

European Green Dimensions: Fundamental, Applied, and Industrial Aspects

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edited by
Olena Mitryasova
Chad Staddon

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SYSTEMATIC ANALYSIS OF HYDROMETEOROLOGICAL ADAPTATION OF THE INTERZONAL GEOECOTONE «FOREST-STEPPE-STEPPE» OF UKRAINE IN THE CONTEXT OF GLOBAL CLIMATE CHANGE

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ABSTRACT

The issue of environmental management is an urgent problem for the development of communities and regions in Ukraine. In modern conditions, the issue of developing and implementing clear guidelines for short-, medium- and long-term development is becoming more relevant. They should primarily focus on the interests of the community. Thus, in order to coordinate all these issues in Ukraine, as well as in the countries of the European Union and North America, it is mandatory to take into account all possible threats to the environment. Minimization of negative impacts on the environment should be of key importance when implementing decisions on the long-term socio-economic development of territorial communities. Designing measures to adapt territories to climate change requires taking into account a number of climate parameters, including extreme ones, which need to be carefully reviewed due to the availability of extended observation series and climate change that has occurred. Since, as a rule, we are talking about using probabilistic and ensured indicators, it is advisable to determine them based on a full series of observations, rather than being satisfied with a 30-year observation period. According to climate data, the territory of the Haivoron and Zavalliv territorial communities is covered by aridization and desertification processes. There is a general clear trend of rising temperatures, which cannot be compensated for by an increase in precipitation in certain periods and, accordingly, an increase in the moisture coefficient.

As a result of climate change, in the context of a significant precipitation deficit and the prolongation of the low-water period in the region, which has already lasted for 15 years in a row, the issue of rational use of water resources is of particular importance. Taking into account the intense anthropogenic load on the water bodies of the Haivoron and Zavalliv territorial communities, it is advisable to carry out regular hydrological observations of the flow of the Southern Bug and its tributaries by arranging a hydrological post and conducting regular surveys of the state of water bodies.

Keywords: rational nature management, adaptation of the territory, climatic parameters, water resources, aridization and desertification, Haivoron and Zavalliv territorial communities, Haivoronskyi old industrial district.

INTRODUCTION

The issue of environmental management is an urgent problem for the development of communities and regions in Ukraine. In today's environment, the issue of developing and implementing clear guidelines for short-, medium-, and long-term development is becoming more urgent. They should focus on the interests of the community and not be hostage to political and bureaucratic interests. Thus, in order to coordinate all these issues in Ukraine, as well as in the countries of the European Union and North America, it is mandatory to take into account all possible threats to the environment. Minimization of negative impacts on the environment should be of key importance when implementing decisions on the long-term socio-economic development of territorial communities. In addition to these traditional components of the analysis, the Russian-Ukrainian war has increased the role of the security factor in all processes of territory development. The intense phase of Russian aggression has deepened the cornerstones of our country's development. For example, the destruction of the Kakhovka hydroelectric power plant dam has forced us to pay more attention to Ukraine's water sector, the peculiarities of adverse climate change, and the increase in anthropogenic pressure on the environment. All this requires an adequate response to reduce the risks of environmental degradation [21; 23].

Despite the degradation of many territories, it is worth highlighting those that are developing rapidly, or at least looking for ways to develop. In our opinion, these include the territory within the former Haivoron administrative-territorial district of Kirovohrad region (according to the reform of the administrative-territorial division of Ukraine, approved by the Resolution of the Verkhovna Rada of Ukraine No. 3650 of 17. 07.2020 «On the Formation and Liquidation of Districts»), which unites the Haivoron city and Zavalliv rural territorial communities and has the features and characteristics of both old-developed and old-industrial districts, forming the so-called Haivoron old-industrial district. This territory is a socio-geographical unit with a relatively low level of technological development of the industrial complex and excess production capacity, represented by large and medium-sized enterprises with outdated equipment, which played the role of city and village forming centers [17; 18].

Located in the west of the Holovanivsky district of Kirovohrad region, the Haivoron old industrial district borders on the Haisynskyi district of Vinnitsa region, the Podilsk district of Odesa region, and the Uman district of Cherkasy region. It belongs to the interzonal forest-steppe geoecotone of Ukraine, a territory rich in historical events and various natural resources, which, in fact, determined the trends of its development and current state. The uniqueness of the studied territory also lies in its location within the southern part of the West Prydniprovia denudation upland, which belongs to the South Podillia and South Prydniprovia upland regions of the Dniester-Dnipro forest-steppe region [17]. Within the Haivoron Old Industrial District, powerful industrial facilities have historically emerged and still exist today, which, despite the difficult economic conditions, have significant potential and are of great importance for the development of not only the area, but also our country as a whole.

The peculiarities of the landscape structure, the presence of various mineral resources and significant deposits of rare minerals within the Haivoron old industrial area are largely influenced by its proximity to various structures of the Ukrainian Shield [8; 18].

Not always well-thought-out economic development of the territory has led to fundamental changes in the properties and structure of natural components and landscape complexes, the formation of new, still insufficiently studied anthropogenic landscapes, and the aggravation of environmental and ecological problems. Accordingly, the modern knowledge of the nature of the Haivoron region should include the study of natural areas, historical features and consequences of its economic development, the current state of natural and anthropogenic components, and its landscape complexes [15; 23].

The territory of the Haivoron district has been explored for a long time, due to the development of mineral deposits, the construction of railways and highways, etc. Scientists and teachers of higher and secondary education institutions, as well as local historians, made a significant contribution to the study of the region. Today we can state that, from a geographical point of view, the Haivoron region has been studied in great detail [17]. However, despite the large

number of publications, a coherent geographical or natural history image of the Haivoron region has not been formed until recently. Considerable attention is paid to climatic conditions, quality and quantity of water resources as an integral component of the interzonal geoecotone «forest-steppe-steppe» of Ukraine and the Haivoron old industrial area in the publications of such scientists as V. I. Vyshnevsky, Donich O.A., Melnyk S.V., Denysyk G.I., Sytnyk O.I., Kravtsova I.V., Nikolayevsky V.P., Kosovets O.O. and others. The authors (Denysyk G.I., 2012; Denysyk G.I., 2020; Sytnyk O.I., 2019; Sytnyk O.I., 2021; Sytnyk O.I., 2024; Nikolayevsky V.P., 2022; Vyshnevsky V.I., 2022; Melnyk S.V., 2023; Kosovets O.O., 2023; Rozhi T.A, 2023) highlights the landscape structure, climatic conditions, condition and main problems of water bodies of the territories with excessive anthropogenic load, which include the Haivoron old industrial area.

Object of research: hydrometeorological support for the adaptation of the territory of the Haivoron city and Zavalliv village territorial communities (Haivoron old industrial district) of Kirovohrad region to modern climate change.

The subject of the study is the systematization of information and analysis of the current state of climatic conditions and water resources use in the territory of the interzonal geoecotone «forest-steppe-steppe» of Ukraine within the Haivoron old industrial district.

The purpose of the study is to substantiate measures aimed at the rational use of water resources in the territory of the interzonal geoecotone «forest-steppe-steppe» of Ukraine within the Haivoron old industrial district.

METHODS AND EXPERIMENTAL PROCEDURES

The data presented in the article were obtained by analyzing archival, statistical and cartographic materials, as well as from our own field and analytical research. To analyze the current state of water resources of the territory of the interzonal geoecotone «forest-steppe-steppe» of Ukraine within the Haivoron old industrial area, we used the GIS packages SAS.Planet.Release and GoogleEarthPro, whose database made it possible to analyze the process of anthropogenization of the objects of the studied territory and determine the temporal patterns of their development.

THE RESEARCH RESULTS AND DISCUSSIONS

The current features of climate fluctuations on the globe are characterized by the redistribution of heat and moisture over its territory over time. Studies of changes in climate characteristics in space and time are carried out continuously in most countries, including Ukraine. The results of these studies are used in various models and forecasting schemes in many reports and guidelines. Climate change in Ukraine is manifested in an increase in air temperature, precipitation and evaporation. In general, there is a significant difference in temperature and humidity conditions in Ukraine between the decades of the late twentieth and early twenty-first centuries [21].The rate of global warming in Ukraine is generally higher than in Europe.

The report of the International Panel on Climate Change (IPCC), a United Nations body exclusively dedicated to the scientific aspects of climate change, presents five scenarios of climate warming. Under the first one (SSP1-1.9), from 2021 to 2040, the average surface temperature will be 1.5°C higher than the pre-industrial level, and in 2041-2060 and 2081-2100 - by 1.6 and 1.4°C, respectively. The second (SSP1-2.6), third (SSP2-4.5) and fourth (SSP3-7.0) scenarios are also based on the hypothesis that global warming is most likely to reach 1.5°C in 2021-2040, with differences in the estimates for 2041-2060 (1.7, 2.0, 2.1°C, respectively) and 2081-2100 (1.8, 2.7, 3.6°C). Finally, according to the fifth scenario (SSP5-8.5), the average global surface temperature will increase by 1.6°C in 2021-2040, by 2.4°C in 2041-2060, and by 4.4°C in 2081-2100 [21].

For the period of 2021-2100, the SSP2-4.5 scenario predicts an increase in annual air temperature (0.27 °C/10 years), an increase in the number of extreme high temperature events, and a decrease in the number of extreme low temperature events on average across Ukraine. Precipitation indices are characterized by positive trends, including an increase in annual precipitation and an increase in the number of extreme precipitation events. The most intense changes will be manifested in a decrease in the number of frosty days (-3.2 days/10 years), an increase in the number of summer and tropical nights (3.0 and 2.51 days/10 years, respectively), and an increase in annual precipitation (2.39 mm/10 years). Under the SSP5-8.5 scenario, a much sharper increase in annual air temperature (0.68 °C/10 years), an increase in the number of high temperature extremes, and a decrease in the number of low temperature extremes are

projected. The biggest changes are observed in the increase in the number of tropical nights (7.9 days/10 years), decrease in the number of frosty nights (-7.78 days/10 years), increase in the number of summer nights (6.84 days/10 years) and increase in the percentage of warm nights (1.91%/10 years). Among the precipitation indices, the largest increase in extreme precipitation is projected for the number of days with heavy precipitation (0.16 days/10 years) and very wet days (0.96%/10 years). The largest differences between the scenarios are observed in the frequency of tropical nights and frosty days. The precipitation indices also show significant differences, in particular, the annual precipitation on average for Ukraine under SSP5-8.5 has a negative trend (-1.28 mm/10 years), while under SSP2-4.5 it is positive (2.39 mm/10 years). Under the SSP5-8.5 scenario, much stronger changes in very wet and extremely wet days are expected [21].

The calculated differences/deviations show that more intense climate change should be expected at the end of this century compared to its middle. For the period 2031-2060, the projected changes in precipitation and air temperature indices under both scenarios SSP5-8.5 and SSP2-4.5 are comparable. For the period 2071-2100, the SSP5-8.5 scenario provides for much stronger background changes in all temperature indices compared to SSP2-4.5. For precipitation indices in the period 2071-2100, the SSP2-4.5 scenario shows a larger background increase in annual precipitation compared to SSP5-8.5.

It is believed that the third scenario (SSP2-4.5) is the most likely and realistic. For the second scenario (SSP1-2.6) to come true, all countries must make more ambitious climate commitments as soon as possible [21].

Compared to the current climate norm, the average annual temperature is 1-2°C above normal every year. According to the National Academy of Agrarian Sciences of Ukraine, in recent decades, the boundaries of the country's natural and climatic zones have actually shifted 100-150 km to the north.

In recent years, vegetation conditions in the traditional northern steppe sub-zone (Dnipropetrovska, Kirovohradska and other regions) should de facto be classified as the southern steppe sub-zone.

The steppe region of Ukraine is gradually approaching the dry subtropics, which, for example, includes the territory of Greece. If the current trends in climate change continue in the next 20 years, there is a real danger that not only the steppe zone, but also more than half of Ukraine's arable land will be lost to intensive agriculture. Fluctuations in maximum temperatures during the growing season may require irrigation even for crops that did not need it before (e.g., wheat), which will lead to a significant increase in financial costs. At the same time, the effects of climate change and shifting climate zones on the agricultural sector may also be positive.

Among the consequences of climate change are the degradation and desertification of agricultural land, while changes in topsoil fertility and crop yields are observed. There are also changes in the microclimate of settlements and many health problems among the population due to the temperature of buildings and air in residential areas, which also creates difficulties for the existence of green spaces in them, etc.

In recent years, the duration of snow cover in winter has decreased significantly. Given this trend, it is believed that the period of «classic» winters is coming to an end. This period is being replaced by another one with the «winter season»[10].

Climate change is also affecting the flow regime in Ukraine. In particular, there is a decrease in flood peaks and an increase in lowland runoff, an increase in the number of thaws, a shift in the course and intensity of rains toward increased erosion hazards, and overgrowth and siltation of small rivers. At the same time, destructive floods due to intense rainfall are also observed [13; 17; 21]. Therefore, there is an urgent need to adapt territorial communities (urban and agricultural areas) to climate change. That is, to successfully address the issues of adaptation measures, it is necessary to have complete and comprehensive information on the course of hydrometeorological parameters of the territory and its structure [2; 23].

The Hydrometeorological Service already has experience in covering, preparing, and publishing a wide range of hydrometeorological information that can fully meet the needs of designing climate change adaptation measures. This includes the publication of climate reference books, the State Water Cadastre, the Climate Cadastre of Ukraine, as well as the work of scientists to summarize climate change in individual territories, etc. [2].

Taking into account the recommendations of the WMO, generalizations have recently been made for 30-year periods (1961-1990, 1991-2020). It is believed that 30-year periods more appropriately reflect the state of the climate of the territories. However, the 30-year series may not be sufficient to generalize extreme climate indicators, so it is recommended to use the entire series of observations.

Of course, the relevant conclusions about the territory of Ukraine can be made only on the basis of reliable and long-term data that are properly processed and analyzed. This extensive work was completed at the climatology department of the Boris Sreznevsky Central Geophysical Observatory. Similar to the previous edition of the Climate Cadastre of Ukraine, the new edition covers the period 1991-2020. The newly created Climate Cadastre of Ukraine is a comprehensive collection of information about the country's climate. It contains generalized results of observations at all 187 weather stations in Ukraine during 1991-2020. The collected data make it possible to establish spatial and temporal patterns of climate, to assess changes that have occurred over a long period of time, which is of great interest for many spheres of state life [2, 5].

In this regard, it is worth paying attention to the spatial and temporal features of changes in temperature and moisture conditions in the territory of the interzonal geoecotone «forest-steppe and steppe» of Ukraine. For example, for the Haivoron and Zavalliv territorial communities of Kirovohrad region, we have a number of representative observations of air temperature and precipitation made at the Haivoron weather station since 1924 (Tables 1-3) [17; 20].

The average monthly temperature and precipitation for 1961-1990 was used as the climatic norm until 2020 (Table 1). Taking into account the trends in temperature and precipitation, starting in 2021, new climatic norms were adopted, calculated according to each meteorological station (Table 2). Thus, the average annual temperature increased by 1.3 °C, and precipitation decreased by 27 mm (Tables 1, 2).

Table 1 − Average monthly temperature, precipitation and relative humidity at the Haivoron meteorological station for 1961-1990.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
t °C	-5.1	-3.6	1.2	9.1	15.2	18.2	19.5	18.9	14.4	8.3	2.8	-1.6	8.1
Precipitation, mm	38.0	39.0	34.0	41.0	55.0	85.0	85.0	55.0	42.0	28.0	39.0	41.0	582.0

Table 2 − Average monthly temperature and precipitation at the Haivoron meteorological station according to the calculations of the climatic norm for 1991−2020.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
t,°C	-3.0	-1.6	3.2	10.2	15.9	19.6	22.5	20.7	15.2	9.0	3.5	-1.3	9.4
Precipitation, mm	32.0	29.0	33.0	36.0	52.0	81.0	75.0	49.0	53.0	39.0	40.0	36.0	555.0

There is a downward trend in soil moisture. The simplest reason is that if annual precipitation varies (2019 - 536.7 mm, 2020 - 473.7 mm. 2021 - 649.5 mm, 2022 - 475.8 mm, 2023 - 454.1 mm), remaining approximately the same, but the temperature rises and evaporation increases. For example, as of July 2024, the dry soil layer was 60 cm, which is largely due to high temperatures (over 30 °C) for a long time. The ratio of precipitation to evaporation, which reflects the moisture (aridity) coefficient, affects natural ecosystems more than the absolute amount of precipitation alone.

The analysis of the results of meteorological observations for 1961-1990, 1990-2019, 2020-2024, taking into account the average temperature, precipitation, relative humidity, evaporation, and the accepted climatic norm, showed that the territory of the Haivoron and Zavalliv

territorial communities is located within the subhumid zone of degradation and desertification and is characterized by moisture coefficients, respectively: 1.2, 1.0, 0.9 [17, 20].

Thus, we should not forget about the need to deploy irrigation systems. In short, new challenges mean new tasks. If we think about them in time, the Haivoron and Zavalliv territorial communities will be able to win a worthy place as centers of agricultural production in the new realities of management.

An integral component of hydrometeorological support is the mandatory and systematic provision of urgent and general hydrometeorological information, including the state of water bodies, to state authorities, local governments and the public. The territory of the Haivoronsky Old Industrial District has a fairly extensive river network, with the Pivdennyi Buh River and its tributaries flowing through its territory, which is one of the largest rivers in the Haivoronsky district and Ukraine as a whole. The distribution of rivers and the density of the river network are determined primarily by the peculiarities of the relief, climate, lithological composition of rocks and economic activity of the population [17; 19; 20].

As you know, according to I. Voyeikov: «rivers can be considered as a product of climate», which remains true today, since all other factors, united under the general name of landscape, can only partially affect the conditions of river nutrition without changing its basic character. This fully applies to the territory of the Haivoron and Zavalliv territorial communities. Rivers are fed mainly by rain, melted snow, groundwater and groundwater. The water regime is generally constant, with spring floods, summer and winter low water, and ice formations in winter (except in certain areas). However, spring floods have not always been pronounced in recent decades due to the fact that the permanent snow cover does not last long as a result of frequent thaws. Rain floods (minor increases in water levels) occur mainly in the summer after heavy rains or prolonged rains in the fall. As a result of the disruption of the precipitation regime, the level of groundwater and rivers has significantly decreased [13].

Table 3 − Extreme temperatures and frequency of adverse weather events at the meteorological station Haivoron.

No.	year	$t^0 \geq 30^0$C	max. t ºC	min. t ºC	thunder-storm	hail	fog	rainfall	Snow/ wet snow	rainlessness
1	2006	18	33.1	-27.6	28	1	33	47	10/2	8
2	2007	54	39.9	-18.0	30	1		58	5	40
3	2008	26	37.9	-18.7	27		31	68	6/4	11
4	2009	35	35.4	-20.0	32		33	62	7/1	20
5	2010	42	36.3	-27.0	46	1	39	66	/1	11
6	2011	28	33.5	-16.2	29	3	23	68	9/2	20
7	2012	58	33.5	-28.4	38	2	24	90	8/1	35
8	2013	24	33.4	-17.2	38	2	47	75	12	23
9	2014	23	35.2	-23.4	28	4	38	75	4	15
10	2015	47	37.0	-19.8	23	2	22	87	8/3	34
11	2016	39	35.2	-21.8	31	2	19	82	19/4	9
12	2017	40	37.4	-20.3	29	3	21	59	6/1	20
13	2018	31	33.5	-22.4	27	1	34	58	10/3	25
14	2019	47	35.4	-19.2	46	3	30	64	1/4	21
15	2020	53	35.0	-9.8	27		18	68	1/9	22
16	2021	31	34.1	-18.4	36	2	22	75	4/7	18
17	2022	26	35.4	-12.3	28		18	75	2/20	18
18	2023	33	37.2	-13.0	28		8	75	1/6	23
19	2024	15	35.1	-15.8						24

Due to this trend of shortening the duration of snow cover in winter, experts at the Borys Sreznevsky Central Geophysical Observatory note that the period of «classic» winters is coming to an end. This period is being replaced by another one with the «winter season» [10]. While 15-20 years ago it was believed that ice on all rivers formed, as a rule, in mid-December and melted mostly in March, in modern conditions, stable ice cover on rivers does not form or its duration is insignificant. Changes in climatic conditions also affect the flow regime.

At the beginning of the twenty-first century, due to warming, the role of air temperature as one of the main climatic factors increased. Particularly significant is the increase in air temperature

during the winter hydrological season and its transition through 0°C into positive values, which leads to a decrease in water reserves in the snow cover before the start of the flood, as well as the depth of soil freezing and the formation of winter floods. Climate change has resulted in a decrease in maximum and annual runoff [10,13]. In particular, there is a decrease in flood peaks and an increase in low water runoff, an increase in the number of thaws, a shift in the course and intensity of rains towards increased erosion hazards, and overgrowth and siltation of small rivers. At the same time, there are devastating floods caused by intense rainfall. Therefore, there is an urgent need to adapt territorial communities (urban areas and areas of industrial and agricultural use) to climate change.

The geomorphological and climatic conditions of the territory of the Haivoronsky old industrial area, the formation of surface runoff, and the different intensity of erosion processes affect the amount of river sediment. Most of them get into rivers and reservoirs as a result of surface flushing of plowed river valley slopes. The formation of small riverbeds in modern conditions is characterized by an almost twofold increase in the volume of sediment and the particle size distribution of bottom sediments. This is due to increased soil washout as a result of changes in the use of agricultural land and a significant increase in the area of plowed land [19].

Despite the relatively large number of rivers, the Haivoron and Zavalliv territorial communities are insufficiently provided with local water resources, and hydrogeological conditions are not favorable for the formation of groundwater reserves, as the area is located in the Ukrainian crystalline massif zone. This is the reason why about 30% of the drilled wells are waterless, while others have low flow rates, which makes it possible to meet mainly the needs of agricultural production [22].



a)



b)

Fig. 1. Flooded quarry sites: a) Zavalliv graphite deposit;

b) Haivoron migmatite field.

In total, there are 89 artificial water bodies (ponds and reservoirs) on the Southern Buh River and its tributaries within the Haivoron Old Industrial District that regulate the flow of water. Their total area is 1091.4 hectares. A special place is occupied by reservoirs resulting from the flooding of the spent areas of quarries and the creation of tailing ponds for the treatment of waste from the concentrator (Fig. 1, 2).



Fig. 2. Takyrs and aeolian formations resembling arid morphosculpture arise with the drying of the solid phase of the tailings.

Accordingly, groundwater also plays an important role. Today, high-quality drinking, slightly mineralized groundwater reserves suitable for irrigation, expansion of the drinking water supply network and production of bottled water have been discovered within the study area. South of the Zavalliv graphite field, the Kirovgeologiya State Geological Enterprise's exploration and survey expedition No. 46 discovered radon healing waters in 1988 during geological survey work. Four wells in total produced more than 0.5 m3/hour of highly mineralized radon water. One of the natural monuments of local importance is the Ivankova Krynytsia spring, which covers an area of more than 2 hectares and is located in a large flat beam near the village of Kotivka.

Along with the presence of an extensive hydrological network, a number of negative factors worsen the ecological condition of water bodies. The rivers of the Haivoron region have experienced a significant anthropogenic load - their basins are areas of ancient settlement and plowing. During the twentieth century, the area of forests, especially on floodplains and terrace slopes, decreased, water quality deteriorated, and numerous environmental problems arose.

Most small rivers suffered particular damage in the 1960s and 1970s, when the riverbeds were straightened and dredged, which resulted in a qualitative change in their morphology and development conditions. These actions resulted in a change in the natural types of channel processes (meandering and floodplain multi-branching) and the processes of siltation began to prevail. It is worth emphasizing that anthropogenic impact on small rivers in modern conditions is one of the main factors that determines the formation of riverbeds, the amount of water flow, the nature of sediments, etc.



a)



b)



c)

Fig. 3 (a, b, c) Changes in the course of the Southern Bug in the territory of the Haivoron and Zavalliv territorial communities as a result of the construction of hydroelectric power plants (HPP):
a) Haivoron HPP and the Haivoron reservoir; b) Berezivska (Savranska) HPP;
c) Salkivska HPP [16,18].

As a result of the construction of hydroelectric dams, new tracts of the lower reservoir reaches were formed, with the central channel or rapids as the paleolandscape basis. Depending on the mode of operation of hydroelectric power plants, their parameters, and the type of dams, these tracts have acquired different characteristics that are constantly changing. In particular, as a result of the construction of the Haivoron HPP, a reservoir was formed, the corresponding coastal morphosculpture began to form, and abrasive and accumulative processes developed (Fig. 3) [1; 17; 19].

In addition, as a result of anthropogenic development of the Southern Bug riverbed and its tributaries, artificial islands, derivation channels, technological embankments, reservoirs, and ponds were created, which significantly changed the nature of the currents, intensified or slowed down erosion processes, and led to the emergence of various previously uncharacteristic landforms (Fig. 4) [1; 18; 19].



a)



b)

Fig. 4 (a, b). Artificial landforms in the Southern Buh riverbed:

a) an embankment island created to prevent erosion of the river bottom during the discharge of water from the Haivoron HPP; b) a technological embankment used during exploration work near Zavallia.

Today, the problems of rational use, conservation and reproduction of water resources in the Haivoron Old Industrial District have become more acute and require immediate solutions. The permitting system for the planned use of water for irrigation is not working, there are no specialized organizations dealing with the construction and maintenance of reclamation systems, and the «Procedure for determining the size and boundaries of water protection zones and the regime of economic activity in them» is systematically violated. A large number of ponds are shallow and overgrown, turning into moisture evaporators [17; 19].

The Southern Bug River is subject to constant anthropogenic pressure; its water is used for technical and municipal needs, and for irrigation of fields. At one time, it was one of the

cleanest rivers in Ukraine, but during the twentieth and twenty-first centuries, pollution from industrial emissions and the use of pesticides in agriculture led to a decline in fish stocks and the extinction of some species.

Since a significant amount of water is used for domestic needs, a large amount of chemical impurities enter water bodies in the reverse process, affecting the overall ecological state of the river and the organic world in it (Tables 4-6) [8, 9].

Table 4 − Concentration of chemical compounds entering the Southern Bug River within the city of Haivoron according to 2020 data.

Polluting substances, the discharge of of which is regulated	Actual concentration, mg/dm^3	Actual discharge, g/hour	Maximum permissible concentra-tions mg/dm^3	MPD (Maximum permissible discharge), g/ hour	MPD, recalculated in t/year
Ammonium nitrogen	7.7	112.34	0.5	15.74	0.137
BOC_5 (biological oxygen consumption)	70.5	1028.52	15.0	472.28	4.113
ChOC (chemical oxygen consumption)	205.0	2990.75	80.0	2518.80	21.939
Suspended solids	15.25	222.48	15.25	480.15	4.182
Petroleum products	0.1	1.46	0.05	1.57	0.014
Nitrates	90.2	1315.93	40.0	1259.40	10.969
Nitrites	4.58	66.82	0.23	7.24	0.063
Sulfates	109.8	1601.87	100.0	3148.50	27.423
Phosphates	19.0	277.19	2.145	67.54	0.588
Chlorides	134.4	1960.76	134.4	4231.58	36.857
Dry residue	1065.5	15544.58	1000.0	31485.00	274.233

Table 5 − Water quality assessment of the Southern Buh River within the Haivoron Reservoir in 2010-2020 by the CPI (combinatorial pollution index) method according to fishery MPC (maximum permissible concentration).

n=10; n′=8; M=80%; CPI =42; SCPI =4,2; quality class IV a - «very dirty»										
Indicator	$[BOC_5]$	$[O_2]$	$[SO_4^{2-}]$	$[Cl^-]$	$[NH_4^+]$	$[NO_3^-]$	$[NO_2^-]$	[Pmin]	SSAS	[ChOC]
N	41	41	41	41	41	41	41	41	41	41
N′	30	1	41	40	4	15	36	0	0	39
Hi	73.1	2.4	100	97.6	9.8	36.6	87.8	0	0	95.1
Evaluation indices	4	1	4	4	1	3	4	1	1	4
Ki	1.89	0.54	5.05	8.05	0.42	3.15	3.57	0.27	0.34	1.75
Evaluation indices	1	1	2	2	1	2	2	1	1	1
Evaluation points Si	4	1	8	8	1	6	8	1	1	4

Table 6 − Comparative assessment of the water quality of the Southern Bug River within the v. of Stavky in 2010-2020 by the CPI method according to fishery MPC standards.

n=10; n′=8; M=70%; CPI =31; SCPI =3,1; quality class III b - «dirty»										
Indicator	$[BOC_5]$	$[O_2]$	$[SO_4^{2-}]$	$[Cl^-]$	$[NH_4^+]$	$[NO_3^-]$	$[NO_2^-]$	[Pmin]	SSAS	[ChOC]
N	35	35	35	35	35	35	35	35	35	35
N′	29	3	0	0	7	1	31	0	1	17
Hi	82.8	8.6	0	0	20	2.9	88.6	0	2.9	48.6
Evaluation indices	4	1	1	1	2	1	4	1	1	3
Ki	2.21	0.72	0.33	0.13	0.57	0.4	32.4	0.27	0.36	1.2
Evaluation indices	2	1	1	1	1	1	3	1	1	1
Evaluation points Si	8	1	1	1	2	1	12	1	1	3

Given the growing negative impact of global climate change (warming, increased and uneven precipitation, flood risks), as well as the overregulation of small and medium-sized river flows in the Southern Bug basin within the Haivoron and Zavalliv territorial communities, we can expect the intensification of dangerous exogenous geological processes. Soon, the main problematic issue will be the study of the state of groundwater in the region and the problems associated with it. It is of great importance to assess the protective properties of the aeration zone, which is a natural protection of groundwater from pollution in natural and extreme conditions. Its characteristics determine the time of contamination penetration into the first aquifer from the surface, and the processes of sorption and ion exchange are carried out within it. The main natural indicators on which the estimates of the time of pollutant intrusion from the ground surface into groundwater are based are its thickness and lithological composition of the pore zone, which is largely modified as a result of anthropogenic load.

The study of critical infrastructure of hydro resources is also gaining special attention in the time of russian aggression. After the destruction of the Kakhovka hydroelectric power plant, there is an understanding of the development of a number of relatively transient short-term and long-term, mostly irreversible, environmental and technological hazards to the operation of critical infrastructure. The presence of three hydroelectric power plants on the Southern Buh River within the Haivoron old industrial area requires strict control over their condition.

During the observations in the 80s and 90s of the twentieth century, plants and animals characteristic of the Ukrainian steppe were rarely found in the area. Today, some species are widespread throughout the territory of the Haivoron territorial community.

On the example of the Haivoron territorial community, it can be argued that the boundaries of natural zones are shifting and, given the trends in temperature changes, it is reasonable to assume that the study area will eventually turn into a dry steppe [2].

CONCLUSION

Designing measures to adapt territories to climate change requires taking into account a number of climate parameters, including extreme ones, which need to be carefully revised due to the availability of extended observation series and climate change that has occurred. Since, as a rule, we are talking about the use of probabilistic and assured indicators, it is advisable to determine them based on a full series of observations, rather than being satisfied with a 30-year observation period.

Global climate change and the replacement of forest, forest-steppe and mainly steppe landscapes with field landscapes have led to significant regional changes in climatic conditions within the interzonal geoecotones of Ukraine. For example, within the interzonal forest-steppe geoecotone of Ukraine, the annual precipitation trend has been mostly negative for almost 60 years, and relative humidity has been decreasing. There is a general trend of temperature increase, which cannot be compensated for by an increase in precipitation in certain periods.

Accordingly, the humidification coefficient decreases. The territory of the geoecotone is covered by aridization processes. Altogether, this leads to the destruction of the unstable dynamic balance of landscapes in the transition zone of forest-steppe and steppe. Possible consequences may include a shift of the steppe boundary to the north, a change in the species composition of vegetation, a change in landscape structure, and a deformation of the configuration of the interzonal geoecotone boundaries. Field landscape studies confirm that these processes have already begun.

According to climate data, the territory of the Haivoron and Zavalliv territorial communities is covered by aridization and desertification processes. There is a general clear trend of temperature increase, which cannot be compensated by an increase in precipitation in certain periods and, accordingly, an increase in the humidification coefficient. The statistical analysis of the results of hydrometeorological observations shows that the territory of the Haivoron old industrial area is characterized by processes and phenomena similar to those observed throughout Ukraine: constant uneven precipitation, which is associated with abnormally wet periods with extremely severe droughts, especially in the last 15-20 years; the spread of drought phenomena that were not considered the norm for the study area. Thus, the fact of redistribution of average annual precipitation is undeniable. A steady decrease in precipitation in the winter-spring period cannot be fully compensated by an increase in precipitation in the summer-autumn period, which leads to the destruction of the dynamic relationship that once existed in the transitional zone of forest-steppe and steppe, to which the study area belongs. Possible consequences of temperature increase and redistribution of precipitation may also include: 1) shifting the boundaries of the steppe zone to the north and aridizing the territory of communities; 2) changing the species composition of vegetation; 3) changing the landscape structure of the territory, etc. Thus, the location of the Haivoronsky district within the interzonal forest-steppe geoecotone of the Right Bank of Ukraine and relative to the Voyeikov barometric axis, as well as local landscape features, contribute to the formation of climatic conditions that are unique to this district. Their further research is necessary for a more detailed understanding of the nature of the Haivoron district, rational use of natural resources, solving environmental problems and nature protection.

As a result of climate change, in the face of a significant precipitation deficit in the region and the prolongation of the low-water period, which has already lasted for 15 years in a row, the issue of rational use of water resources is of particular importance. After all, the lack of «high water» does not allow to flush riverbeds and accumulate the necessary amount of water. This has led to the catastrophic shallowing of the Southern Bug, whereas 10-15 years ago not everyone could swim across it, but now, in some places, it is possible to wade across (Fig. 5). The situation is very complicated and requires a deeper study and decisive action to improve the river's water content [3].



a)



b)

Fig. 5 (a, b). Shoaling of the Southern Bug River: a) near the narrow-gauge bridge across the river (the town of Haivoron); near the village of Zavallia [3; 17].

In addition, within the Haivoron old industrial area, the level of pollution of the Southern Bug is quite high, which indicates that its waters are unsuitable for the safe conduct of certain types of business. The dominance of nitrogen compounds, BOC_5 and ChOC is associated with significant organic pollution of the river by wastewater and limited self-purification capabilities due to significant water regulation. This is due to the significant level of anthropogenic pressure on the Southern Bug River basin and the associated wastewater discharge from enterprises and farms of various forms of ownership.

Taking into account the intense anthropogenic load on the water bodies of the Haivoron and Zavalliv territorial communities, it is advisable to carry out regular hydrological observations of the flow of the Southern Bug and its tributaries by arranging a hydrological post and conducting regular surveys of the state of water bodies.

REFERENCES

[1] Anthropogenic landscapes of the Southern Bug riverbed and floodplain: monograph / compiled by: Denysyk G.I., Lavryk O.D. Vinnytsia. PE «TD 'Edelweiss and K', 2012. 208 c.

[2] Hydrometeorological support of adaptation of the territory to climate change. Proceedings of the Borys Sreznevsky Central Geophysical Observatory. Kyiv: Business Printing House LLC, 2023. Issue 19(33). P. 52-57.URL: http://cgo-sreznevskyi.kyiv.ua/uk/pratsi-tsgo-vipusk-19-33 (Accessed: 02.12.24).

[3] In Ukraine, the Southern Bug River is catastrophically shallow. URL: https://agronews.ua/news/v-ukraini-katastrofichno-obmiliv-pivdennyy-buh/ (Accessed on November 15, 24).

[4] Vyshnevsky V.I., Donich O.A. Long-term changes in precipitation in Ukraine. Kyiv. Business Printing House LLC, 2022. Issue 18 (3). P. 10-18. URL: http://cgo-sreznevskyi.kyiv.ua/uk/pratsi-tsgo-vipusk-18-32 (Accessed: 15.11.24).

[5] Vyshnevsky V., Donich O. Climate cadastre of Ukraine - the largest and most reliable source of data on the climate of the state. Kyiv: Business Printing House LLC, 2023. Issue 19(33). C. 31-39. URL: http://cgo-sreznevskyi.kyiv.ua/uk/pratsi-tsgo-vipusk-19-33 (Accessed: 02.12.24).

[6] Denysyk H.I., Sytnyk O.I., Chyzh O.P., Bezlatnia L.O., Denysyk B.H., Voyna I.M. Interzonal geoecotones of Ukraine: monograph / edited by H.I. Denysyk, O.I. Sytnyk. Vinnytsia. LLC «Tvory», 2020. 363 c.

[7] Denysyk H., Sytnyk O., Bezlatnia L., Pratsovyty M. Spatial and temporal analysis of the process of anthropogenization of the interzonal geoecotone «forest-steppe» of the Right Bank of

Ukraine. Historical and geographical research in Ukraine: a collection of scientific papers. 2022. Issue 16. C. 61-81. URL:http://resource.history.org.ua/issue/geo/2022/16 (Accessed on 15.11.24).

[8] Environmental Impact Assessment Report on the extraction of charnockite from the Zavallivske deposit in the Haivoron district of Kirovohrad region. Cherkasy. 2020. URL: http://ekolog.kr-admin.gov.ua/files/ZVIT_03_07_2020.pdf (Accessed on November 15, 24).

[9] Kompaniets Y.A. Water quality analysis of the Southern Bug River. URL:http://eprints.library.odeku.edu.ua/5927/1/Kompaniets_Otsinka_yakosti_B_2019.pdf. (Accessed on November 15, 24).

[10] Kosovets O.O., Kutsyi A.V., Donich O.A. Former winters in Ukraine are becoming a thing of the past. Works of the Central Geophysical Observatory named after Borys Sreznevsky. LLC «Printing House Business Printing», 2023. Issue 19(33). P. 85-87. URL: http://cgo-sreznevskyi.kyiv.ua/uk/pratsi-tsgo-vipusk-19-33 (Accessed: 02.12.24).

[11] Kravtsova I. V. Garden and park landscape structures of landscape and technical systems of the Middle Dnipro region. Landscape science. 2023. 4(2). P. 69-78. URL:https://intranet.vspu.edu.ua/landscapescience/index.php/journal/issue/view/6 (Accessed: 15.11.24).

[12] Mineral resources of Ukraine. URL: http://minerals-ua.info (Accessed: 02.12.24).

[13] Melnyk S.V., Loboda N.S. Changes in the water regime of Podillia rivers. Proceedings of the Borys Sreznevsky Central Geophysical Observatory. Kyiv. Business Printing House LLC, 2021. Issue 17(31). P. 41-47. URL:https://drive.google.com/file/d/1VuskgeqwlQAhpu4VVausRezGLUNPCi2Q/view (Accessed on 15.11.24).

[14] Paliy V.M. Zavallivske deposit of graphite. Encyclopedia of Modern Ukraine. URL: http://esu.com.ua/search_articles.php?id=14999 (Accessed 02.02.2024).

[15] Rozhi T.A. Taking into account the landscape structure of community territories for rational nature management. Landscape science. 2023. 4(2). P.85-91. URL:https://intranet.vspu.edu.ua/landscapescience/index.php/journal/issue/view/6 (Accessed on 15.11.24).

[16] Salkivska HPP. URL: https://www.energo.ua/ua/assets/salkivska_hpp (Accessed 15.11.24).

[17] Sytnyk OI, Kravtsova IV, Kurnos IT, Nikolayevsky VP, Khlevnyuk OY, Petrychuk OI Natural geography of the Gaiworon region. Vinnytsia, Tvory, 2021. 184.

[18] Sytnyk OI, Nikolayevsky VP. Haivoronskyi old industrial district: formation, current state, prospects for further development. Scientific Notes of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University. Series: Geography. Issue 31, No. 1-2. Vinnytsia. 2019. C. 46-60.

[19] Sytnyk O.I., Tsymbalista L.V. Inland waters of the Gaivoronsk region: current state and problems of their use. Proceedings of the III International Scientific and Practical Conference, Theory and Practice of Coastal Science and Nature Management. Odesa. Bondarenko M.O. 2024. P. 52-58: URL: https://onu.edu.ua/pub/bank/userfiles/files/ggf/naukova_diyalnist/naukovi_konf_GGF/zbirnik_materialiv_Teoria_i_praktika_beregoznavstva_2024.pdf (Accessed on 15.11.24).

[20] Hydrometeorological support for the adaptation of territorial communities of the interzonal geoecotone «forest-steppe-steppe» of Ukraine to modern climate change. Nature and society: challenges and progress. Proceedings of the International Scientific Conference dedicated to the 80th anniversary of the Geography Faculty of Yuriy Fedkovych Chernivtsi National University

(Chernivtsi, October 11-13, 2024): Chernivtsi National University, 2024. P. 90-93. URL: https://geo.chnu.edu.ua/media/a0qnbnib/conferenc_material_80.pdf (Accessed on 15.11.24).

[21] Sidenko V. Modern (1946-2020) and future (up to 2100) changes in extreme air temperatures and precipitation in Ukraine Nature and Society: Challenges and Progress. Proceedings of the International Scientific Conference dedicated to the 80th anniversary of the Geographical Faculty of Yuriy Fedkovych Chernivtsi National University (Chernivtsi, October 11-13, 2024). Chernivtsi, Chernivtsi National University, 2024. P. 94-96: URL: https://geo.chnu.edu.ua/media/a0qnbnib/conferenc_material_80.pdf (Accessed on 15.11.24).

[22] Memorandum on the quality indicators of groundwater and surface water within the Zavallivske deposit for use in the technological processes of graphite production to the Director of Zavallivske Graphite LLC R.K. Saramaga (2022) / geologist V.P. Nikolayevsky.

[23] Todorov V.I. On the issue of strategic environmental assessment of community development planning documents. Bondarenko M.O. 2024. P. 47-51. URL: https://onu.edu.ua/pub/bank/userfiles/files/ggf/naukova_diyalnist/naukovi_konf_GGF/zbirnik_materialiv_Teoria_i_praktika_beregoznavstva_2024.pdf (Accessed: 02.12.24).