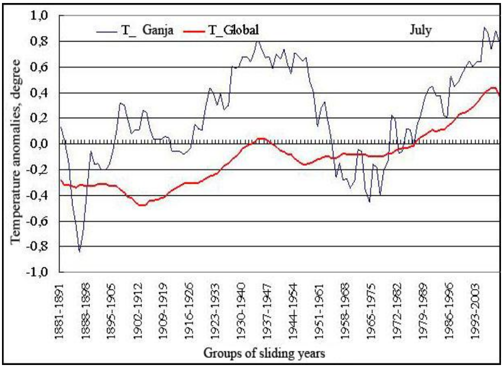
In addition, global climate change, drought in all forest ecosystems, the expected increase in the probability of forest fires, future climate change and further increase, the frequency of recurrence of droughts in the regions of the country.

The chapter examines aspects of the climate and its possible effects on the environment, the main indicators of which are high temperatures, extreme weather events, meteotropic and infectious diseases, and the climatic and ecological characteristics of the north-eastern slopes of the Lesser Caucasus.

During our time, the funds received for changes in the economic situation, climate change or climate change have been monitored for at least three decades. Obtaining a climate impact on an ecological solution after assessing the response of the ecosystem to climate change. Eco-climate information to help regional conditions. The regional approach allows us to determine the dependence of global climate change on geographical conditions.

The chapter assesses "**The tendency of changing ecologically important climatic factors in the northeastern slopes of the Lesser Caucasus**". For this purpose, the daily data base of hydrometeorological stations (HMS) of Ganja, Shamkir, Agstafa, Gadabay, Dashkesan and Goygol (resort) for the period 1971-2009 and database of average monthly weather temperatures for Ganja 1881-2009, Gadabay HMS 1936-2009 and for the rest of HMS for the period 1961-2009 was created. The possibility of a correlation between regional and global temperatures was investigated, and it was found that although the differences between global temperatures and anomalies in Ganja were maximal until the end of the 1970s, they have significantly decreased in recent decades (graph 1).

The correlation coefficients between temperature anomalies in Ganja and in the world for different periods was calculated. In all months, with the exception of April 1971-2009, the correlation coefficients were very high: changed from 0,81 to 0,89 in the first 6 months of the year and from 0,92 to 0,96 in the remaining 4 months, and in December it was 0,74.

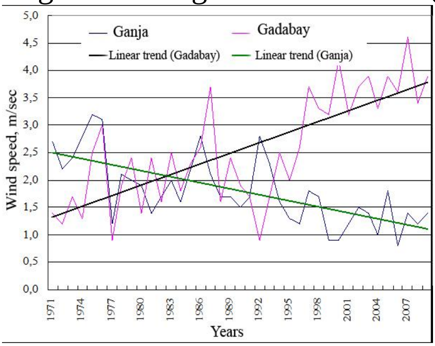


Graph 1. Ganja HMS and long-term volatility of global temperature anomalies in July

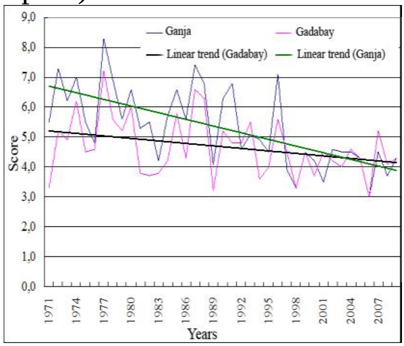
Later in this chapter, long-term change trends of maximum and minimum air temperatures was evaluated. For this purpose, the norms of their new values for months were calculated, the characteristics of spatial and temporal variability were analyzed, also an analysis on the statistical significance coefficient of the tendency of long-term changes, on the rate of temperature changes (^{0}C/10 years) and on changes of indicators (^{0}C) for the period 1971-2009 was carried out. The characteristics of spatial and temporal variations of biological indicators of regional climate change were also evaluated. The days when the average daily air temperature is above 5^{0}C degrees and lower, and also the duration of the interval between these days, were taken as a biological indicator and their statistical characteristics were given. According to the linear trend correlation coefficient and the rate of change of transition dates the early arrival of spring was identified. This acceleration was statistically significant in Ganja and Shamkir, the rate of acceleration in these areas was 3,7 ... – 4,1 days / 10 years, Agstafa – 2,3 days / 10 years, Gadabay – 0,4 days / 10 years. , Dashkesan 1,5 days / 10 years and -1,2 days / 10 years in Goygol. In general, in the period 1971-2009. the beginning of spring came 9-16 days earlier on the plains and 1,6-5,9 days in the mountains.

Taking into account the fact that the wind regime in any region has a strong influence on the activity of living organisms, the trend of wind speed change was estimated. For this, the question of assessing the long-term change in the average monthly wind speed according to a linear trend for the region under consideration was solved for the first time (graph 2).

In the second chapter, an assessment of the change trend in the amount of cloudiness was carried out; for this purpose, the average values of the total amount of cloudiness for 1971-2009 were calculated, their variability was analyzed, and the characteristics of long-term changes were revealed (graph 3).



Graph 2. Long-term dynamics of the average wind speed for January and their linear trends in the Ganja and Gadabay HMS for 1971-2009



Graph 3. Long-term dynamics of cloudiness for January and their linear trends in the Ganja and Gadabay HMS for 1971-2009

The chapter of the dissertation is devoted to the study of "**Meteorological aspects of hazardous environmental processes**". For this purpose, the current state of the problem was analyzed and evaluated, and the risk of recurrence of the forest fires in the northeastern slopes of the Lesser Caucasus was assessed for the first time. The MacArthur Forest Fire Hazard Index (FFHI) of the Australian Bureau of Meteorology was used to predict fire hazards[2]:

$$\mathrm{FFHIN}_N = 2 \cdot \exp\left[-0{,}45 + 0{,}987 \cdot \ln(SM) - 0{,}0345 \cdot NR + 0{,}0338 \cdot t_N + 0{,}0234 \cdot V\right] \quad (1)$$

[2]Gubenko, I.M. Comparative analysis of methods for calculating fire hazard indices / K.G. Rubinshtein // Hydrometeorological Center of Russia, - 2012. No. 347, - p. 207-222.

Here, $FFHI_N$ - represents calculated value of the index for the current day; *SM* - The moisture index of the surface materials of the forest, %; RH- the minimum value of relative humidity during the day, %; t_N - maximum air temperature during the day, ^{0}C; V- The average wind speed during the day, km/h.

SM indicates that surface materials in the forest are "ready" to catch fire and is calculated using the following formula[2]:

$$SM = \frac{1,9 \cdot \left[\left(T_{\text{drought}} + 104 \right) \cdot \left(\Delta_n + 1 \right)^{1,5} \right]}{3,52 \cdot \left(\Delta_n + 1 \right)^{1,5} + \left(R_{24} - 1 \right)} \tag{2}$$

Here, T_{droght} - represents soil drought index (Kitch-Birama Index); Δ_n-number of days after the last rains; R_{24} - sum of atmospheric precipitation for the last 24 hours, mm.

The Kitch Birama Index is calculated as follows[2]:

$$\left(T_{\text{drought}} \right)_N = \frac{0,001 \cdot \left\{ \left[800 - \left(T_{\text{drought}} \right)_{N-1} \right] \cdot \left[0,968 \cdot e^{0,046 t_N} - 8,30 \right] \cdot \Delta_n \right\}}{1 + 10,880 \cdot e^{-0,441 \cdot R_{\text{year}}}} \tag{3}$$

Here, $(T_{\text{drought}})_N$ - represents soil drought index for current day; $(T_{\text{drought}})_{N-1}$- soil drought index for the previous day; R_{year}- average annual rainfall for the investigated area.

The fire hazard degrees were classified according to the selected scale based on the calculated numerical values of $FFHI_N$ (table 1).

Calculations and related assessments were made for the period (April - September), taking into account the fact that fire hazard is most likely occurs in the hot period of the year . In this case, the repetitions of each of the fire hazard scales shown in Table 1[1] for all days of these months were calculated and the sequences for the period of 1971-2009 for use in subsequent analyzes were compiled.

Average index of forest fire hazard recurrence (%) of different intensity for 1971-2009 on the northeastern slope of the Lesser Caucasus was systematically presented. In this case, the Australia FFHIN categorization scale was used.

Significant differences were found in the spatial and temporal repetition of the "very high dangerous" degree of forest fires (figure 1). It was revealed that their recurrence was more on the plains and amounted to 26-56% in all the warm months of the year and in the mountains it was 7-29%.

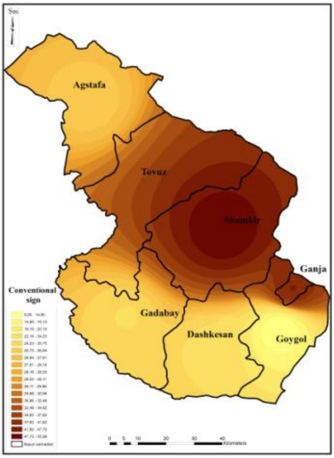


Figure 1. Very high frequency of forest fires in July on the northeast slopes of the Lesser Caucasus (%)

Table 1[3]

Forest fire risk index scale in Australia

$FFHI_N$	Fire hazard rate
From 0,0 to 5,0	Low
From 5,1 to 12,0	Moderate
From 12,1 to 24,0	High
From 24,1 to 50,0	Very high
More than 50,0	Extreme

To assess trends in the long-term dynamics of forest fire hazard recurrence by the corresponding gradations in the area under consideration an analysis of the repeatability of the hazard degree

[3]Gubenko, I.M. Comparative analysis of methods for calculating fire hazard indices / K.G. Rubinshtein // Hydrometeorological Center of Russia, - 2012. No. 347, - p. 207-222.

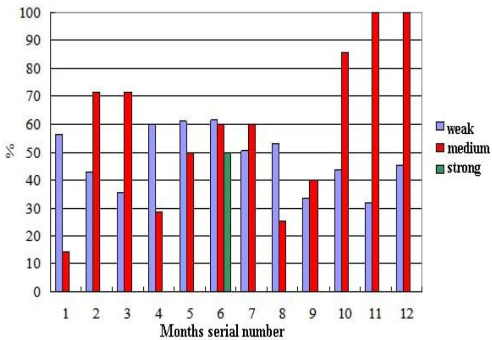
sequences for each station was made. The linear trend correlation coefficients were calculated to assess the reliability of the results and their trends for 39 years (%).

The meteorological drought recurrence assessment was based on a standardized rainfall index (SRI) method[4]:

$$SYİ = \frac{X_i - \overline{X}}{S_x} \quad (4)$$

Here, X_y- represents atmospheric precipitation (annual or monthly) for each year; $\overline{X}$-rainfall sequence avarage value S_x-avarage squared deviation.

In accordance with the SRI index, calculations were carried out for each month depending on the degree of severity of the drought, the results were presented in tabular and graphic form (graph 4), and a drought catalog was prepared for each region.

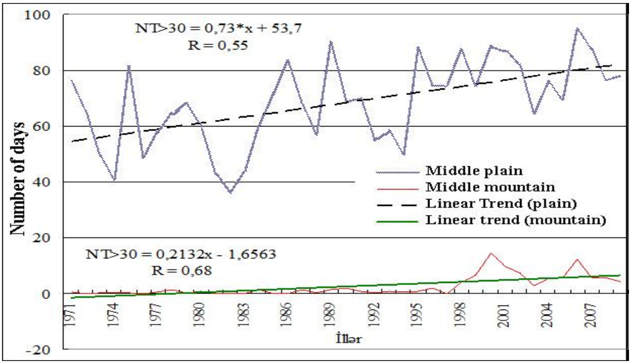


Graph 4. Drought recurrence of different intensity in 1991-2009 relative to the total number fixed at the station in Ganja (%)

Similarly, the trend of climate change extreme indicators was considered, years with an absolute maximum and minimum temperature were found, their maximal and minimal values was systematically presented over the years. The number of days with a

[4]Hayes, M.J. Monitoring the 1996 drought using the Standardized Precipitation Index / M.D.Svoboda, D.A.Wilhite, O.V.Vanyarkho // Bulletin of the American meteorological society, - 1999. vol. 80, №3, - p. 429-438.

maximum temperature of more than 30^0C per day was averaged over plains and mountainous areas, their constant volatility were estimated using the linear trend method, and the results were presented graphically (graph 5).



Graph 5. Trend of long-term changes in the number of days with maximum temperatures above 30°C in the foothills and mountains of the northeastern slopes of the Lesser Caucasus

The chapter **"The assessment of meteorological conditions affecting environment on the northeastern slopes of the Lesser Caucasus"** analyzes the current state of the impact of climate change on the environment and the climatic factor is substantiated in a complex and differential form as one of the main problems of the environment.

In this chapter, the estimation of the variation in oxygen density depending on meteorological factors was performed with the following formula[5]:

$$\rho_{O_2} = \frac{P-a}{R \cdot T} \cdot 0{,}2315 \cdot 10^6 \qquad (5)$$

Here, P-represents atmospheric pressure, hPa; $a = 217 \cdot \frac{e}{T}$ absolute humidity, q/m^3; T=273,1+t- air temperature, t ^0C; e - water vapor elasticity hPa; R=287- universal gas constant, C/(kq·K).

[5]Climate and human health of Baku and Absheron peninsula / AJ Ayyubov, ZF Musayev, AA Karimov [etc.] - Baku: Azerbaijan State Publishing House, - 1997. - 124 p.

Analysis and ratings based on statistical indicators, such as monthly avarage oxygen density ($\overline{\rho_{O_2}}$, q/m^3), avarage squared deviation (σ, g/m^3) and correlation coefficients(R), which are criterion of statistical significance of the long-term variability were carried out.

Studies have shown that the monthly average value of $\overline{\rho_{O_2}}$ on the northeastern slopes of the Lesser Caucasus decreases from January to July and begins to increase in August. In the plain part of the area in winter, this amount varies between 285,2-291,9 g/m^3 and in the mountains - 244,7-252,6 g/m^3. In spring, the density decreases faster than in the winter and summer months, and on the plains the difference between the indicators in March and May reaches 13 g/m^3, and in the mountain zone - 9 g/m^3. The lowest values of $\overline{\rho_{O_2}}$ were observed in the summer months, on the plains it was 259,2-266,8 g/m^3, and in the mountains 228,3-235,5 g / m^3. It was also found that these values continued to increase during the autumn, and varied in the range of 265,8 g/m^3 in Ganja, Shamkir and Agstafa and 232,8-247,2 g/m^3 in Gadabay, Dashkesan and Goygol. It was confirmed that $\overline{\rho_{O_2}}$ varies linearly and functionally depending on the height. It is confirmed by the fact that the correlation coefficients between the studied values and heights were estimated at almost 1,0 (table 2).

Table 2

Linear trend equations for calculating the change in oxygen density by height

Months serial number	Linear trend equations	The square of the correlation coefficients of the equation
1	2	3
01	$\rho_{O_2} = -0{,}0309 \cdot H + 297{,}34$	0,9989
02	$\rho_{O_2} = -0{,}0300 \cdot H + 295{,}16$	0,9992
03	$\rho_{O_2} = -0{,}0286 \cdot H + 289{,}98$	0,9997
04	$\rho_{O_2} = -0{,}0272 \cdot H + 282{,}45$	0,9995
05	$\rho_{O_2} = -0{,}0257 \cdot H + 276{,}77$	0,9995

Continuation of Table 2

1	2	3
06	$\rho_{O_2} = -0{,}0243 \cdot H + 270{,}91$	0,9992
07	$\rho_{O_2} = -0{,}0236 \cdot H + 266{,}94$	0,9993
08	$\rho_{O_2} = -0{,}0239 \cdot H + 267{,}85$	0,9995
09	$\rho_{O_2} = -0{,}0252 \cdot H + 273{,}90$	0,9997
10	$\rho_{O_2} = -0{,}0271 \cdot H + 281{,}92$	0,9993
11	$\rho_{O_2} = -0{,}0293 \cdot H + 289{,}68$	0,9990
12	$\rho_{O_2} = -0{,}0307 \cdot H + 295{,}15$	0,9982

Due to the fact that this amount, which is one of the most important environmental factors that varies due height has great practical importance, its values were calculated by gradation of height (table 3)

Table 3

Oxygen Density indicators depending on altitude

Indicators, $\frac{q}{m^3}/100m$

Altitude indicators,m	Months											
	01	02	03	04	05	06	07	08	09	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12	13
0- 200	291	289	284	277	272	266	262	263	269	277	284	289
201-400	285	283	279	272	267	261	258	258	264	271	278	283
401-600	279	277	273	266	261	256	253	254	259	266	272	277
601-800	273	271	267	261	256	252	248	249	254	260	266	271
801-1000	266	265	261	255	251	247	243	244	249	255	260	264
1001-1200	260	259	256	250	246	242	239	239	244	249	255	258
1201-1400	254	253	250	244	241	237	234	234	239	244	249	252
1401-1600	248	247	244	239	236	232	229	230	234	239	243	246
1601-1800	242	241	239	234	231	227	225	225	229	233	237	240
1801-2000	236	235	233	228	225	222	220	220	234	228	231	234
2001-2200	229	229	227	223	220	217	215	215	219	222	225	228
2201-2400	223	223	221	217	215	213	210	211	213	217	219	222

With the exception of the Goygol station, the oxygen density in the area under consideration decreased during the period 1971-2009, and the intensity of such changes was not the same.

This chapter also assesses the degree of climate comfort based on equivalently effective temperatures. The A. Missenard formula was used to calculate the equivalent-effective temperature index (EET)[6]:

$$EET = 37 - \frac{37 - T}{0{,}68 - 0{,}0014 \cdot f + \frac{1}{1{,}76 + 1{,}4 \cdot v^{0{,}25}}} - 0{,}29 \cdot T \cdot \left(1 - \frac{f}{100}\right) \qquad (6)$$

Here, T- represents air temperature ^{0}C; f -relative humidity %; v- wind speed, m/sec (to change the wind speed from the standard height to 1,5 m you need to multiply it to 2/3).

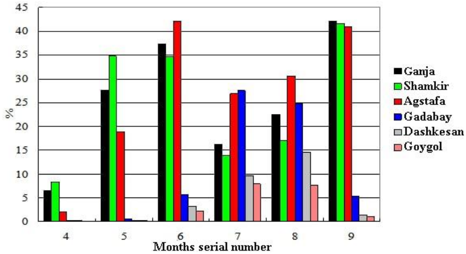
Based on EET indicators, an assessment of the level of environmental comfort from a climatic point of view was made. Comfort level was estimated in the hottest period of the year (april-september) (graph 6).

In this section, the environment based on the climate cold stress index was also evaluated. In the cold half-year, a clinical index or general pathogenicity index was used to quantify the degree of impact of meteorological factors on the human body[7]:

$$I = I_t + I_f + I_V + I_n + I_{\Delta P} + I_{\Delta t} \qquad (7)$$

Here, I_t- represents pathogenicity index of air temperature; I_f - humidity pathogenicity index; I_V - wind speed pathogenicity index; I_n -Pathogenicity index of daily dynamics of cloudiness; $I_{\Delta P}$ - pathogenicity index of changes in atmospheric pressure between days; $I_{\Delta t}$ - index of pathogenicity of fluctuations in air temperature between days.

[6]Андреев, С.С. Climatic resource and comfort of the territory of the southern federal district of Russia: / Author's abstract. dissertation. on the search. уч.степени. Dr. geogr. science. / - Saint-Petersburg, 2010. - 37 p.
[7]Кобышевой, Н.В. Guidance on specialized climatology-Czech economic service. - Saint-Petersburg: - 2008. - 336 p.



Graph 6. Average long-term indicators of the "comfort" climate recurrence in the warm half of the year on the northeastern slopes of the Lesser Caucasus, %

The optimal indicators of the pathogenicity parameters of the minimum meteopathic reactions are : air temperature 18^0C, relative humidity 50%, wind speed 0 m/s, total humidity 0 points, change in atmospheric pressure betweent days 0 hPa/day, and change of temperature between days 0^0 C/day.

These indices were calculated as follows:

$$I_t = \begin{cases} 0{,}02 \cdot (18 - t)^2, & t \le 18°C \text{ when} \\ 0{,}2 \cdot (t - 18), & t > 18°C \text{ when} \end{cases}, \qquad I_f = (f - 70)/2,$$

$$I_V = 0{,}2 \cdot V^2,$$

$$I_{\Delta t} = 0{,}3 \cdot (\Delta t)^2, \quad I_n = 0{,}06 \cdot N^2, \quad I_{\Delta P} = 0{,}06 \cdot (\Delta P)^2,$$

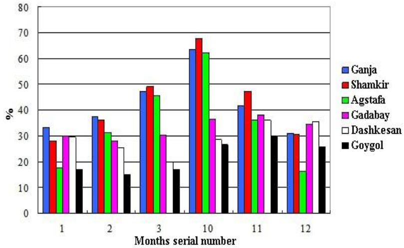
$$I_{\Delta t} = 0{,}3 \cdot (\Delta t)^2 \,.$$

Here, *t* –represents daily average air temperature (^{0}C); *f* –daily average relative humidity (%); *V* –daily average wind speed, (m/s); *N* – total amount of cloudiness (points); Δt –change of air temperature between days (^{0}C); *Δp* –change in atmospheric pressure between days (hPa).

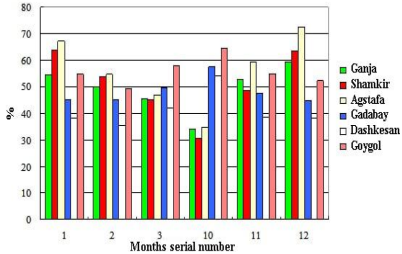
The general meteorological index of pathogenicity indicates its irritating effect on the human body, and not a change in the nature of the weather. Pathogenicity indicators are evaluated on the following scale, depending on *I*: I=0-9 -optimal conditions; I=10-24 -irritating conditions; I> 24 -acute conditions.

Graph 7,8,9 presents the avarage repetitions of the optimal, irritating, acute conditions of the pathogenicity of the climate in the cold season.

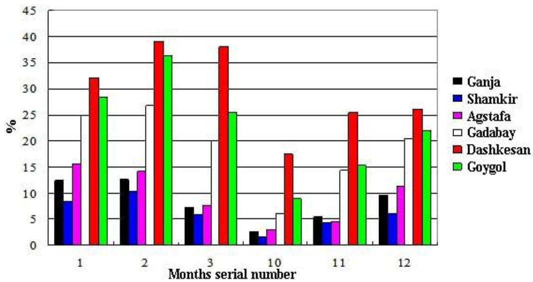
A study of the regional characteristics of heat waves was considered for a quantitative and qualitative assessment of the trend of an increase in the repeatability of hot weather conditions.



Graph 7. The average value of the repetition of optimal conditions (I=0-9) depending on the pathogenicity degree of the climate in the cold season, %



Graph 8. The average value of the repetition of irritating conditions (I=10-24) depending on the pathogenicity degree of the climate in the cold season, %



Graph 9. The average value of the repetition of acute conditions (I>24) depending on the pathogenicity degree of the climate in the cold season, %

Against the background of global and regional climate change, the assessment of the trend of multiplication of hot air waves, one of the most important indicators of meteorological conditions of the environment, is of great theoretical and practical importance. Research in this direction in various scientific centers around the world once again confirms the above considerations. For example, according to a study by an international team of scientists, since 1980, the length of hot air waves in Western Europe has doubled, and their frequency has tripled[8]. Although extreme hot weather in the European part of Russia may be caused by natural factors, global warming related to human activities has increased the probability of such events by ≈3 times[9].

The hottest air wave of the last decade was observed in southeastern Europe in the summer of 2007, when the highest temperatures were recorded during the instrumental observation period.Temperatures up to 45^0C were observed in Bulgaria, Bosnia and Macedonia, 46^0C in Serbia and Greece, and the average temperature in Romania, the Czech Republic, Slovakia and Hungary ranged from 35^0C to 40^0C. The consequences of such weather conditions include the increase in meteorological deaths and forest fires in these countries.Similar weather conditions were observed in Europe, the most intense in Russia, the June-August period was characterized by the hottest weather in the last 130 years, killing more than 11,000 people in Moscow alone[8].

The main purpose of all these studies was to quantitatively and qualitatively assess the growing trend of recurrence of hot weather, to develop certain recommendations for health professionals.

Taking into account that there are different approaches for determining the criteria for heat waves, the following methods were used in the study:

- From 9 indicators that are accepted as universal evaluation criteria in different regions of the earth, long-term changes trends in the indicators of the hottest day, hottest night, tropical nights was estimated
- The criterion of the "heat wave" named as the "index of the duration of the heat wave" accepted at the 4th evaluation report of Intergovernmental Group of Experts on Climate Change was used. In this regard, heat wave indices were calculated for the hot months of 1971-2009.

[8]Overchenko, A. Temporal regularities in the distribution of air temperature extremes in the warm period of the year / Dissertation for the degree of Doctor of Geographical Sciences - Chisinau, 2013. - p. 135.

[9]Dole, R. Was there a basis for anticipating the 2010 Russian heat wave? / M.Hoerling, J.Perlwitz, J.Eischeid [et al.] // Geophysical Research Letters, - 2011, vol. 38, iss. L06702, - p. 5.

RESULTS

1. Warming on the northeastern slope of the Lesser Caucasus since the 1970s to the present, is closely related to global warming and warming in the Northern Hemisphere and was determined that revealed trends in the dynamics of long-term changes of maximum and minimum temperatures correlates well with global similar processes [8,15].

2. Dates when the average air temperature exceeded 5^0C in the spring were accelerated, temperature decrease dates in autumn were delayed and the length of time between these dates extended. The extension of the time interval, as biological indicators confirmed that climate change occurs with different intensities on the northeastern slope of the Lesser Caucasus [9].

3. It was established that the long-term dynamics of forest fire hazards recurrence in certain gradients has complex and spatio-temporal character, long-term trends of meteorological drought was estimated, catalog that has environmental and meteorological significance was compiled [4,14,21].

4. It was found that changes in oxygen density depending on height are linear and functional; the vertical gradients of decrease of this indicator with different intensities were also determined [12].

5. The most frequent repetitions of equivalent-effective temperature were in the plains of 41,0-42,1% in September, at least 2,0-8,3% in April, and 24,7-27,6% in the mountains in July and august. According to the climate cold stress index, it was found that the increase in the repeatability of optimal conditions was 71,7% of all cases, and the number of decrease was 58,3% [13,18].

6. The months when summer noon ,tropical nights was observed was found for different years, the proportion of the hottest days and nights was quantified, over the whole territory in ≈55% of cases the hottest days were observed in 2000-2007, and the hottest nights in ≈81 % of cases in 1998-2008 [19,20].

7. Persistence and repetition of the hot wave occurred in the majority in the mountainous areas, and therefore the habitat deterioration in those areas was found.

The following scientific works were published in accordance with the topic of the dissertation:

1. Ramazanov R.H. On the impact of global and regional climate change on the environment // News of the National Aerospace Agency, – Baku: – 2013. Volume 16, №3, – p. 49-53, (together with N.F. Karimov).

2. Ramazanov R.H. Impact of global climate change on environmental factors // National Aviation Academy, Scientific Proceedings, – Baku: – 2014. Volume 16, №2, – p. 45-50, (together with B.M. Azizov, G.Y. Mehdiyeva).

3. Ramazanov R.H. Impact of global climate change on water basins // Eco Energetics Scientific – Techinical Journal, – Baku: – 2014. №2, –p. 29–33, (together with G.Y. Mehdiyeva).

4. Ramazanov R.H. Some issues of forest fire hazard assessment // News of Pedagogical University, – Baku: – 2014. №4, – p. 106-109, (together with S.H. Safarov).

5. Ramazanov R.H. Features of the processes observed in forest ecosystems against the background of global climate change // Materials of the VIII traditional International Scientific Conference dedicated to the "Year of Industry" on "Ecology and protection of life activities", – Sumgayit: – 2014, – p. 488-492, (together with S.H. Safarov).

6. Ramazanov R.H. Possible effects of climate and its changes on the living environment // Materials of the III International Scientific Conference of Young Researchers dedicated to the 92nd anniversary of the National Leader of the Azerbaijani people Heydar Aliyev, – Baku: – 2015, – p. 294-295.

7. Ramazanov R.G. Study of the Long-term Dynamics of Some Indicators of the Number of Days With Precipitation on the North-Eastern Slope of the Lesser Caucasus // Problems of Hydrometeorological Support of Economic Activities in a Changing Climate, Collection of Scientific Articles of the International Scientific Conference, – Minsk: – 2015, – p. 143-145.

8. Ramazanov R.G. Evaluation of Possible Relationships Between Global and Regional Air Temperatures (On the Example of the North-Eastern Slope of the Lesser Caucasus) // Problems of Hydrometeorological Support of Economic Activities in a Changing Climate, Collection of Scientific Articles of the International Scientific Conference, – Minsk: BSU, – May 5-8, – 2015, – p. 145-147, (together with S.G. Safarov).

9. Ramazanov R.H. Assessment of the trend of multivariate change of biological indicators of climate change on the north-eastern slope of the Lesser Caucasus // – Baku: News of the National Aerospace Agency, – 2015. Volume 18, №2, – p. 27-33.

10. Ramazanov R.H. Assessment of modern trends in wind speed in Ganja–Gazakh zone // Scientific works of the National Aviation Academy, Baku: – 2015. № 2, – p. 159-169, (together with S.H. Safarov).

11. Ramazanov R.H. Some issues of assessing the impact of modern climate change on people's living environment // Geography: Theory, Practice and Innovation, – Baku: – 2015, – p. 587-592.

12. Ramazanov R.H. Estimation of changes in arrow density on the north-eastern slope of the Lesser Caucasus depending on meteorological factors // News of Azerbaijan Higher Technical Schools, – Baku: – 2015. № 6 (100), – p. 77- 82, (together with T.I. Suleymanov).

13. Ramazanov R.H. Estimation of climate comfort level on the north–eastern slope of the Lesser Caucasus on the basis of equivalent–effective temperature index // Baku: Scientific Works of Azerbaijan Technical University, Technical Sciences, – 2015. № 4, – p. 37-43.

14. Ramazanov R.H. Assessment of the recurrence of drought on the north-eastern slope of the Lesser Caucasus // Collection of Works of the Azerbaijan Society of Soil Scientists, – Baku: Science Volume –14. - 2016. – p. 129-133, (together with S.H. Safarov).

15. Ramazanov R.H. Determining the relationship between temperature anomalies in the Northern Hemisphere and regional temperature anomalies // – Baku: Young Researcher Scientific–

Practical Journal of the Azerbaijan National Academy of Sciences, – 2016. volume II, №1, – p. 51-55.

16. Ramazanov R.H. Assessment of the trend of multi-year change of the total amount of clouds in the Ganja-Gazakh zone // Works of the Azerbaijan Geographical Society, – Baku: – 2016. № 1, – p. 50-54, (together with T.I. Suleymanov, S.H. Safarov).

17. Ramazanov R.H. Estimation of space-time changes of absolute maximum and minimum temperatures on the north-eastern slope of the Lesser Caucasus // Materials of the Republican Scientific–Practical Conference on Geographical Problems of the Regions of Azerbaijan, – Baku: – 2016, – p. 224-229, (together with T.I. Suleymanov, S.H. Safarov).

18. Ramazanov R.H. Assessment of human habitat on the north-eastern slope of the Lesser Caucasus on the basis of cold stress index of the climate // National Aviation Academy Scientific works, – Baku: – 2016. № 1, – p. 32-47, (together with T.I. Suleymanov, S.H. Safarov).

19. Ramazanov R.G. Estimation of spatio-temporal variability of the hottest days and nights in the warm period of the year on the northeastern slope of the Lesser Caucasus (within the Republic of Azerbaijan) // HYDROMETEOROLOGY AND ECOLOGY, scientific and technical journal, – Almaty: – 2016. No. 1, – p. 49-59, (together with T.I. Suleimanov, S.G. Safarov).

20. Ramazanov R.G. Estimation of spatial and temporal variability of extreme values of air temperature in the warm period of the year on the northeastern slope of the Lesser Caucasus (within the Republic of Azerbaijan) // Bulletin of the Russian University of Friendship of Peoples Series Ecology and Safety of Life, – Moscow: – 2016. No. 3, – p. 66-74, (together with Suleimanov T.I., S.G. Safarov).

21. Ramazanov R.G. Estimation of recurrence according to the degree of danger of forest fires (on the example of the northeastern slope of the Caucasus) // – Nizhny Novgorod region, Russia: International scientific journal "Alternative Energy and Ecology", – 2020. No. 07-18, –p. 115-125.

The defense of the dissertation will take place on 29th march, 2022 at 14:00 at the meeting of the Dissertation Council BFD 1.23, operating at the Institute of Geography named after academician H.A. Aliyev of the National Academy of Sciences of Azerbaijan.

Address: AZ 1143, Baku, G. Javid Avenue 115, Azerbaijan National Academy of Sciences, Institute of Geography named after academician H.A. Aliyev.
E-mail: institute@geograph.science.az

The dissertation is available at the library of the Institute of Geography named after academician H.A. Aliyev of the National Academy of Sciences of Azerbaijan.

Electronic versions of the dissertation and abstract are published on the official website (www.igaz.az) of the Azerbaijan National Academy of Sciences, Institute of Geography named after academician H.A. Aliyev.

Abstract was sent to the required addresses on 25th February, 2022.

Signed for print: 21.02.2022

Paper format: A5

Volume: 34008

Number of hard copies: 100