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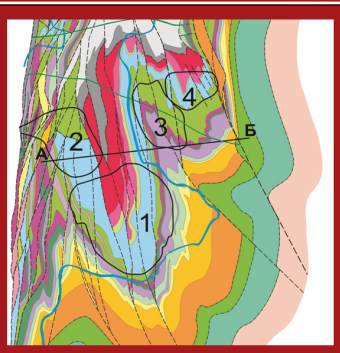

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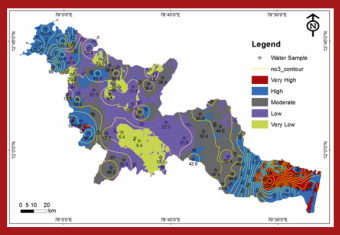

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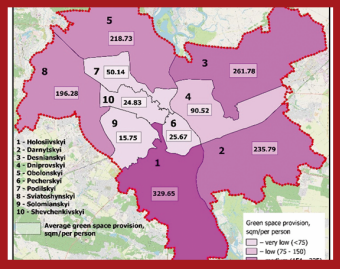

Green space provision

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Long term hydrological and environmental monitoring of the Stryi River using remote sensing data and GIS technologies

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Abstract. The proposed research sets the task of conducting monitoring aimed at determining the horizontal displacements of the channel of the Stryi River the largest right-bank tributary of the Dniester River. For this purpose, the river was zoned according to morphometric and hydrological characteristics. Three parts were identified, namely highland, piedmont and lowland ones, which radically vary in the nature of the flow and the amount of the displacement. The main research purpose consists in analyzing the impact of anthropogenic factors on the hydrological regime of the Stryi River, as well as studying the effect of the Ukrainian Carpathian Foredeep (UCF) and the Stryi Deep on the mode of horizontal displacements. The research object is processes occurring within the Stryi River channel. Considering main natural factors affecting the channel's horizontal displacements, special attention is paid to the geological and sedimentological structures located in the region where the Stryi River and its tributaries flow; among the anthropogenic factors, deforestation and the extraction of building materials from the river channel are highlighted. Topographic, geological, soil maps and satellite images of various periods uploaded into ArcGIS software allowed us to monitor displacements observed for as long as 140 years ago. To monitoring the Stryi River channel displacements, such materials as topographic maps scaled 1: 75000 (Austrian period – 1874), 1: 100000 (Polish period – 1933, Soviet period – 1990); satellite images of Sentinel-2 (2019 and 2020 (after the flood)); a map of Quaternary sediments and a soil map scaled 1: 200000 were used. The Stryi River flows between two structures, i.e. the Skybovi Carpathians and the UCF. The right-bank tributaries (Bystrytsia, Limnitsia, Stryi, etc.), which begin in the Carpathians, cross the outer and inner boundaries of the UCF and are characterized by the stable river channel in its mountainous part, multi-braided in its piedmont part, as well as perennial and significant meandering within the Pre-Carpathian region. Lithological deposits have a significant impact at the mouth of the Stryi River. According to the research study results, displacements of up to 1,350m are measured in this area. The research includes an analysis of the influence of geological and sedimentological structures on the Stryi River displacement and the nature of its flow. It has been established that deforestation in the river basin, as well as unauthorized extraction of gravel materials, creates a significant environmental problem in this region. The results of monitoring of the channel deformation processes should be taken into account when solving problems related to river channel processes, namely the construction of hydraulic structures, the design of power transmission networks crossing rivers, the development of gas pipelines, the identification of hazardous flooding zones, the determination of consequences of destruction after floods, the establishment of boundaries of water protection zones, the management of recreational activities, monitoring of border lands and the establishment of an interstate border along rivers.

Key words: geological structures, monitoring, topographic maps, satellite images, Ukrainian Carpathians

Гідролого-екологічний моніторинг річки Стрий за довгостроковий період з використанням матеріалів ДЗЗ та ГІС-технологій

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Анотація. В запропонованому дослідженні поставлено завдання реалізації моніторингу з визначення горизонтальних зміщень русла річки Стрий, найбільшої правобережної притоки Дністра. З цією метою здійснено районування річки за морфометричними та гідрологічними характеристиками. Виділено три частини: гірську, передгірську і рівнинну, які кардинально відрізняються характером протікання і величинами зміщень. Мета роботи – проаналізувати вплив антропогенних чинників на гідрологічний режим річки Стрий, а також дослідити вплив Передкарпатського та Стрийського прогинів на характер горизонтальних зміщень. Об'єктом цього дослідження є руслові процеси річки Стрий. Розглядаючи основні

природні чинники, що впливають на горизонтальні зміщення русла, особливу увагу надано геологічним та сегментологічним структурам у регіоні, де протікає річка Стрий та її притоки, серед антропогенних виділено вирубку лісів та забір будівельних матеріалів з русла річки. Застосовуючи програмний пакет ArcGIS, здійснено моніторинг зміщень протягом більше 140 років, використовуючи топографічні, геологічні, ґрунтові карти та космічні зображення різних періодів. Для моніторингу зміщень русла Стрий використано топографічні карти в масштабах 1:75000 (австрійський період – 1874р.), 1:100000 (польський період – 1933, радянський період – 1990р.); космічні зображення Sentinel2 (2019 та 2020 р. (після паводку)); карту четвертинних відкладів та ґрунтову карту масштабу 1:200000. Річка Стрий протікає в межах дії двох структур – Скибових Карпат та Передкарпатського прогину. Правобережні притоки (Бистриця, Лімниця, Стрий та ін.), які починаються в Карпатах, перетинають зовнішні та внутрішні межі Передкарпатського прогину і характеризуються стійкістю русла річки в гірській частині, багаторукавністю в передгірській частині та багаторічним і значним меандруванням у межах Прикарпаття. Седиментогенні родовища мають значний вплив в гирлі річки Стрий. За результатами дослідження в цій ділянці зміщення досягають 1350 м. Дослідження включає аналіз впливу геологічних та сегментологічних структур на зміщення річки Стрий та характер її протікання. Встановлено, що вирубування лісів в басейні річки, як і несанкціонований відбір гравійних матеріалів створює значну екологічну проблему в регіоні. Результати моніторингу процесів деформації русла необхідно враховувати при вирішенні завдань, пов'язаних з русловими процесами річки, а саме: будівництві гідротехнічних споруд, проектуванні мереж електропередачі при перетині річок, розвитку газопроводів, визначенні небезпечних зон затоплення, визначенні наслідків руйнування після повеней, встановленні меж водоохоронних зон, управлінні відпочинковою діяльністю, моніторингу прикордонних земель та встановленні міждержавного кордону вздовж річок.

Ключові слова: геологічні структури, моніторинг, топографічні карти, космічні зображення

Introduction

Like the blood vessels of an organism, rivers have become a life-giving force of the entire living world on the Earth. On the one hand river channels are subject to the objective laws of channel formation, and on the other hand, they undergo constant changes resulting from human activity. The study of horizontal reshaping of river channels makes it possible to understand the mechanism of their development more precisely. This applies to a plethora of national economy sectors, the functioning of which is associated with the use of riverbeds and floodplains. In particular, it is impossible to reliably build and operate hydraulic structures, design river crossings, and develop floodplain lands without taking into account the development of channel deformations (both vertical and horizontal). When making artificial water bodies it is necessary to take into account the displacement of a riverbed in recreational areas hosting tourist routes.

The issues of deformation of river channels under natural conditions and conditions of anthropogenic load require detailed research. Therefore, great attention to the study of the state of river basins and individual rivers, the study of the impact of channel processes on the environment, is fixed in European and Ukrainian documents.

Due to the insufficient knowledge on channel processes, flooding of settlements occurs. Accidents at various structures and utility lines happen as the result of absence or lack of data on the morphodynamic characteristics of river channels, changes in the channel regime and their relationship with the hydrological characteristics of rivers. In Ukraine, the issue of a profound study of rivers, taking into account hydrological and morphological analysis and assessment of the intensity of channel transformation, has become acute recently.

The relevance of the problem of determining changes in river channels and monitoring them is confirmed by a number of state and administrative decrees and recommendations, as well as numerous research works on this topic. In 1995 the Water Code was adopted; in 2001 – the Land Code; various Resolutions of the Cabinet of Ministers of Ukraine concerning water protection activities were adopted in 1996 and 2009. In the Land Cadastre, the study of channel processes is associated with the determination of boundaries of water protection zones and the establishment of regulatory restrictions. In 2000, the EU Water Framework Directive was adopted, which defines the basic principles of water resources management and ways to achieve good water quality. One of the main principles, set out in this EU Directive, is an integrated basin-based model of water resources management, which provides for the joint actions of all states, located in the river basins. Directive 2007/60/EC of the European Parliament and of the Council of the European Union on the assessment and management of flood risks, presents an action plan for the assessment and management of flood risks aimed at reducing negative impacts on human health, the environment, cultural heritage and economic activity. The Expert Group is engaged in the development of the flood protection plan, which has the best practices and specific recommendations for the protection of the Danube River from floods. In Poland, *IT System for the Country's Protection Against Extreme Hazards* project (the ISOK project) has been developed. It is aimed at creating a system capable of improv the protection of the economy and society from extreme threats, in particular from floods.

Among other problematic issues, considerable attention to the study of channel processes is provided by the World Wide Fund for Nature (WWF), a branch

of which operates in Ukraine. A special Water and Rivers Commission deals with the problem of degradation of rivers and channel processes. Such researches contribute to the prevention of natural hazards and their consequences, to reduction of material losses and, most importantly, to protection of human life.

There are two mutually exclusive processes associated with rivers. Since rivers are the water sources for settlements, water is taken from them for life and economic needs. Often, water is intaken not only ineffectively, but also irresponsibly without observing sizes of water protection zones, and documents regulating these sizes have not been revised or specified for decades. This promotes ruination of the floodplain, its housing development, erosion processes and, as a result, the siltation and degradation of rivers. This problem, which relates mainly to the steppe territories of Ukraine, but also occurs in other regions, is emphasized in P. Yatsyk's work (Yatsyk et al., 1991). Other hazardous phenomena, namely high flows and floods, are dangerous as they lead to huge material losses and even human casualties.

In the 21st century in the Carpathian and Pre-Carpathian regions there have been three significant destructive floods: in 2008, 2014 and 2020 (June 23-28). The flood in 2020 was especially powerful. The greatest losses were suffered by Ivano-Frankivsk and Chernivtsi regions, although "the big water" also caused a lot of damage in Lviv and Zakarpattia regions. Due to torrential rains, the Carpathian rivers, the Black and the White Cheremosh overflowed their banks, and in a couple of days – the same happened with the Dniester and Prut rivers. All rivers in the regions where devastating floods occur originate in the Carpathians. Witnesses to the 2020 flood witnesses recalled how the water flow rapidly increased, without encountering any resistance, sweeping away everything in its path, carrying huge stones from the mountains, trunks of trees torn with their roots, several non-residential buildings, heaps of waste were often dumped near rivers. The water rose so quickly that it was not possible to save any household property and cattle. In the village of Yasinya, Zakarpattia region, the water rose by 1 meter in one hour. The Prut rose by 5 meters, near Galych the Dniester reached an unprecedented level, i.e. 7 meters. This flood is considered the greatest in the past 60 years in Western Ukraine. According to the Ecological League experts (www.ecoleague.net), 14,000 houses, thousands of kilometers of roads were destroyed, 150 bridges and other infrastructure objects were ruined or significantly damaged. Some villages of the Carpathians remained encircled by the high water and completely cut off from the world due to large landslides that blocked roads and became threatening to houses. Crops, household goods and belongings were destroyed. To help the population and eliminate the consequences of the flood, 1,500 national guardsmen and rescuers were involved. According to preliminary estimates, the costs for overcoming the consequences of the disaster amount to UAH 4-5 billion.

It is obvious that the reason for the floods that have afflicted the Pre-Carpathian region, Bukovyna and Zakarpattia during the previous centuries, was torrential rains, that is, a natural factor, but in several publications (Kovalchuk, 2003, Parpan and Olijnyk, 2009), the reasons are associated with anthropogenic factors: the housing development of the floodplain, extraction of stone, gravel and sand from channels, but deforestation is considered the most important among them.

Knowledge on the patterns of development of channel processes allows for more rational use of rivers and their ecosystems, and ignoring them leads to negative consequences, in particular, to the destruction of hydraulic structures, erosion of banks, landslides, etc. Obeying the objective laws of channel formation, nevertheless, channels undergo constant changes caused by the human activity.

To effectively solve management problems, including those related to channel processes, it is necessary to use a complex approach, based on the utilization of satellite images of different spatial resolution for monitoring channel processes, images from UAVs, topographic and special maps with their follow-up processing using GIS technologies. It will allow one to take into account the main factors that significantly affect the said processes, namely deforestation of the river basin, extraction of building materials from channels, and housing development on land in the floodplain.

The task of our research study is to monitor the horizontal displacements of the Stryi River starting from the headwaters to the mouth where it flows into the Dniester River and analyse the impact of the most important natural and anthropogenic factors significantly influencing these displacements. The effect of geological and sedimentary structures, the peculiarities of geomorphology, changes in the riverine area due to the deforestation and extraction of building materials from the river channel and floodland are considered.

The results of monitoring the deformation processes occurring in the channel should be taken into account when solving problems related to river channel processes, namely the construction of hydraulic structures, the design of power transmission networks or gas pipelines across rivers, the determination of

hazardous flooding zones, consequences of destruction after floods, the establishment of boundaries of water protection zones, the management of recreational activities, monitoring of border lands and the establishment of an interstate border along rivers.

The research study objective is to determine the hydrological changes in the Stryi River channel and the factors that cause these changes. In particular, we considered the influence of such natural factors as geomorphological and hydromorphological; geological, lithological and anthropogenic: deforestation on the slopes within the riverbed territories and the extraction of boulder-gravel materials from the riverbed and floodplain. It has been established that the first catalysts of channel changes are high water and flood phenomena. Common consequences of these natural phenomena are not only changes in the parameters of the channel, its bottom topography, such as meandering, but also huge material and social losses. Therefore, the issues of deformation of riverbeds under natural conditions and conditions of anthropogenic load require detailed research.

Literature review

Changes in morphological characteristics and riverbed displacements. The study of the stability of river channels is closely intertwined with studies of their horizontal reshaping, as well as the factors influencing them, their direction and intensity. These main reasons for studying channel processes are indicated in (Shuliarenko, 1998).

Due to the removal of a significant amount of sediment from the mountains and the flood regime of the Pre-Carpathian rivers, their channels are actively changing and deforming. The flow is influenced by the geological and geomorphological structure, which determines free or limited conditions for the development of channel displacements, which in turn determine the width of the valley bottom, the channel itself and the floodland. Actually, water runoff, geological, and geomorphological structure are the leading natural factors of channel processes.

The designed methodology based on the application of remote sensing data and geoinformation technologies allowed us to determine and analyze planned displacements of the Dniester and Tisza rivers (Burshtynska et al., 2016). The obtained results indicate the influence of geomorphological and geological factors on the channel displacement. The research data cover a period of 140 years. The maximum displacements for the Tisza are 930 m, for the Dniester they are 620 m. The Tisza basin is twice the size of the Dniester basin, which explains the greater water flow. In addition, the greater hydrological regime is influenced by the geomorphological factor, in particular the heights from which the tributaries of the Tisza flow down (1000 - 2020 m above sea level). The Dniester and its tributaries flow down from the altitude of 900-1200 m above sea level. Large floods are observed in the Tisza basin, since, in addition to summer floods, winter and spring floods are observed for the Tisza tributaries, especially typical for the Teresva, Borzhava and others. But the geological structures along which these two rivers flow are identical. For the Dniester, these are the Skybovi Carpathian Mountains and the UCF, while for the Tisza they include the Skybovi Carpathians and the Trans-Carpathian Deep, neither of which differ significantly. The methodology for monitoring channel displacements and the research results were presented at the ISPRS Congress in 2016.

In (Burshtynska, 2017), a methodology for monitoring the displacements of the Dniester River from the town of Galych to the town of Zalishchyky is considered and the specifics of the displacements for various sections of the plain and canyon parts are presented.

The research, empowered by new approaches and technologies for monitoring channel processes, is presented in (Burshtynska et al., 2019). It testifies to a significant difference between the values of horizontal displacements of the right-bank and left-bank tributaries of the Dniester river, located on different geological structures: the former are located within the UCF, the left-bank ones are located within the Volyn-Podilsk Upland. In the same research work, mathematical expressions for determining the stability of channels, proposed by various authors, have been analyzed.

Channel changes significantly affect natural and cultural landscapes as well as human economic activities. On the other hand, anthropogenic activities, in particular mining and construction works in the river valleys also cause changes in the river channels and significant environmental problems. Substantial displacements of the Stryi River channel, associated with the features of the lithological structure, as well as with hydrological and ecological disturbances of the channel and its floodland, are indicated in (Shevchuk and Burshtynska, 2011). The paper presents an analysis of the horizontal displacements of the Stryi River over a 140-year period and indicates that they have reached 1,200 m in its mouth part.

The influence of the upper geological structures on the character of the Dniester River and its right-bank tributary in the piedmont part is considered by (Rudko and Petryshyn, 2014). Actually, the specific geological structure of the UCF with its thick deposits

of gravel and sand has become not only a place for the extraction of this valuable raw material, but also a territory of significant environmental disturbances and losses. The authors note that boulder-gravel-sandy rocks within Ukraine are distributed very unevenly. Their significant reserves are concentrated in the UCF. They were formed by Quaternary alluvial, deluvial, fluvioglacial and aeolian deposits. They occur as lenses and stratal deposits up to 20-25 m thick at a depth of 0-3.0 m.

Monitoring of the Stryi River estuary for the period of 1896-2006 was performed by means of a similar methodology using topographic maps and Google-images (Horishnyi, 2014). The author emphasizes that the riverbed displacement is associated with the lithological structure of the UCF. Interesting studies of changes in the Stryi riverbed, dependent on the extraction of raw materials for the production of building materials, are presented in (Volosetskyi and Shpyrnal, 2013).

Large-scale studies of riverbed deformations are carried out in different countries. Thus, in (Buffington et al., 2014), the influence of topography, geology, climate, vegetation, and land use on the spatial and temporal change of channel processes in the Pacific Northwest is indicated. The authors investigate the influence of channel types on physical models, which can be used to predict changes in channel morphology.

The relationship between the topography of the earth's surface and the hydraulic characteristics of a channel, in particular the influence of surface and underground water flows, as well as studies of the morphology and structure of the Amazon River channel, are presented in (Beighley et al., 2009).

Scientists from the Great Britain (Hooke, 2006) investigated the intertwining and tortuosity of single-thread and multi-thread river channels with the determination of meandering and interlacing coefficients. It is noted that multi-threaded rivers are more meandered than single-threaded ones.

Studies of the problems of channel processes in Western Australian rivers are presented in (Janicke, 2000). The influence of anthropogenic factors on the transportation of sediment and siltation is noted. Attention is drawn to the solution of the problem of degradation of rivers and channel processes, which is dealt with by a special Water and Rivers Commission.

In (Guneralp et al., 2011) the migration of the Brazos River in Texas over the period of 1910-2010 has been analyzed. Topographic maps and satellite images of different time periods were used. Not only the migration of the channel, but also the meanders, the slope and the shape of the channel of this river have been studied. Channel migration zones, which combine historical channel displacements and forecast future displacements, have been identified presenting an analytical tool for forecasting areas that may be at risk of catastrophic floods.

In (Legg and Olson, 2014) the objects of study are the rivers of Western Washington, in particular, the riverbeds' migration is investigated. It is indicated that channels migrate within the floodplains due to the processes of channel expansion, changes in bends and their frequency.

Stratigraphic, geomorphological, and paleoecological data were collected from high-altitude water intake areas in the Great Basin of Central Nevada to assess the relationship between the Late Holocene climate change, land-forming processes, forest cover, and modern channel dynamics (Miller et al., 2001). They indicate that the transition to drier, warmer climates 1300-2500 years ago led to a complex set of geomorphological reactions. The initial reaction was massive erosion of mountain slopes and, simultaneous gravitation of lateral valley alluvial deposits. It was replaced by sediment stabilization, as fine-grained sediments formed from rocks, and, in particular, changes in sedimentary processes and runoff occurred. It has been proven that the current dynamics of channels and associated bank ecosystems significantly affect the shape of forests.

New Orleans professor Stephen A. Nelson explains the formation of meanders as follows: due to the rate of change in the structure of the flow, especially in rivers with easily eroded soils, straight sections become tortuous. At the outer part of the meanders, at the bends, where the flow rate is the highest, the development of soil erosion occurs. Silting occurs along the interior part, where the velocity is low (Nelson, 2012).

Deforestation impact. Let us consider some works related to another factor that has a significant impact on the hydrological regime of rivers, i.e. the deforestation in the river basin.

The monograph (Kovalchuk, 2003) comprehensively considers natural factors of channel processes, in particular, the state of the river flow in the Dniester basin and the amount of precipitation in the region over the second half of the 20th century. The monograph highlights the insufficient amount of afforestation of water intake areas (40.2% in the Ukrainian Carpathians and 25% in the Pre-Carpathians). The study also notes the state of forests, including excessive forest felling, changes in the age and species composition of forests, anthropogenic reduction of its upper boundary by 200-300 m, as well as the fact that the percentage of afforestation in the Carpathians is

steadily decreasing.

Environmentalists of the state agency of Ukraine have long been concerned about unauthorized deforestation. Studies (Kabal, 2016) indicate a great role of forests in maintaining water balance. The optimal forest cover for elementary water intake areas should be 65-70%. Trees begin to accumulate water after reaching 40 years of age.

In (Parpan and Olijnyk, 2009) the formation of floods, the structure of forests and their water regulating role in the Ukrainian Carpathians has been analyzed. There are also proposals for enhancing the protective properties of forests. As initial data, the statistical data on the calculation of afforestation in the region, as well as hydrological and experimental studies over a 50-year period were used. Scientists point out that the forest in the Carpathians reduces the flow of water on the slopes by about 4-5 times, the trunks and crowns of trees restrain water flows by 20-30%. The forest prevents landslides, while in dry weather it contributes to the feeding of rivers with groundwater.

In (Bayrak, 2011) the issues of deforestation in the Pidbuzh river basin, as well as changes in its hydrological regime have been considered.

The paper (Burshtynska et al., 2014) is devoted to the problems of forest felling in the Carpathian region. Satellite images with high spatial resolution were used for the study. The study has established that satellite images can be used to detect not only areas, but also the time of felling. In (Kokhan et al., 2020), a new approach to the use of vegetation indices for vegetation identification has been proposed.

The state of forests in Uganda is discussed in (Josephat, 2018). Uganda is noted to have suffered the adverse effects of climate change, especially during the last decade, as evidenced by numerous periods of erratic rainfall, prolonged droughts, floods, repeated mudflows, thunderstorms, increased pests and diseases, hunger and declining agricultural productivity. The population growth and migration have increased the demand for agricultural land and firewood, and rural poverty limits the ability to invest in sustainable land management practices.

The Yangtze River flood in 1998 (Xin Zong You, 2012) set the limit for the Chinese government to take measures to protect the environment for sustainable development. The Chinese government strictly banned deforestation in the wake of the disaster, prompting mixed criticism from the international community. However, based on the literature reviewed, it was concluded that forest and flood are closely related to each other, and deforestation does have a huge impact on the intensity of floods or their frequency.

For centuries, forests have been believed to provide flood protection. However, such claims created controversy, and there was no large-scale quantitative evidence of a possible role for forests in flood protection. Using data collected during 1990-2000 in 56 developing countries, the authors (Bradshaw et al, 2007) prove, that with a decrease in the area of natural forests by 10%, the average model forecasting of the frequency of floods increases within 4% - 28% among the simulated countries, and also led to an increase in the total duration of floods by 4-8%.

The article (Ali, 2014) focuses on the study of the role of deforestation, its impact on climate change and its consequences in Pakistan. Forests protect biodiversity, soil and regulate the hydrological cycle, air temperature, help to cope with the effects of climate change. With the population growth and the trend towards urbanization, the rate of deforestation has increased, disrupting natural atmospheric and climate patterns and exacerbating the devastating impact of natural disasters, including catastrophic floods.

Carbon emissions and the risk of deforestation are high on the list of globally important externalities (Buys, 2007). For example, a strong global commitment to the Framework Convention on Climate Change, which calls for the stabilization of greenhouse gases' release in the atmosphere, would mean conditions for the conservation of forests. The hydrological effects of deforestation are extremely sensitive to local conditions. In the past, politics was influenced by hydrological myths, including that forests produce water. Reliance on these myths has backfired forest restoration and may have undermined efforts to protect forests.

Current knowledge shows that the greatest benefits from watershed management occur within small watersheds, in small steep basins from which cities intake water, or along river boundaries. Fine-tuning the behaviour of a watershed requires attention not only to the presence or absence of trees, but also to their placement, agricultural activities, and especially the placement and maintenance of roads. On the other hand, the conservation of forests, motivated primarily by biodiversity, can stabilize the hydrological regime in the basins of large rivers. However, the scientific understanding of hydrological processes is incomplete. In some cases, large-scale deforestation can affect the regional climate. There is also discussion of the extent to which deforestation can reduce runoff during the dry season. Detailed scientific and economic research is needed to identify situations in which deforestation poses these risks.

The article (Li-An et al., 2018) indicates that the global increase in the frequency and extent of floods

is caused by anthropogenic activity. From 1980 to 2009, floods killed more than 500,000 people and affected more than 2.8 billion people worldwide. Through urbanization, deforestation and large-scale agricultural activities landscape alteration contributes to flooding urban and rural areas. Industrialization in developing countries increases carbon emissions by activating an aerosol-induced mechanism. As a result, a catastrophic flood occurred in Sichuan in 2013. In addition, rainfall in urban areas has increased due to the urban heat island effect.

Materials and methods

The Stryi River is the largest right tributary of the Dniester, which originates at an altitude of 1,120 meters. The length of the river is 232 km. In the highland part, the river flows along a narrow valley, the average channel width is 30-50 m. In the hilly part, the width of all spits can reach up to 120 m. In the lowland part, the width does not exceed 80 m.

Materials of different time periods used for research require an assessment of the accuracy of their transformation. These researches were carried out by the method of coordinate transformation using power polynomials by means of ArcGIS 10.1 software product. Since the topographic maps used were created in different time periods and in different cartographic projections, and satellite images are stored in the UTM projection (Table 1), it is necessary to normalize all available materials to the universal topographic Mercator UTM projection.

Table 1. The main materials for the study of horizontal displacements of the Stryi River channel

No	Input materials	Year of publication / survey	Ellipsoid	Projection type	Coordinate system
1.	Topographic map (Austria-Hungary)	1874	Austrian ellipsoid of 1810	Zoldner - Cassini	Halychyna coordinate system
2.	Topographic map (Poland)	1933	Austrian ellipsoid of 1810	Zoldner - Cassini	Halychyna coordinate system
3.	Topographic map (USSR)	1990	Krasovsky	Gauss - Krueger	SK-42
4.	Sentinel 2 satellite images	2019/2020	WGS-84	UTM	WGS-84

A power polynomial is used to transform one map projection into another. The formula for transforming one cartographic projection into another using power polynomials is:

$$X = X_0 + \sum_{i=0}^{n} \sum_{j=0}^{n} a_j x^i y^j \quad (1)$$

, $$Y = Y_0 + \sum_{i=0}^{n} \sum_{j=0}^{n} b_j x^i y^j \quad (2)$$

where: x^i, y^j are coordinates of the first projection taking into account the average value;

X, Y are coordinates of the second projection;

X_0, Y_0 are coordinates of the average value of the second projection;

a_{ij}, $b_{i,j}$ are conversion function coefficients.

To convert the n-th power it is necessary to have at least p_n common points:

, $$p_n = p_1 + \sum_{i=2}^{n} (i+1) \quad (3)$$

where: p_1 is the number of common points for the transformation of the first degree.

For the reference common points were used, which are identified on topographic maps and images: bridges, crossing points on railway tracks, places of worship, etc. The transformation is carried out by a 2nd degree polynomial using 10 common points. For comparison, Table 2 shows the alignment accuracy using 1st and 2nd degree polynomials.

The research results

Geological and sedimentological structures The Stryi River crosses the following geological structures of western Ukraine – thrust-and fold elements of the Ukrainian Carpathians, the UCF, (the inner and outer zones). The question of how geological features have influenced and still influence the nature of the river arises. Another question is how the river itself influences the formation of some geological

Table 2. The main materials for the study of horizontal displacements of the Stryi River

River	Map	Polynomial of the 2nd degree (m)	Polynomial of the 1st degree (m)
The Stryi	Austrian period	20	34
	Soviet period	15	20

formations, such as alluvial deposits. A very important factor that should be taken into account is the influence of man on the processes taking place in and around the river. The Stryi River has a length of 232 km, the area of the basin is 3,060 km² (Fig. 1).

Geomorphologically it intersects the Carpathians and Pre-Carpathians. In the Carpathians, the Stryi River has a mountainous character with a narrow valley, while in the Pre-Carpathians it is partly a plains river.

nappes is composed of layers of sandstones, siltstones and argillites, which form the so-called flysch. The thickness of the flysch complex in the thrusted state is 12 km.

The Cretaceous deposits in the study region were formed in two different tectonic and paleogeographic conditions, i.e. platform and geosynclinal ones (Havrylyshyn et al., 1991). Mostly, the direction of the riverbed of the Stryi River is caused by tectonic factors, namely regional faults transverse to the

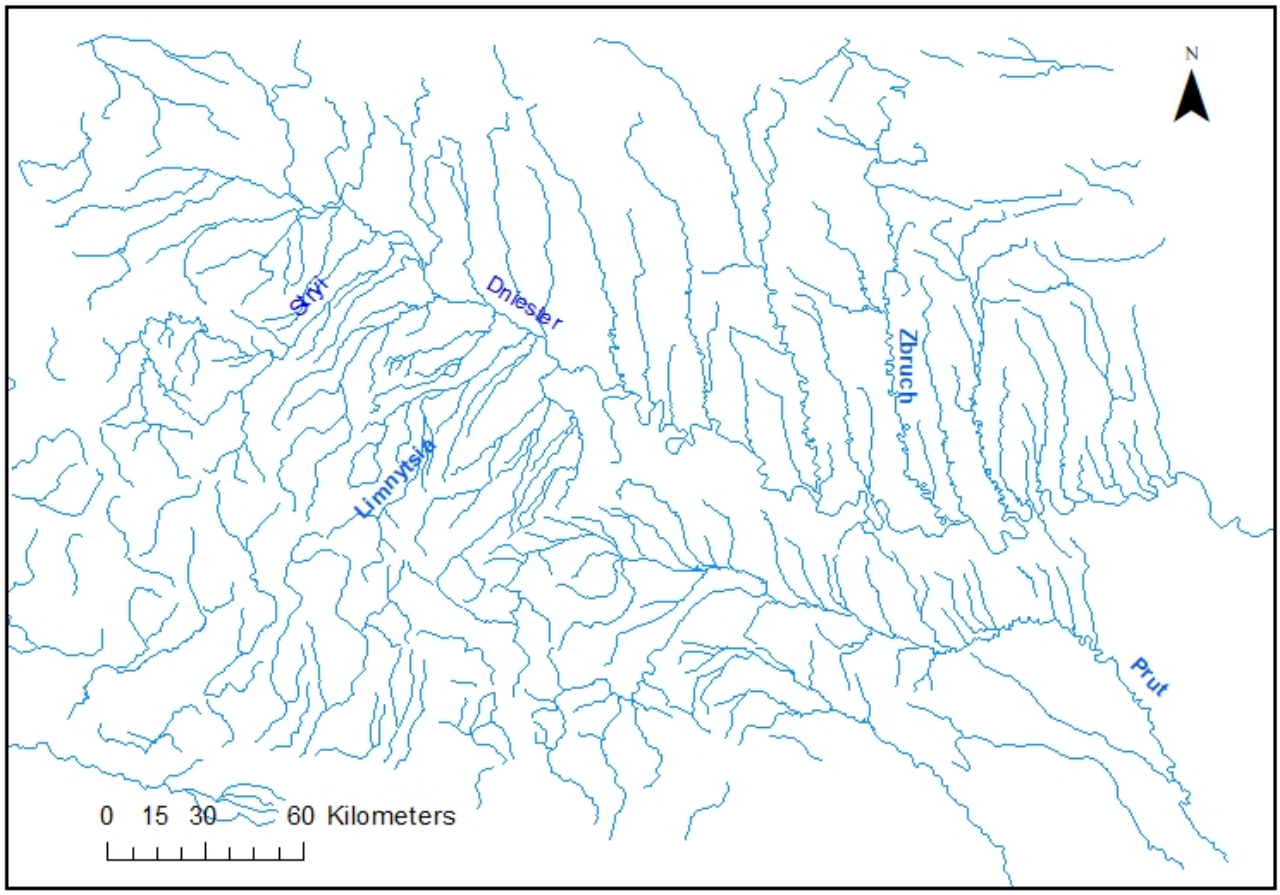


Fig.1. The location of the Stryi River in the Dniester River basin

The Stryi River crosses two high order structures, i.e. the thrust and folded-belt of the Ukrainian Carpathians and the UCF which superimposes the platform (Fig. 2).

A number of structures - nappes - have been identified in the thrust and folded-belt (Bubniak I., Bubniak A., 1997). It runs through two nappes of the Ukrainian Carpathians – Krosno and Skyba. The other two nappes through which the Stryi Rriver flows - Boryslav-Pokuttia and Sambir ones – belong to the UCF (Nakapelyukh et al., 2018). Adjacent to these structures from the east is the Bilche-Volytska zone (Outer) of the UCF, which is an autochthonous tectonic unit. All these nappes (except Sambir) are composed of formations ranging in age from the Cretaceous to the Neogene. The bulk mass of the

Carpathians. Part of the Stryi tributaries is also controlled by faults of smaller orders and fractured zones, which have a fairly regular location (Hintov et al., 2011). Although there are some exceptions, for example, the meander of the Stryi River near the village of Rybnyk may be due to the composition and mechanical properties of rocks. The situation is significantly different in the Bilche-Volytska zone of the UCF. The foredeep is filled with upper molasses and Quaternary sediments, which differ in lithological composition and mechanical properties from flysch. Here, in our opinion, the main factors influencing the deformation of the channel are lithological ones.

Geomorphological factors. The geological and sedimentological structures along which the Stryi River flows, determine the diverse relief of the territo-

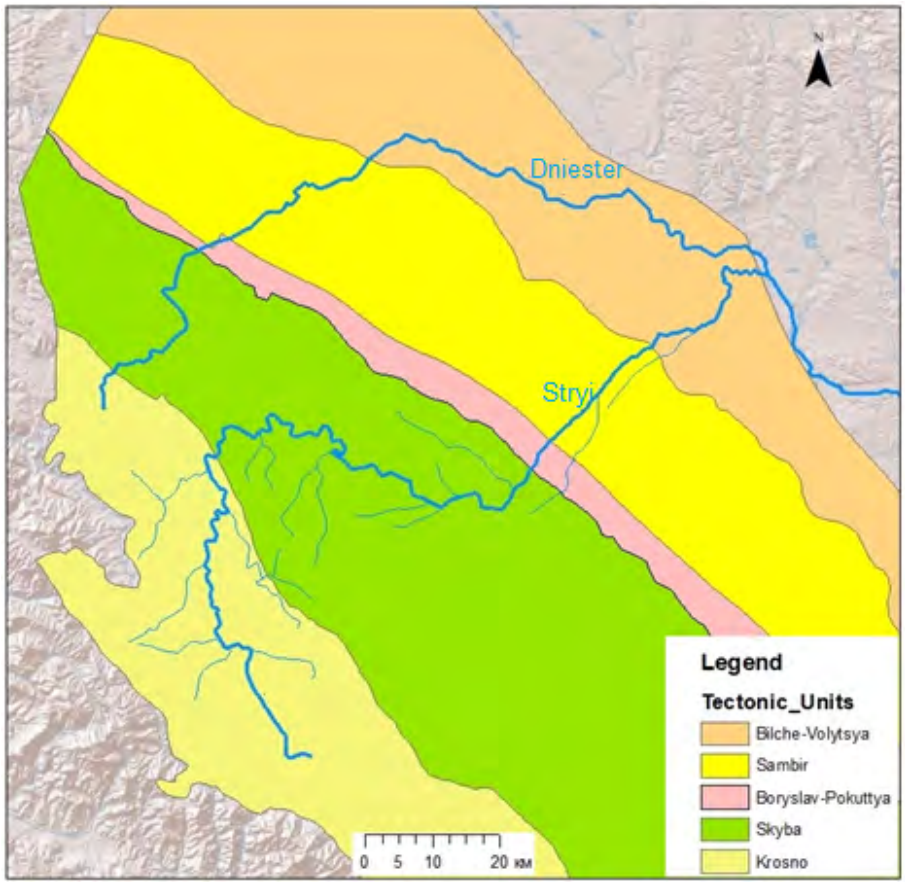


Fig.2. The main tectonic structures of the Stryi River basin

ry. In the upper part there is a mountainous relief with narrow valleys. The lower part of the course of the Stryi River is conditionally divided into piedmont and plain. This division is due to the different nature of the riverbed in these areas. In the piedmont part, the river is characterized by a significant number ofbraids and the absence of meandering. In its lowland flat part, the river flows practically as one channel with significant meandering and the presence of oxbow lakes. A fragment of a digital elevation model with an overlaid digitized channel of the Stryi River is shown in Fig. 3.

Study of the Stryi River displacements. It is no wonder that this river was chosen for monitoring since the Dniester and part of its right-bank tributaries, including the Stryi, are located in the UCF Within this foredeep, the Stryi Deep is distinguished, which significantly influenced the nature of the riverbed, its floodplain and valley (Table 3). In some places the Stryi has a very winding channel. In particular, it makes a large meander near the village of Rybnyk, which is not typical for the mountainous part.

Monitoring was carried out for over a 140-year period. The Stryi River was conditionally divided into mountain, piedmount and flat parts. To monitor the Stryi River channel meandering, the following were used: topographic maps scaled 1: 75000 (1874) and 1: 100000 (1933 and 1990); satellite images obtained from the Sentinel-2 satellite (2019 and 2020), for the mountainous part a high-resolution image from the Bing service was also used; 1: 200000 scaled maps of the Quaternary sediments (1970) and a soil map (1967). The methodology for performing the study is presented in (Burshtynska et al., 2017, Burshtynska et al., 2018).

Table 3. The main characteristics of the Stryi River

Characteristics of the river	The upper (mountainous) part	Middle (piedmont) part	The lower (plain) part
The main hydrological and morphometric characteristics			
Width, m	10-90	30-120	30-80
Depth, m	0.5-1.5	1.0-2.5	3.5-4.0
Speed, m/s	0.9	0.4	0.2
Slope m/km	5	1.7	0,.8
Meteorological and hydrological characteristics			
Precipitation, mm	1,200	900	800
Average annual runoff, m^3/s	20	35	50

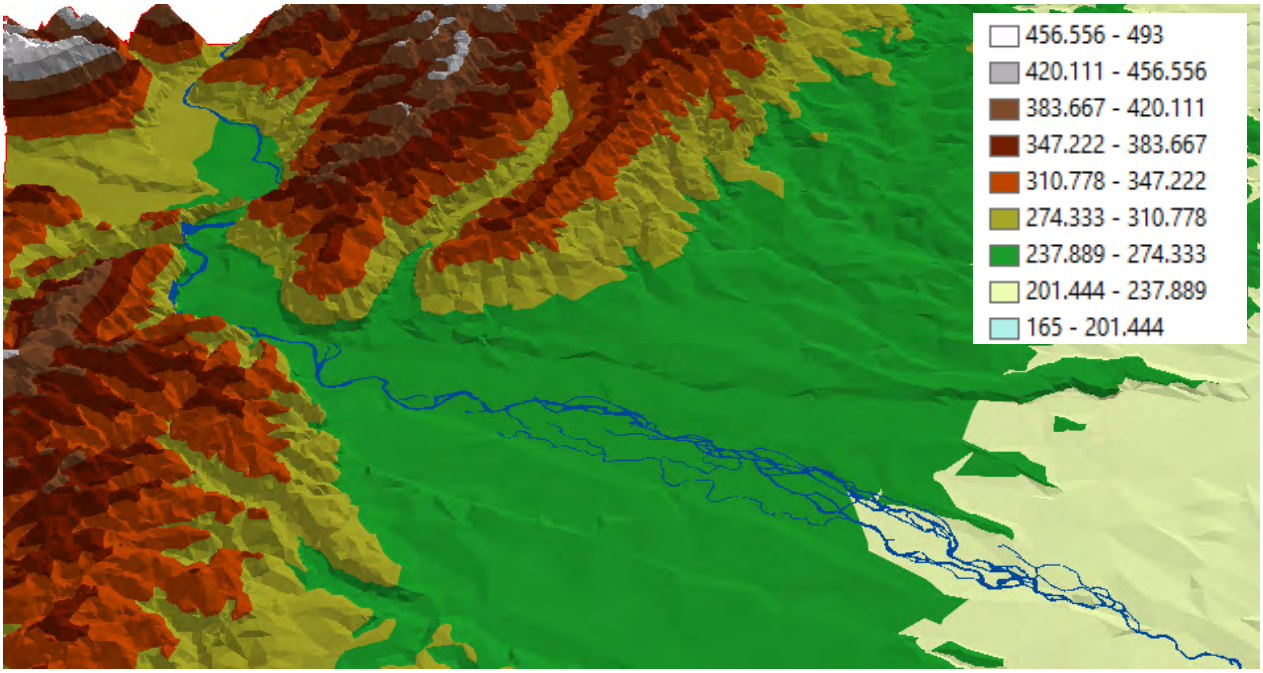


Fig. 3. Fragment of the TIN model with the overlaid Stryi river channel during its transition from the mountainous to the piedmont part

Mountainous part. The mountainous part of the river is characterized by the presence of one channel. The difference in height from the source to the exit of the river to the piedmont territory is about 750 m within a 150 km long section, that is, on average 5 m/km. A fragment of a section of the Stryi riverbed in the mountainous part is shown in Fig. 4. Since the valley of the river flow in the mountainous part is predominantly narrow, the values of channel displacements during the study period are relatively small. The results of measurements of channel displacements in areas with maximum deviations when approaching the piedmont part of the channel are presented in Table 4. The maximum displacement recorded in this area is 200 m.

Table 4. Maximum displacements of the Stryi River channel in the mountainous part

Measurement point number	Maximum displacement
1	130
2	120
3	120
4	170
5	160
6	150
7	200
8	130
9	140

Enlarged fragments of the channel with details of the maximum changes are shown in Fig. 4. In the mountainous part, only 9 points were selected to determine the displacements (in the places of the greatest deviations), since in this part the channels practically overlap. The maximum displacement value obtained for the years of 1874-2019 is 200 m, that is, the displacement is relatively insignificant. In the mountainous part, the displacements are insignificant and do not exceed the accuracy of the representation the topographic map.

Piedmont part. The length of the piedmont part of the Stryi River (from the urban settlement of Verkhne Syniovydne, Skole district, Lviv region to the urban settlement of Gnizdychiv, Zhydachiv district, Lviv region) is about 50 km. The drop in this section is 85 m, that is, 1.7 m/km. This part is characterized by a significant multi-braided structure of the river channel (Fig. 5). Therefore, for this section, the number of spits and the measured width of the distance between the outermost river threads are supplied (Table 5). In 1874, the maximum spit width was up to 1.5 km, the river was divided into 3-6 spits.

In more than 100 years (1990), the width between the outermost river spits decreased to 500 m. In general, a decrease in the channel width is recorded in all sections of the river, which indicates a decrease in its water content. Within the piedmont part, the displacements are the differences between the width of the river spits. It should be noted that in this section the channel shifts in the north-western direction, which poses a risk that the international highway might be eroded.

Plain part. The most varied part of the river in

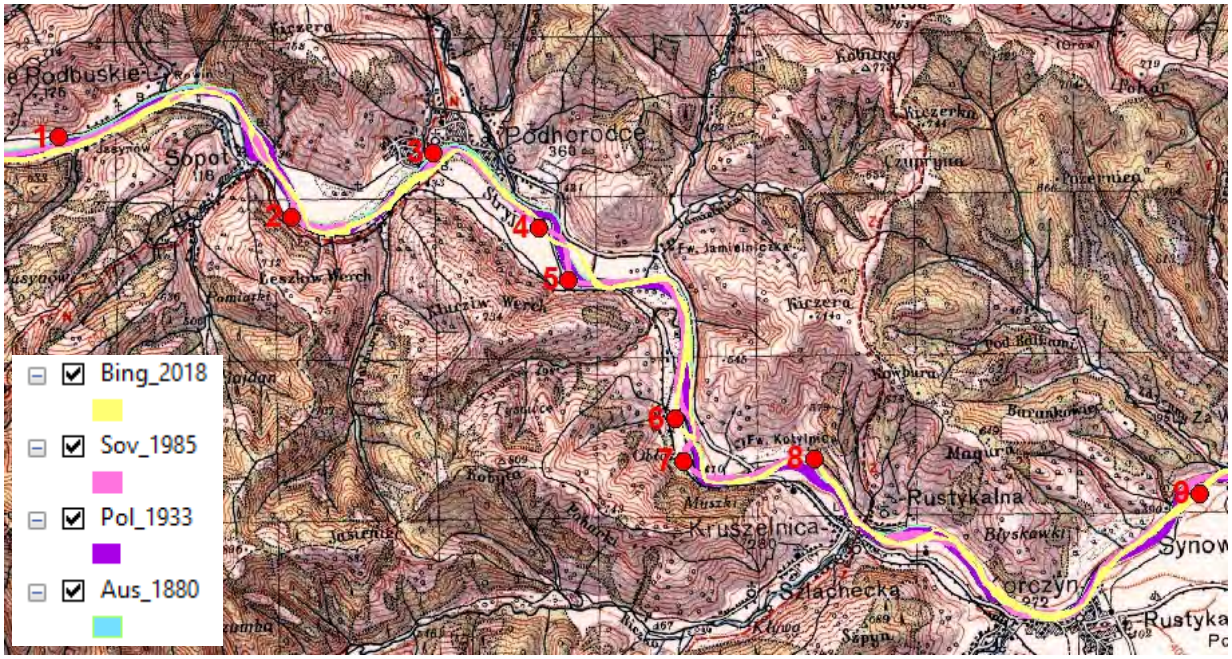


Fig.4. Fragment of digitized channels of the mountain part of the Stryi River overlaid on the topographic map of 1933 and places of displacement measurement

terms of changes and water regime is the channel located in the lowland part of the area up to its entering the Dniester River (Fig. 6). The length of the plain part of a large number of meanders and abandoned oxbow lakes, in some areas the terrain is swampy. The Stryi River makes the most interesting meanders near the

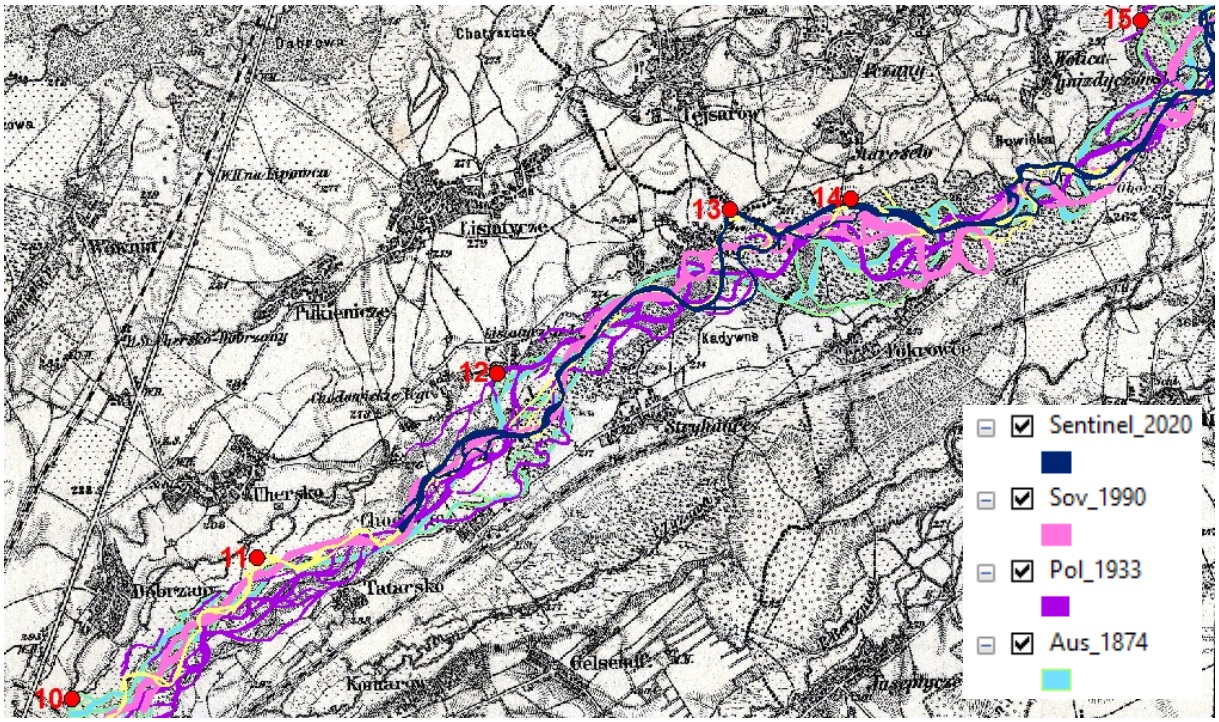


Fig.5. Fragment of digitized channel images of the piedmont part of the Stryi River overlaid on the topographic map of 1933 and sites of measuring the number of river channel braids

the Stryi River (from the village of Gnizdychiv, Zhydachiv district up to the inflow into the Dniester River near Zhydachiv, Lviv region) is 18 km. The elevation difference in this section is 15 m, that is, 0.8 m/km. In this part, the Stryi has a very winding channel with town of Zhydachiv, where it flows in several different directions for several kilometers. This part of the riverbed is mostly dependent on the geomorphological structure, which is characteristic of the UCF. The river, crossing sections of rocks of different hardness,

forms valleys of various types, ranging from narrow, almost terraceless, to wide ones at the intersection with soft rocks. It is known, that deposits of various geological periods are included in the structure of the UCF. The UCF Quaternary sediments are represented by four types: old, middle, new and modern. The new type is associated with a continuous cover of loess-like loams. The modern includes sandy-pebble-clayey sediments of floodplains of river valleys, fan cones, swamps, alluvial-deluvial formations (Horishnyi, 2014).

used satellite images from the Landsat-7 (2000) and Sentinel-2 (2020) satellite systems. The imaging equipment of Landsat-7 satellite operates per the optoelectronic principle of scanning in eight spectral channels: panchromatic with a spatial resolution of 15 m, six multispectral channels of visible, near and mid-infrared ranges with a resolution of 30 m, and far infrared ranges with a resolution of 60 m. Upon images synthesizing we applied a pan-sharpening method allowing receiving images with spatial resolution of 15 m.

Table 5. The number of braids and the measured width of the distance between the outermost river spits

Nos. of points	1874		1933		1990		2020	
	The width of the river spits (m)	Number of the river spits	The width of the river spits (m)	Number of the river spits	The width of the river spits (m)	Number of the river spits	The width of the river spits (m)	Number of the river spits
10	80	1	700	2	100	1	350	2
11	490	2	650	2	420	2	140	2
12	1,610	5	1,320	4	560	3	100	1
13	1,550	5	1,720	3	520	2	160	2
14	1,370	5	1,500	6	470	3	240	2
15	1,190	6	1,250	6	750	3	670	2
16	1,140	6	230	2	140	1	40	1
17	100	1	730	6	120	1	150	2
18	1,270	5	1,390	4	100	1	410	4
19	250	2	880	3	90	1	560	2
20	1,100	3	300	2	470	2	370	3

One of threatening processes is the intensive extraction of gravel and sand from riverbeds, the development of deposits of boulder-gravel-sandy rocks on the Dniester, Stryi, Svicha and Opir rivers within the territory of Lviv region, which negatively affects the ecological state of the environment. Deposits of boulder-gravel-sandy rocks within Ukraine are distributed very unevenly.

Table 6 shows data on riverbed displacements. Table 7 shows the number of oxbow lakes and alluvial islands; the total area of oxbow lakes is calculated for the lowland part of the Stryi River near the town of Zhydachiv.

The reduced area of oxbow lakes in 1990 can be explained by the fact that only large oxbow lakes are indicated on the map, as well as those that contrasted significantly in-situ.

Deforestation and gravel removal from the riverbed. Recently, deforestation has increased many-fold, especially in the Carpathian region. It is know that in the absence of an active root system rainwater drains into the valley much faster and often causes floods. To determine the areas of forest felling we

Table 6. Riverbed displacements of the Stryi River plain part

Nos. of points	Riverbed displacements, (m)	
	1874-1990	1990-2019
21	600	500
22	1,350	140
23	900	80
24	780	130
25	330	260
26	630	170

Table 7. The number of oxbow lakes and alluvial islands within the Stryi River plain part

Years	Number of oxbow lakes	Oxbow lakes total area, ha	Number of alluvial islands
1874	20	129	12
1933	20	95	6
1990	20	142	2
2019	12	104	2

In order to obtain a digital terrain model, the Sentinel-2 satellite consists of two identical satellites Sentinel-2A and Sentinel-2B. The satellites are

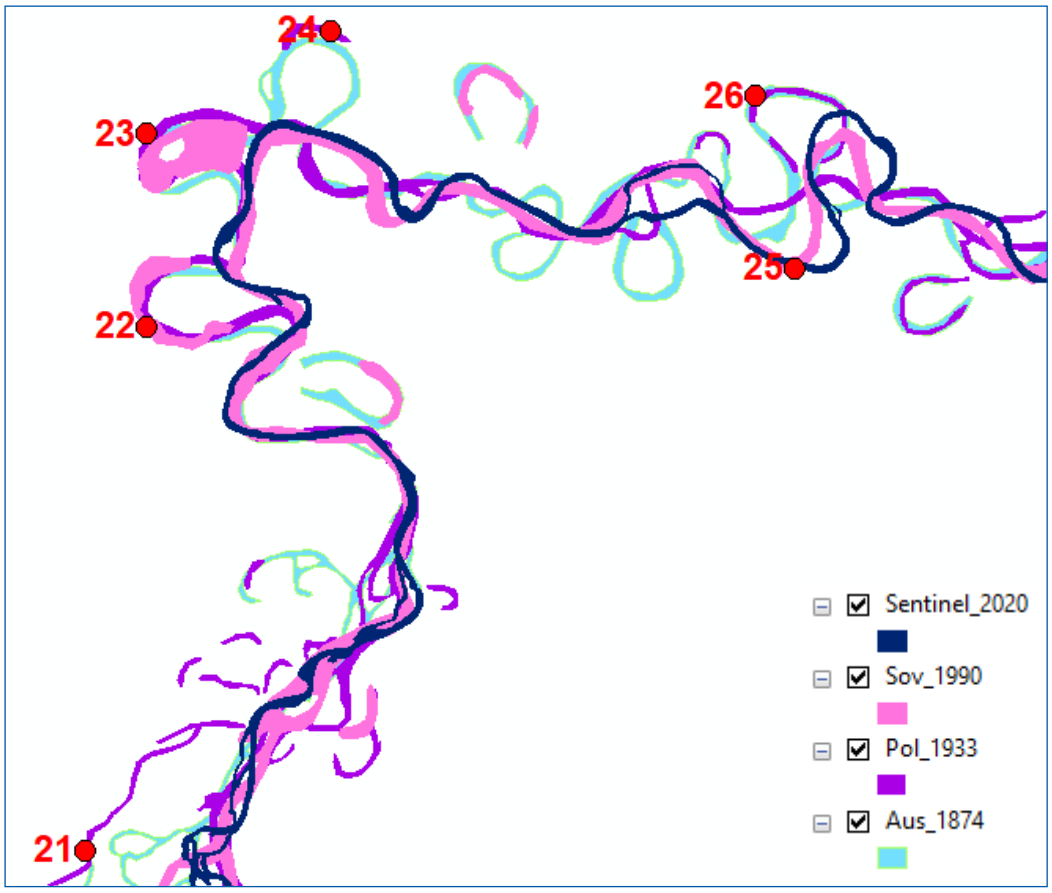


Fig.6. Fragment of digitized channel images of the plain part of the Stryi River and places of displacement measurement

equipped with optical-electronic tools, which operate in 13 multispectral ranges: visible, near and middle infrared ranges, the resolution of the equipment is 10 m, 20 m, 60 m, and respectively.

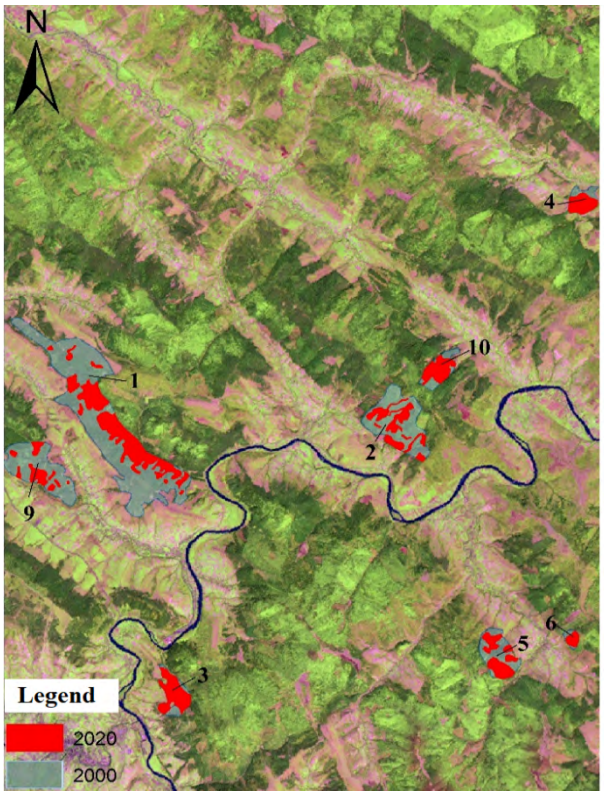


Fig. 7. Location of the study plots with deforestation traits along the Stryi River

Figure 7 shows post-processed and transformed images specifying the studied plots in the Turka forestry located within the Stryi River basin. On these plots, the areas of forest felling have been determined. The 2020 image shows fellings, which are distinguished by a clear geometric structure and a light tone (Fig. 8).

Table 8 shows the results of measurements of changes in the forest areas over a 20-year period. The measurements were carried out at ten test sites by digitizing satellite images shot by Landsat-7 (2000) and Sentinel-2 (2020). Thus, it has been established that over a 20-year period, the area of deforestation in these areas is about 540 hectares.

In Internet publications (https://varta1.com.ua/, https://stryi.in.ua/) there are reports that in the summer months, tons of gravel (up to 150 cars) are illegally extracted from the Stryi River every day. Such extraction could change the course of the river, leading to an environmental disaster. In support of these words, we present an image of the Stryi riverbed from the Google Earth service taken at the place of significant gravel extraction (Fig. 9) in 2009 and 2017.

The 2009 image shows how clearly visible the

Table 8. Changes in forest cover areas for the period of 2000-2020 in the Stryi River basin

Plot number	Forest cover area in 2000, ha	Areas of deforestation in 2020, ha
1	487.0	134.0
2	159.6	44.2
3	53.3	43.1
4	35.9	25.3
5	77.7	37.8
6	11.8	8.0
7	135.0	135.0
8	54.4	54.4
9	136.4	26.9
10	47.1	30.7
Σ	**1,198.2**	**539.4**

gravel area is. After active gravel extraction, the river washed out the bank from the side of the extraction and changed its course (2017), despite whicht the gravel was extracted from the inside of the meander, where erosion is usually insignificant. This is just one of numerous examples observed for the Stryi River.

a) b)

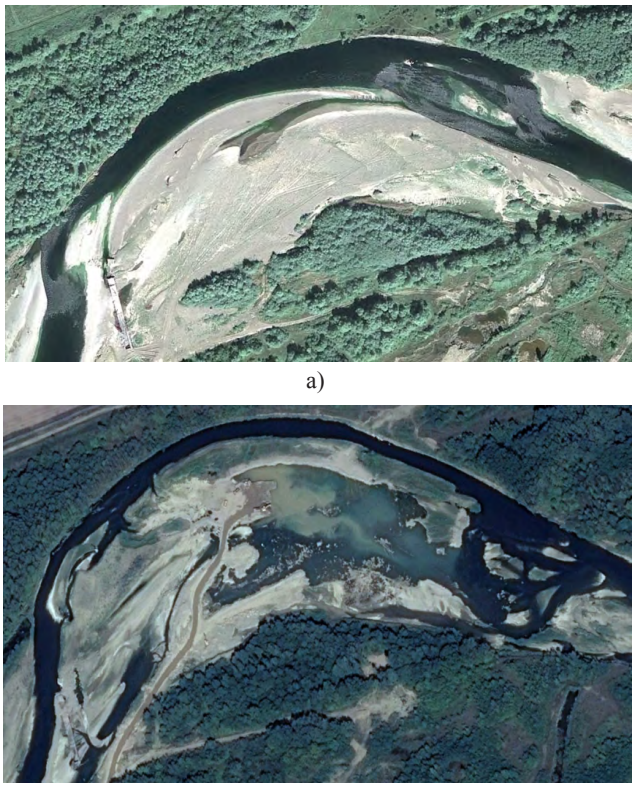
Fig. 8. Enlarged fragment of site No. 9 on satellite images of 2000 (a) and 2020 (b)

Thus, remote sensing data make it possible to determine the quantitative characteristics of deforestation and to identify the sites of gravel and sand material extraction, which lead to changes in the riverbed associated with environmental threats.

Conclusions

In order to study the stability of the Pre-Carpathian rivers and the factors impacting rivers within the region, a methodology for long-term riverbed processes monitoring has been proposed. It consists in using topographic maps of different times, satellite images obtained with different spatial resolution, geological, soil and other special maps then processed by means of GIS systems.

Features of the hydrological regime of the right-bank tributaries of the Dniester, Stryi, Limnitsia, Bystrytsia and other rivers flowing in the Carpathians and Pre-Carpathian region are associated with the geological and sedimentological structures of the Skybovi Carpathians and the UCF. The tectonic structure also influenced the hydrological regime of the rivers, neotectonic movements resulted in a block-like structure of the outer zone of the UCF, intersected by a number of large and small disturbances. This fact determines the high erosion-denudation potential of the relief, active development of erosion and landslide processes.



a)

b)

Fig. 9. Fragment of the Stryi River channel before (a, 2009) and after (b, 2017) significant removal of gravel

Based on the results of processing topographic maps and satellite images, it has been established that the nature of the Stryi River channel indicates three different parts in terms of displacement values: the channel flows in the mountainous part without significant displacements; the second part is multi-braided river channel; the third indicates an unstable character, significant meandering, intertwining, and the formation of buttes. The maximum displacements in the mouth part reach up to 1,350m.

The research study testifies that due to lithological features and significant ecological disturbances the river channel has significant horizontal displacements near Stryi city and at the river mouth.

The anthropogenic factors influencing channel processes include deforestation and the extraction of sand-gravel materials. Deforestation leads to a several-fold increase in surface water runoff during

floods. Experimental study has shown that the area of deforestation within the Stryi river basin near the town of Turka amounts to 540 ha during a 20-year period (2000-2020).

Processing of Earth remote sensing materials using GIS technologies makes it possible to determine hydrological and ecological disturbances associated with deforestation and extraction of gravel-sand materials.

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Taking into account regional environmental conditions in the functioning of road landscape-engineering systems

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Abstract. We analyzed the effects of regional and local natural conditions on the process of construction and functioning of road landscape-engineering systems (RLES) – modern actively developing operating roads with the required infrastructure. It has been reported that compared with other anthropogenic landscapes, those of roads do not receive sufficient attention from environmental geographers and landscape scientists, especially regarding the impact of regional and local nature conditions on their functioning. On the example of a region, which is specific according to natural conditions and landscape structure – Podillia, we analyzed three natural factors that significantly affect the functioning of RLES in the region, particularly the manifestation of unfavourable processes in them. These factors include broad distribution (72% of the territory of Podillia) and thick layers of loess rocks (up to 5-7 metres), high differentiation of the surface and cloudburst pattern of atmospheric precipitations. Those factors create preconditions for the development of unfavourable processes in the RLES, especially if this is aggravated by poor planning of their construction and irrational exploitation of RLES of Podillia. In more details, it was analyzed in two natural areas of actively functioning road landscape-engineer systems: Khmelnytsky-Vinnytsia (outskirts of Yakyshyntsi village) and Vinnytsia-Uman (outskirts of Voronovytsia town). We should note that the impact of local peculiarities of the natural conditions and unfavourable processes they had caused often depend on confinement of the RLES to two of the most dynamic types of landscape in Podillia – slopes and floodplains. Manifestation of local peculiarities of natural conditions and landscape complexes was analyzed on the example of Podillia`s commonest slope-type habitats – ravine tracts that intersect the road landscape-engineer systems. The paper demonstrates that regional and local peculiarities of natural conditions of Podillia and their impact on the functioning of road landscape-engineering systems should be considered against the background of expression of zonal natural factors and current conditions of the development of society. Taking into account regional and local natural peculiarities in the process of construction and functioning of RLES is one of the realistic ways to ensure long and safe rational exploitation.

Key words: *automobile road landscapes, Podillia, local, local nature conditions, road microcenters, unfavourable processes, rational functioning*

Врахування регіональних природних умов у функціонуванні дорожніх ландшафтно-інженерних систем

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Анотація. Розглянуто вплив регіональних і локальних природних умов на процес розбудови і функціонування дорожніх ландшафтно-інженерних систем (ДЛІС) – сучасних активно діючих автомобільних доріг з належною їм інфраструктурою. Зазначено, що у порівнянні з іншими антропогенними, дорожнім ландшафтам, географи-природничники й ландшафтознавці не приділяють належної уваги, особливо це стосується впливу регіональних і локальних природних умов на їх функціонування. На прикладі своєрідного за природними умовами і ландшафтною структурою регіону – Поділля, розглянуто три природних чинника, які суттєво впливають на функціонування ДЛІС регіону, зокрема й прояв в них несприятливих процесів. Серед цих чинників – широке розповсюдження (72% території Поділля) і значні товщі лесових порід (до 5-7 м), висотна диференціація поверхні та зливовий характер атмосферних опадів. Ці чинники створюють передумови для розвитку несприятливих процесів у ДЛІС, особливо якщо вони підсилюються необґрунтованою їх розбудовою і нераціональною експлуатацією ДЛІС Поділля. Детальніше це розглянуто на двох натурних ділянках активно функціонуючих дорожніх ландшафтно-інженерних систем:

Хмельницький-Вінниця (околиці с. Якушинці) й Вінниця-Умань (околиці містечка Вороновиця). Зазначено, що вплив локальних особливостей природних умов та зумовлених ними несприятливих процесів часто залежить від приуроченості ДЛІС до двох найдинамічніших типів місцевостей Поділля – схилового і заплавного. Прояв локальних особливостей природних умов і ландшафтних комплексів розглянуто на прикладі найбільш розповсюджених у межах Поділля схилового типу місцевостей – урочищ балок, які перетинають дорожні ландшафтно-інженерні системи. Показано, що як регіональні, так і локальні особливості природних умов Поділля та їх вплив на функціонування дорожніх ландшафтно-інженерних систем необхідно розглядати на фоні прояву зональних природних чинників та сучасних умов розвитку суспільства. Врахування регіональних і локальних природних особливостей у процесі розбудови та функціонування ДЛІС – один із реальних шляхів їх тривалого і безпечного раціонального використання.

Ключові слова: дорожні ландшафти, дорожні ландшафтно-інженерні системи, Поділля, регіональні природні умови, дорожні мікроосередки, несприятливі процеси, раціональне функціонування

Introduction

Together with the residential areas, road landscapes develop a specific carcass of anthropogenic landscapes of any territory. Without roads and proper infrastructure (road landscapes), the development of contemporary economics is impossible: *"...cities plus road network is a carcass, on the basis of which everything stands"* (Baranskyi, 1960). In the early XXI century, the problem of the development and functioning of road landscapes is one of the most relevant.

Road landscapes are complex and dynamic nature-economic systems. In their structure, the essential element is the road landscape-engineering system (RLES). It is a three-block (nature, technology, management) system, in the study of which environmental geographers and landscape scientists are not actively involved. It is especially relevant concerning the effects of regional and local conditions on the process of construction and further rational use of road landscape-engineer systems. It would be practical to survey the local specifics of the development of unfavourable environmental (nature, nature-anthropogenic, anthropogenic) processes in the RLES of Podillia in separate areas of the exploited road system, where they manifest most actively. Taking into account regional and local peculiarities of functioning of the nature block of road landscape-engineering systems allows development of real measures for preventing the manifestation of unfavourable processes and ensuring the rational exploitation of RLES in any region of Ukraine.

Therefore, the ***objective*** of the study was substantiation of the necessity of taking into account the impact of regional and local natural factors that form preconditions for the development of unfavourable environmental (nature, nature-anthropogenic, anthropogenic) processes in the functioning of road landscape-engineering systems.

Materials and methods

While writing the article, we used the materials of our own field landscape surveys conducted during 2017-2020 on 8 natural plots along the Vinnytsia-Khmelnytsky and Vinnytsia-Uman highways. Cartographic models of these two plots are presented in the article. The studies also involved the results of analyses of the projects of construction of these highways in 1998–2001 and 2016–2017 and materials from Vinnytsia Oblast Archive.

The research we carried out is based on the methods of environmental and constructive geography, anthropogenic landscape science, landscape ecology, using the methods of systemic approach, structural analysis and synthesis, comparative-geographic method, cartographic and graph-analytical visualization of the results.

Analysis of previous research

The first to note the road landscapes and distinguish them as a separate class of anthropogenic landscapes was F. M. Mylkov (Mylkov, 1973), though without the analysis of the structural organization of road landscapes. This was carried out later in research on road landscapes (Denysyk, 2005; Voloshyn, 2009; Valchuk-Orkusha; 2010;), particularly in the process of studying the general peculiarities of formation and development of road landscapes, their structure, classification and ecological impact on the environment. More attention to RLES was paid by geochemists and ecologists (Denysyk, 2005; Voloshyn, 2009;Vanchura, 2011; Halahan, 2014). This is due to the fact that geochemical and ecological results of operation of active highways have the greatest impact on adjacent territories and health of the population (Denysyk, 2005; Voloshyn, 2009). Regional and local peculiarities of nature conditions and landscape structure and their role in construction and operation of road landscapes have not been considered in the available researches, though manifestations of unfavourable processes caused by their specifics are mentioned (Denysyk, 2001; Valchuk-Orkusha, 2010; Vanchura, 2011). These processes manifest most actively in currently functioning road landscape-engineering systems, including the ones in Podillia, where one of the dens-

est network of roads (road landscapes) in Ukraine has been developed.

Results and research

To thoroughly research the current road landscapes, it is practical to distinguish three components in their structure: the abovementioned road landscape-engineering system (RLES), road landscape-technogenic systems (RLTS), which are former RLES without a management block, and specifically road landscapes (SRL) – decommissioned RLES and RLTS (Denysyk, 2005). Against the background of zonal landscapes, these structures manifest in different ways (Table).

Table. Structural zonality of road landscapes

Class of anthropogenic landscapes	Structural constituents	Zonality
Road landscapes	Road landscape-engineer systems	Azonal
	Road landscape-technogenic systems	Zonal-azonal
	Specifically road landscapes	Zonal

From the distinguished constituents of road landscapes, the one having the greatest importance in their current functioning and further development is road landscape-engineer systems. The surveys of RLES need to be given a special attention due to active development of social-economic processes in Ukraine, particularly unification of roads (road landscapes) of Ukraine and West Europe and the beginning of construction of the European transport corridors within our country. This will cause significant changes in the structure and specifics of functioning of the existing road landscape-engineering systems, and also notably alter their effects on the adjacent landscapes and health of the population of the regions of construction.

However, geographic and landscape-study analytical review of the literature-cartographic sources concerning the contemporary construction and functioning of landscape-engineering systems over the past 20 years demonstrates that road experts mainly focus on the engineer-construction requirements and safety (Denysyk H.I., 2005, Voloshyn I.M. 2009). At the same time, practically no attention was paid to the regional specifics of the natural conditions and landscape structures of the construction sites and further functioning of the RLEC. For this purpose, to prevent the manifestation and development of negative processes in the road landscape-engineer systems, it is necessary to take into account regional specifics of the environment and the pattern of impact on the further development of the RLEC of each geocomponent and landscape complex. We shall analyze it in more details on the example of Podillia – a region that is distinct in Ukraine for specific environmental conditions and landscape structure (Denysyk, 2001; Denysyk, 2014).

Among the natural factors that stimulated in the past, influence now and will influence in the future the development of negative processes and phenomena in the processes in the operation of the RLEC in Podillia, the main three are:

- *broad distribution of thick layers of loess rocks.* Loess (German, *Löss*) is defined as a continental sedimentary rock with distinct light and pale-yellow colour, high porosity (40-55%), domination of dusty (0.01-0.05 mm) fractions, represented by microaggregations, carbonate content, presence of visible vertical capillaries, hidden horizontal lamination, ability to develop columnar jointing in dry condition (cliffs in the conditions of natural bedding). This definition lacks one trait and has one inaccuracy. It does not indicate that loess (loess-like rocks) are easily washed out and driven by the water current, and in general quickly change their properties under the effect of water. The inaccuracy is that in natural condition, neither cliffs nor gullies, develop in loess and other loess-like rocks.

According to the conditions of bedding, completeness of the section and physical-mechanical properties, two zones are distinguished; the zone of beyond-the-glacial loess and zone of loess of the Dnipro glacial current. Most part (94-96 %) of the territory of Podillia is in the zone beyond the glacial. The conditions of bedding of entire loess layer in the interfluves, slopes and high terraces in the region were mainly affected by the neotectonic regime of certain areas and stratification of the terrain. Spatially, loess is distributed in Podillia unevenly; the horizons are characterized by unevenness and varying thickness, dominated by areas with insignificant (5-10 m, rarer 15 cm) covering. Notably, the initial loess layers have developed a subhorizontal slightly wavy terrain surface. Gullies and ravines and their erosive-denudation forms have so far been recorded neither on this surface, nor in the paleolandscapes (Melnychuk, 2004; Kunytsia, 2007).

That is, despite the property of loess and loess-like rocks to be easily washed out by water current in natural conditions, no erosive forms, particularly furrows and gullies have been recorded in the area of loess distribution. The researches by the above-mentioned authors focused on Quaternary deposits, in particular loess and loess-like rocks, paleorelief and paleolandscapes, and include no characteristics of paleo-gullies and paleo-ravines. The impossibility of their development in the natural conditions, and therefore their absence, were confirmed by the results of modeling this process (Denysyk, 2001). Therefore, all ditches, gullies, ravines and upper reaches of the river valleys in loess rocks, which have intersected or will run across the RLES during the construction, have anthropogenic origin. In the conditions of the contemporary Forest-Field of Ukraine, they are mostly unstable, dynamic, and the various processes and phenomena within their boundaries are not always possible to predict. If in the process of construction of the RLES, these anthropogenic forms of terrain are unavoidable or present in the structure of road landscape-engineering systems already, they need to be listed in the cadastre. Thus, in the future, possible scenarios of the development may be composed taking into account the specifics of loess rocks. Measures of prevention or liquidation of deleterious process and phenomena, which may affect the stable functioning of the RLES within Podillia, should be made according to these scenarios;

- *Height of differentiation of the surface*. This needs to be taken into account when calculating the parameters of horizontal and vertical division of the surface the RLEC, steepness of slopes, etc. Around 80% of the Ukraine`s territory has average vertical dimension of the surface ranging 10 to 70 m. In the plains part, the greatest differentiation of the surface is characteristic of the Forest-Field within the Podillia, Cisdniester, Poltava and Central Russian Uplands (Denysyk, 2001). In Podillia, these territories lie in the Dniester Canyon (Middle Prydnistrovie), Podilske low-hill uplands and the Kremenets Mountains, Podilski Tovtry and partially Opillia. Particularly, the height dimension of the canyon-like part of the Dniester basin within Podillia is 100-120 to 200-220 m. This is the so-called Middle Dniester "Low Hill Terrain" (Nuzkohiria). There, and also in the previously mentioned territories, the RLES are characterized by numerous road serpentines, supporting walls, bridges, ditches and embankments, etc. Those dynamic structures and possibility of manifestations of unfavourable processes they cause affecting the early stages of the construction of the RLES are being taken into account partially. However, functioning and development of road landscape-engineering systems of Podillia and their optimization in the future taking into account height differentiation of the territory have not been planned. Moreover, for the further exploitation of the RLES (repair of roadbed, construction of roadside windbreaks, infrastructure, liquidation of unfavourable processes, etc), the same costs are allocated for the areas of Podilllia Prydnistrovie with low hills and the level Middle Pobuzhia, Podilski Tovtry and the Kremenets Mountains and the flat Central Podillia. It is not surprising that the roads within the territories with low hills are in catastrophic condition, and in the plains areas – in more or less normal condition even during current social-economic problems. Such an approach to financing the construction of the RLES needs to be reconsidered. This is especially relevant for local communities.

- *cloudburst pattern of atmospheric precipitations*. This characteristic of atmospheric precipitations in Poddilia is mentioned only when it is manifested significantly, or even catastrophically. Taking into account the significant height differentiation of the surface in some areas of Podillia and the region's almost complete covering with loess rocks that are sensitive to moisture, rainfall pattern of atmospheric precipitations has a great impact on the functioning of road landscape-engineering systems of Podillia, contributing to development of unfavourable processes within their borders.

Precipitations falling on Podillia measure more (650-550 mm) than the zonal norm (550-500 mm). Their distribution is affected not only by the significant length of the territory from west to east, but the high differentiation of the surface. In particular, on non-weathered slopes of the Podilska and the Prydniprovska Uplands, the precipitations account for 15-20% more than in the rest of the territory (Denysyk, 2014). The main amount of precipitations (75-85%) of the annual sum within Podillia falls over the warm period – April to October. They are often accompanied by thunderstorms and have a cloudburst pattern. On average, 25 to 35 thunderstorms occur in Podillia annually, lasting 72-80 hours in total. Usually, thunderstorms are accompanied by wind squalls rainfall, often with hail. Most thunderstorms with cloudbursts occur in Podillia in June-July. Each thunderstorm lasts on average three hours. From May to July, 10-14 days with thunderstorms take place every month, often accompanied by cloudbursts. Cloudburst pattern of atmospheric precipitations within Podillia has not been taken into account in any of the construction projects of the RLES and their further use. Such an addition needs to be made, for great sums are allocated for the liquidation of unfavourable processes in the RLES

of Vinnytsia-Mohyliv-Podilsky (120 km) caused by cloudburst precipitations.

The characterised natural indicators – height differentiation of the surface, presence of loess cover, which is easily washed by away by streams of water and the flood inducing character of atmospheric precipitation create only a precondition for the appearance and development of unfavorable processes in the construction and functioning of RLES in Podillia. For their active development a push is necessary. Such a push is ill thought-out or wrongly projected activity of people in the process of construction and further usage of RLES. The total effect of these indicators sometimes leads to partial reconstruction, rebuilding or relocation of separate RLES sites, which requires considerable expenditure of time and finance. We shall look at this in detail on the example of a section of the Vinnitsa-Uman highway on the outskirts of the town Voronovytsya (Fig. 1).

In this area, construction of the RLES started in the second half of the XIX century without taking into account the regional environmental conditions and landscape structure. This has led to gradual deterioration of the road, even after its numerous reconstructions over the first half of the XX century. In the late 1990s, a critically damaged area of the highway was abandoned, and the road was constructed closer to the water divide, but the upper part of the ravine was damaged in the process, and no drainage was made in the road embankment that intersected the ravine. A swamp is gradually forming , which with time will develop into a roadside water body. In the road embankment of the ravine, shift-caused fractures can be seen.

A distinctive feature of the road landscape, especially its microrelief, is a combination of a straight-line, leveled out roadbed and micro-environments of anthropogenic ditches (measuring in depth 1-2 to 5-8 meters and more meters, with width at the foot ranging 3 to 30 m, and up to 50 and more m in the upper part, the steepness of the slopes ranges 3-5 to 45-60°, sometimes with straight walls) and embankments (0.5-1 to 6-8m and more high, 20-30 m wide at the foot, the steepness of the slopes in the upper part, depending on the road width, is up to 60°). Only on the Khmelnytsky-Vinnytsia highway, at the distance of 120 km, in 2006, we recorded 67 ditches ranging in depth 1.5 to 7 m and 72 embankments 1 to 6 m high. In total, they accounted for 12 percent of the road landscape and notably designated in its structure (Valchuk-Orkusha, 2010).

Ditches and embankments are the most dynamic micro-environments in the structure of the road landscapes of Podillia. This is not related exclusively to their internal dynamic potential, but also to paradynamic interrelations with the adjacent landscape complexes. The intensely developing unfavourable processes in the area are shift, landslips, taluses, sometimes collapses and faults. To reduce the actions of these processes as micro-environments, particularly their slopes, they are being fixated using piles, drainage systems are made, as well as stone and wooden support walls and water drainages. Micro-environments of the ditches and embankment are specific local landscape-engineering systems, where the development of unfavourable processes is regulated by humans (Valchuk-Orkusha, 2010).

The intense dynamics in the structure of the road landscapes of Podillia causes aquatic, aquatic-marshy and marshy micro-environments, untypical for the region, of 0.02 – 0.05 ha area. Without drainage, the aquatic-marshy roadside micro-environments enlarge in the areas in spring and autumn, sometimes leading to activation of undesired processes in the road embankments and ruination of the roadbed. Most often, this manifests in activation of unfavourable processes in places where the road crosses the ravines and hollows of the drainage. On the Vinnytsia-Khmelnytsky highway, on the outskirts of Yakushyntsi village, the shifting processes are being activated particularly because of the aquatic-marshy micro-environments on the roadbed (around 260 m). Fractures and micro-terraces emerge, which are constantly being repaired by construction workers. On the slopes of the road embankment, the shifting processes are clearly notable. Gradually, a shifting micro-environment is becoming distinguished in the roadbed. Its liquidation is impossible without draining the aquatic-marshy micro-environment and stabilizing the erosive-accumulative processes that take place in the ravine the road intersects (Fig. 2).

Taking into account regional and local environmental conditions of the functioning of the road landscape-engineering systems is also necessary for rational construction and further effective operation of their infrastructure. This is especially relevant for green spaces, particularly the roadside windbreaks. Creation of them should be made taking into account the specifics of further self-development depending on existing regional and local properties of the environmental conditions. This is more relevant for outer sides of the roadside windbreaks. Inner (roadside) sides are mostly being controlled by humans and are maintained in the required condition (sporadic cuttings, cleaning, new plantations, etc); while the outer ones develop separately under the effect of the landscapes (agricultural field and meadow-pasture, residential, industrial) they adjoin. Within Podillia, the roadside windbreaks

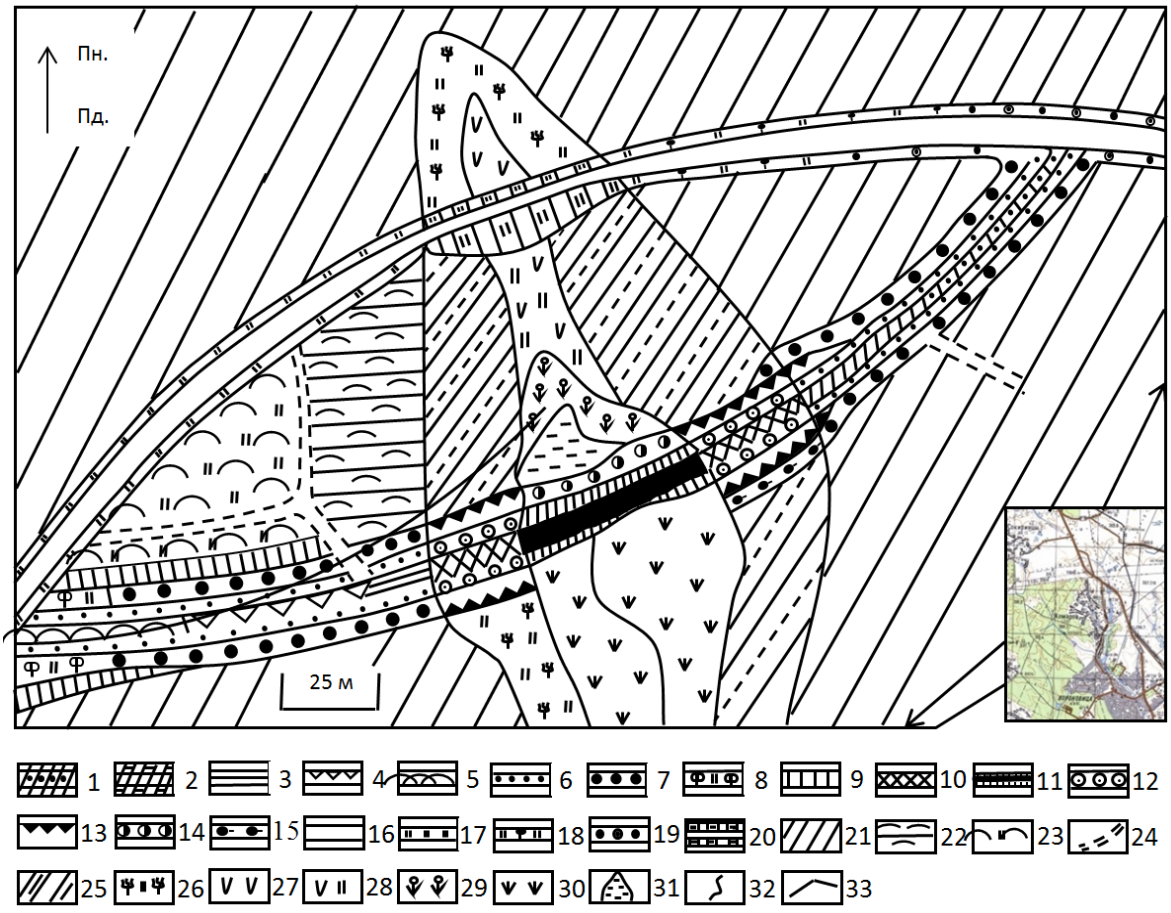

Fig. 1. Impact of regional environmental conditions on construction of RLES in the outskirts of Voronovytsia town in Vinnytsia Oblast

Road landscapes. Specifically road landscapes. Water-divide. Abandoned road site. Complex road tract. Tracts: 1 – asphalted, on low embankment (0.5-0.7 m), 5-6 m wide road, abandoned, with fractures and, partially, ruderal vegetation,; 2 – road on clayey-loam-gravel embankment of up to 0.7 m height, 7 m wide, without road surface, partly covered by turf composed of forbs; 3 – road on clayey-loamy embankment of 0.5 – 0.7 m, up to 8 – 9 m wide, partly covered by turf of forbs, sometimes used for a passage by people engaged in recreation; 4 – remains of road embankment with loess-like loams of 0.7 – 1 m high, and up to 8 m in width, with separate ditches (0.2 – 0.3 m), covered by turf of weeds and forbs; 5 – entirely covered by turf of forbs and grasses, the road embankment with loess-like loams, 2.5 – 2.7 m high, and up to 7 – 8 m wide; 6 – shallow (to 1 m) roadside ditches covered by turf and overgrown by shrubs; 7 – roadside windbreaks of small-leaved lime (*Tilia cordata*) aged 200 – 300 years on dark grey loess soils; 8 – solitarily growing centennial (200 – 300 years) trees of small-leaved lime and common oak (*Quercus pedunculata*) in the roadside windbreaks on dark grey eroded soils; 9 – steep (up to 35 - 40º) slopes of road embankment, composed of loess-like loam and covered by turf of forbs. Slope-ravine. Tracts: 10 – sloping (6 - 8º) road embankments of 0.3 – 0.5 m height, 6 – 7 m width, partially eroded and covered by turf of grasses and weeds; 11 – remains of swamped road of 3 – 4 m width with loess-like loams of dam of 10 m width in the foot with eroded slopes, partially covered by turf of weeds; 12 – shallow (0.5 – 0.6 m), up to 1.5 – 2 m wide roadside ditches, covered entirely by weeds and forbs and shrubs of box elder (*Acer negundo*), silver poplar (*Populus alba*), common sallow (*Salix cinerea*), rose (*Rosa*) and Siberian dogwood (*Swida opiz*); 13 – steep (up to 80º) cliffs of loess-like loams, taluses and single trees of small-leaved lime, poplar (*Populus*) and black locust (*Robinia pseudoacacia*); 14 – hilly turf-covered surface composed of embankment loess rocks, with old (up to 60 – 70 years) poplars and limes (*Tilia*); 15 – sloping loess surface of the ravine with old (up to 200 years) planted limes on the roadside.

Road landscape-engineer systems. Water-divide. Tracts: 16 – asphalt-concrete road, of up to 10 m width, on low embankment (0.7 – 1.2 m), composed of crushed granite stones and sand, with steep (up to 35º) slopes covered by turf; 17 – roadside water-divide ditches of up to 1 m depth and up to 1.5 - 2 m width, covered by turf of forbs and grasses; 18 – young (up to 10 years) roadside windbreaks composed of small-leaved lime and common hornbeam (*Carpinus betulus*); 19 – centennial (up to 300 years) two-row roadside windbreaks of small-leaved lime.

Ravine. Tracts: 20 – asphalt-concrete highway up to 12 m wide, on clayey-gravel-sandy embankment, 6 – 8 m high, with steep (to 35º) eroded slopes, partially covered by turf of ruderal vegetation.

Agricultural landscapes. Field. Water-divide. Tracts: 21 – levelled ploughed surfaces with dark grey loess soils under crop rotation of grain crops; 22 – low-hill surfaces of fallow dark grey, partially covered by turf, soils; 23 – low-hill, sloping, turf-covered dark grey soils for grazing; 24 – field roads of up to 4 – 5 m width. Ravine. Tracts: 25 – sloping (up to 10 - 12º) loess slopes of ravines with weakly eroded dark grey loess soils under agricultural crops; 26 – sloping (8 - 10º) loess slopes of the ravine with dark grey soils, covered by grasses and shrubs of black locust, dog rose, hawthorn (Crataegus); 27 – levelled moistened bed of the ravine with marsh vegetation (*Carex*) for haymaking; 28 – sloping (6 - 8º) moistened bed of the ravine with meadow-marsh soils under forbs and Carex vegetation for haymaking; 29 – sloping (2 - 3º) over moistened surface of the bed of the ravine overgrown with reed thickets; 30 – levelled moistened bed of the ravine occupied by marsh vegetation; 31 – supporting (road) of the water body of 0.1 ha area, up to 1.5 m depth, partially silted; 32 – the upper reach of nameless tributary of the Voronka River, up to 0.5 m wide, 0.3 – 0.4 m deep, silted.

Other signs: 33 – borders of the landscape complexes.

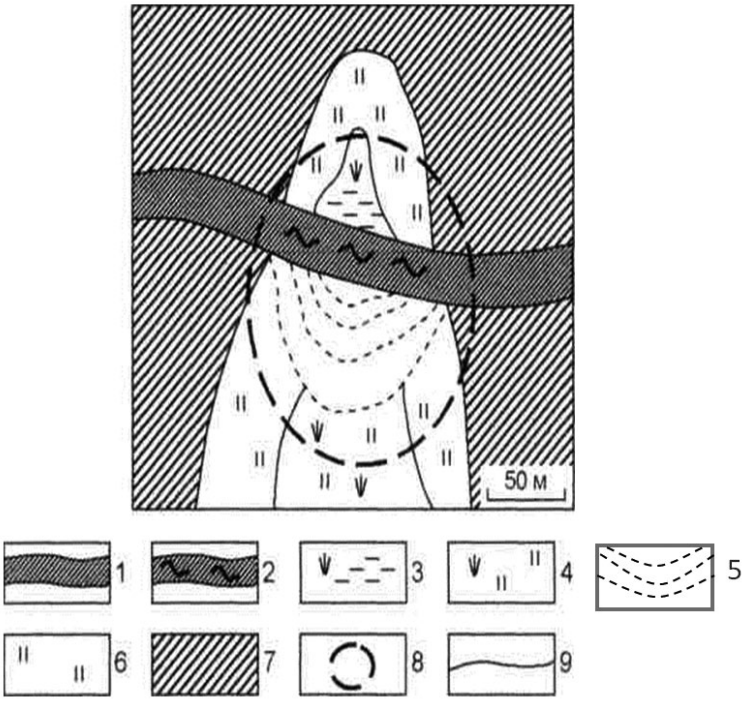

Fig. 2. Impact of local natural conditions on the construction of the RLES in the outskirts of Yakushyntsi village of Vinnytsia Oblast

1 – causeway, up to 1.0 m high, asphalt road is 8-10 m wide, on the water-divide; 2 – causeway within the ravine, with length-wise fractures in the asphalt and signs of shifts; 3 – swamped water-divide in the bed of the upper reach of the ravine, to 1.5 m deep, developed as a result of backwater caused by the road embankment; 4 – moistened bed of the ravine with meadow soils under forbs and marshy vegetation; 5 – shifting slopes of the road embankment with loess-like loams and ruderal vegetation; 6 - steep (to 25°) loess slopes of the ravine, with washed out grey loess soils under meadow forbs; 7 – ploughed loess water-divides with grey loess soils under agricultural crop rotations. Borders: 8 – shifted road micro-environment; 9 - tract.

most often interact with agricultural landscapes, particularly field ones. In such places, the transition from roadside windbreak to the field is contrast, resembling a "wall". If such sharp outer borders of the roadside windbreaks are not taken care of, they begin to gradually alter. A prototype of forest strip develops. Snowdrifts on such borders increase moisture and alkalinization of soil, which in turn creates better conditions for growth of woody plants, especially shrubs. The development of near-forest area on the outer borders of the roadside windbreaks occurs naturally, and should not only be supported, but also encouraged, and developed (Denysyk, 2005). This is not only a natural transition of roadside windbreaks to other landscape complexes. Such "transitional near-forest areas" are the most practical and ecologically favourable part of the windbreaks for establishing numerous modern temporary places of recreation, various shashlik places, cafes, kiosks and even small markets and camping sites. The central part of the roadside windbreak would well protect them against the harmful influence of the road. Currently, all the existing objects of autoservice are located and being built in the most polluted inner (roadside) part of the protective plantations.

Properly created roadside green belts normalize, and in some cases completely suspend the development of undesired geological-geomorphological, hydroclimatic and biogeochemical processes. At the same time, manifestations of some undesired processes require additional measures to be taken. Analysis of the condition of current roadside landscapes shows that such measures have been mostly planned quite professionally, but not implemented in the processes of creation of road landscapes and their operation. Technogenic (terrace embankments and cut slopes, steep slopes of ditches and embankments, abandoned quarries, etc) tracts and engineering (supporting walls, drainage channels and tubes, bridges, etc) elements of road landscapes are only partially, during road construction, "designed" (as road constructionists say) according to the project. They further develop according to the local nature-roadside patterns and due to this reason geological-geomorphological processes are activated in some places.

In the places of active development of karst processes or underground explorations of carbonate rocks, which lead to activation of karst, one needs to use the principle of partial retreat from the area of karst development – transfer a section (area) of the road beyond the borders of its active development

or the borders of underground explorations. In the future, road construction needs to take into account the promising plans of underground explorations. As practice suggests, supporting (with cement or other substances, filling underground cavities, etc) and repairing such roads is unpractical – karst continues to develop, and new faults, subsidence may appear after 30-40-50 years.

Similar processes are also observed while optimizing unfavourable hydrologic processes in the road landscapes. Measures oriented at diversion of water and cleaning the surface runoff from the roads and bridges, according to the projects, are constructed simultaneously with part of a road or bridge – these structures are retention ponds, settling-basin filters, and drainage basins and other highly simple structures.

Conclusions

In the current structural organization of road landscapes of Ukraine, we should clearly distinguish three genetically interrelated constituents: road landscape-engineering and road landscape-technogenic (block) and specifically road (geocomponent) systems. The leading ones are the RLES. The indicated structural constituents of the road landscapes are given enough attention by environmental geographers and landscape scientists of Ukraine, though the nature block is only partly taken into account . In Ukraine, this is seen at both regional and local levels. Our research into the impact of regional specifics of the environmental conditions and functioning of the RLES in Podillia revealed that the main environmental factors in the further reconstruction, construction and exploitation of the road landscape-engineering systems of the region are broad distribution (72% of the territory of Podillia) and large layers of loess rocks (up to 5-7 metres), high differentiation of the surface of Podillia and cloudburst pattern of atmospheric precipitations. The impact of local environmental conditions most often takes place due to landscape structure of the two most dynamic types of habitat: sloped – presence of tracts of steep slopes and ravine, and floodplain. Although the road landscape-engineering systems are identified to the azonal anthropogenic landscape structures, taking into account zonal factors, especially in the process of their exploitation, is necessary. During the development of regional projects and plans of rational nature-use, one needs to pay attention not only to the prevention of unfavourable processes caused by the construction and functioning of RLES, but development of measures of their protection as well.

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Soil degradation in Volyn region: current state, dynamics, ways of reduction

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Abstract. Recently, the problem of decrease in soil fertility has become more serious, posing a threat to food safety of the country. The main cause is violation of technologies of rational arable farming, which leads to deterioration of the qualitative condition of soils, their degradation. Therefore, development of protective measures for soils against degradation processes is a relevant problem nowadays, solving which would preserve soils and improve their condition. The article evaluates the current condition of degradation of soils in Volyn Oblast. We determined the main aspect of degradation processes, their scales and territorial distribution. We determined that in the structure of the land fund of the Oblast, 52% is occupied by agricultural land, indicating high level of agrarian cultivation of lands. For the last 15 years, the structure of the land fund of Volyn Oblast had undergone insignificant changes, and the most of the area of the land remains unaltered. The area of agricultural lands has somewhat decreased, whereas the area of forests and forest-covered territory has increased. The area of open lands with no vegetative cover has decreased by 0.15%. Ploughed fields in the southern districts of Volyn Oblast exceed the allowable limits, accounting for over 60%. We analyzed the dynamics of the degradation process of soils in the Oblast. We determined that the degradation of soils was to the greatest degree caused by manifestations of erosion and deflation. Water erosion manifested in the territory of Volodymyr-Volynskyi, Ivanychi, Lokachi, Horohiv, Lutsk and Kivertsi districts. Deflatable soils in the Oblast account for 258.2 thousand ha, most of which are in Kovel, Turiisk, Rozhyshche, Stara Vyzhivka districts. Measures for improving low-productive lands, and also land conservation, are being implemented in the Oblast. However, their scale is insufficient. We propose a complex of measures for protecting soils and preventing their degradation.

Key words: land use, degraded soils, disturbed lands, exhausted lands, low-productive lands, protection of soils, protection of soils against degradation processes

Деградація ґрунтів у Волинської області: сучасний стан, динаміка, шляхи зменшення

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Анотація. Проблема зниження родючості ґрунтів в світі та в Україні є однією з найгостріших екологічних проблем. Споживацький підхід у землекористуванні приводить до погіршення якісного стану українських ґрунтів, їх деградації. Тому розробка заходів охорони ґрунтів та захисту від деградаційних процесів на сьогодні є пріоритетним завданням. Вирішення його дозволить зберегти ґрунти і поліпшити їх стан. Метою статті є оцінка сучасного стану деградованості ґрунтів Волинської області, територіального розподілу та динаміки деградаційних процесів, розробка комплексу заходів охорони ґрунтів та захисту їх від деградації. Під час дослідження застосовано: методи збору матеріалів, методи статистичної обробки результатів, картографічні методи, метод експертних оцінок. Встановлено, що в структурі земельного фонду області 52% займають сільськогосподарські угіддя. Це високий рівень аграрної освоєності земель. За останні 15 років у структурі земельного фонду Волинської області відбулися незначні зміни. Площа сільськогосподарських угідь дещо зменшилася, натомість дещо збільшилася площа лісів і лісовкритої території. На 0,15% зменшилася площа відкритих земель без рослинного покриву. Розораність в південних районах Волинської області перевищує допустимі межі і становить понад 60%. Найбільшою мірою

деградація ґрунтів викликана проявами ерозії та дефляції. Водна ерозія проявляється на території південних районів області, а дефляція – північних районів. В області недостатньо здійснюються заходи поліпшення малопродуктивних угідь та консервації земель. Першочерговими заходами запобігання деградації ґрунтів та відновлення порушених ґрунтів є: відновлення боліт, заболочених і перезволожених земель, обмеження використання торфовищ для добування торфу, обводнення їх та захист від торфових пожеж, збільшення лісистості регіону, створення ландшафтно-адаптивних систем землеробства із контурно-меліоративною організацією території, екологічно обґрунтоване використання органічних та мінеральних добрив, отрутохімікатів, засобів захисту рослин, впровадження органічного землеробства, заохочення і стимулювання традиційного землекористування як фактору стійкого розвитку місцевих громад, проведення ефективного ґрунтового моніторингу.

Ключові слова: використання земель, деградовані ґрунти, порушені землі, відпрацьовані землі, малопродуктивні землі, деградовані землі, охорона ґрунтів, захист ґрунтів від деградаційних процесів

Introduction

The agrarian sector is extremely important for the development of economy of our country, its export potential and filling of the budget. Decrease in fertility of soils, their degradation cause significant economic losses for Ukraine. For example, according to the research of the State Institution Soil Protection Institute of Ukraine (Derzhgruntohorona), during this century, fertility of the soils is decreasing. This manifests through decrease in humus content in soils. Particularly, during the last 20 years, its losses are assessed 0.4-0.8 T/ha, which at the level of the state causes losses amounting to 453.4 B hryvnias (Baliuk et al., 2010).

The main cause of decrease in the fertility of soils is violation of the technologies of rational arable farming. The condition of soils, increase or decrease in their fertility, depend on following the rules of using these technologies. Most land users take no required measures oriented at preservation of soils and increasing their fertility. Organic fertilizers are introduced in insufficient amounts – to 1 T/ha, while scientifically substantiated requirements are 8-14 T/ha. Structure of cultivated areas does not correspond to scientifically substantiated requirements. Monocultures dominate. At the same time, agricultural crops significantly exhaust the soil (sunflower, rapeseed, maize). The modern approach to land use in our country may be called the consumer`s approach. It causes deterioration of the qualitative condition of Ukrainian soils, manifestation of various processes of their degradation. Therefore, development of measures for protection of soils and prevention of degradation processes is a relevant problem of nowadays, solving which would allow a preservation of soils as means of production and an improvement of their condition. The aspect of agroecological condition of soils and evaluation of degree of their degradation is closely related to the analysis of the contemporary ecological condition of the territory, determining acute ecological problems, development of local ecological programs and programmes of the development of the agrarian production, implementation of public ecological initiatives.

Review of previous research. There is a large amount of scientific studies in the sphere of soil degradation. Most of them focus on regional problems of use of soils and their degradation: decrease of the area of agricultural lands and degradation of soils in Sri Lanka (Nayakekorale, 2020), impact of intensity of degradation of loess and parameters of functioning of soils in North Iran (Kooch et al., 2020), erosion of soils in Russia (Tsymbarovich et al., 2020), evaluation of degradation of lands in Argentina (García et al., 2018), degradation of soils in South Africa (Maltitz et al., 2019), experimental measures against degradation of lands in Germany (Wunder et al., 2019). Many studies focused on soil-science aspects: changes in fractions of organic compound and structural resistance of the soil as a result of degradation and restoration of soils (Jensen et al., 2020), ability of soils to function and provide ecosystem services (Fine et al., 2017), study of dynamics of soil-active organic carbon of Gahai Wetland in north-west China (Wu et al., 2020). A generalizing pattern was determined in the works by the International Collective of Scientists (Núñez-Delgado et al., 2020), and also articles about implementation of the concept of neutral degradation of lands (Akhtar-Schuster et al., 2017), minimization of erosion of organic carbon (Chappell et al., 2019) and many others.

In Ukraine, degradation of soils and development of measures for its reduction were analyzed in numerous scientific works: ecological condition of soils in Ukraine was evaluated in the article (Baliuk et al., 2014) and national reports about the condition of fertility of soils in Ukraine (Baliuk et al., 2010), scientific and practical basics of protection soils against erosion in Ukraine (Baliuk et al., 2010), the condition of soils and peatlands of Ukraine (Truskaveckyj et al., 2010), the main directions of solving problems of degradation and desertification of lands in Ukraine (Movchan, 2017), measures of decreasing the degradation of lands by revitalizing them (Budzjak, 2014) and many others.

In the scientific literature, the aspects of evaluating the condition of extent of degradation of soils in

Volyn Oblast are described quite well. Nonetheless, the condition of soils intensely changes over time, and therefore needs timely monitoring. The first and the most important scientific work in the sphere of studying ecological condition of soils in Volyn Oblast is the monograph (Molchak et al., 1998). Soils in Volyn Oblast, and also partially their current condition and peculiarities of anthropogenic transformation, were analyzed in the monograph (Shevchuk et al., 1999). Deflation processes in soils of Volyn Oblast were studied (Polanskyj, 2015). Impact of drainage reclamation on soils of Volyn Oblast was analyzed in the monograph (Zuzuk et al., 2012). Among the recent studies reporting issues of degradation of soils in Volyn Oblast and measures for its decrease, there is a collective monograph of scientists of the Department of Physical Geography of Lesya Ukrainka Volyn National University (Fesyuk et al., 2016).

The objective of the article

The objectives of the article were evaluation of degradation extent of soils in Volyn Oblast, territorial distribution and dynamics of degradation processes, development of a complex of measures for protection of soils and their protection against degradation.

Materials and methods of research. To prepare the article, we used the materials of Polesia Research Station of the Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky, Volyn Oblast State Project-Technological Center of Protection of Fertility of Soils and Quality of Production, the Main Management of State GeoCadastre in Volyn Oblast, and also materials of our own studies. During the research, we used a broad arsenal of methods of scientific research: methods of collecting materials (work with fund materials, reconnaissance, expedition method), methods of statistical analysis of the results, cartographic methods (development of analytical maps, work with electronic cartographic services), methods of expert assessments (for development of measures for protection of soils and protecting them against degradation processes).

Results and their analysis

The land fund of the Oblast as of 2019 accounted for 2,014.4 thousand ha, including 1,047.6 thousand ha or 52% comprising agricultural lands, which indicates the high level of cultivation of lands. Over the past 15 years, the structure of the land fund of Volyn Oblast has undergone insignificant changes, while the total area of the lands remained the same. The area of agricultural lands somewhat decreased, whereas the area of forests and forest-covered territory slightly increased. A decrease measuring 0.15% occurred in the area of open lands without vegetative cover, which is a positive point from the ecological perspective. Practically unchanged also remained the area of waterlogged lands and aquatic objects.

Two types of landscapes may be distinguished in the structure of natural complexes of the territory of Volyn Oblast, field and forest-steppe types. Use of lands of the region is to a large extent due to soil-climatic conditions that are favourable for agriculture. In the structure of agricultural lands of Volyn Oblast, the leading role is played by tilled lands (tilling). Their share in the structure of the Land Fund is greatest in southern forest-steppe districts. The greatest share of agricultural lands is concentrated in the southern part of the Oblast and is associated with lowland terrain, distribution of podzolized and chernozem soils, sufficient amount of heat and moisture. Podzolized soils dominate in the forest-steppe part of the Oblast. Among them, the following are distinguished : bright grey and grey podzolized; dark grey podzolized; podzolized chernozems (Shevchuk et al., 1999).

In the territory of the Oblast, for a long time, there agriculture has been actively developing. The ploughed area in the southern districts of Volyn Oblasy is above the allowable limits, equaling over 60% (Fig. 1): Horohiv (67%), Lokachi (61%), Lutsk (65%), Ivanychi (60%). The lowest degree of agrarian cultivation is in the northern districts of the Oblast, where the share of ploughed lands in their structure accounts for no more than 20%. When analyzing agricultural use of lands, it is important to evaluate the shares and location of the main constituents of agricultural lands, such as ploughing, multi-year planting, hay fields and pastures. Their area within the Oblast is divided unequally. The greatest share in ploughing was observed in the southern districts, and smaller in the northern districts, the area there has more pastures, hay fields, and also a significant share of lands is occupied by self-sown forests.

The tudy (Fesyuk et al., 2016) determined integral ecological stability of the soils in Volyn Oblast. Soils with high stability comprise 819.84 km^2 (4.05%). Those are mainly deep chernozem and shallow low-humus soils, characterized by comparatively high content of humus, heavy granulometric composition, neutral reaction of soil solution, which occur exclusively in the forest-steppe part of the Oblast. Stable soils are distributed over an area of 743.04 km^2 (3.6% of the territory of the Oblast). There are meadow-marshy soils, which are distributed in the territory as small plots. Turf carbonate, grey, dark grey podzolized soils were evaluated as averagely stable, distributed mostly in the transitional and forest-steppe zones of the Oblast in the area of 2,001.92 km^2 (9.81 %).

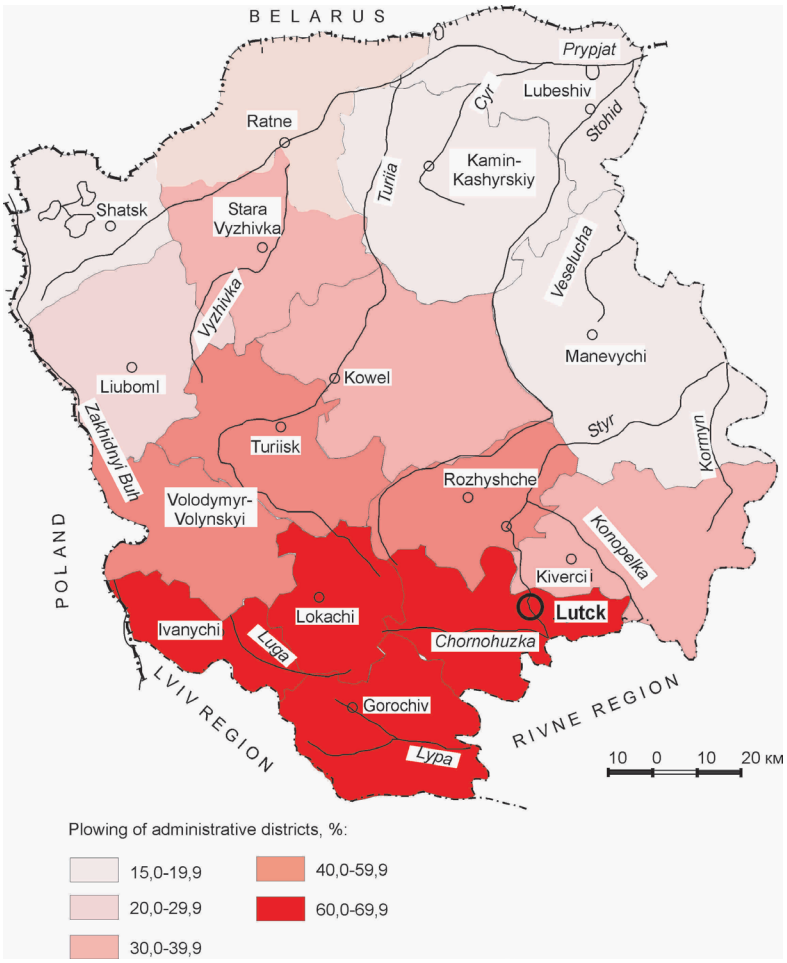

Fig. 1. Ploughing of the administrative units in Volyn Oblast (Fesyuk et al., 2016)

The least stable soils are low-humus, poorly saturated and acidic soils of the Polesia: turfy-podzolized, sandy, loamy sandy and clayey-sandy, and also peat-marshy and peatland types. They comprise large areas, accounting for 14,768.00 km^2 (73.1% of the territory of the Oblast). Also unstable were sandy and clayey-sandy types of turfy-podzolized gley soils. They are approximately distributed over an area of 1,955.84 km^2 (9.5% of the territory of the Oblast).

Active and ecologically irrational use, coupled with low integral ecological stability of soils within the Oblast, lead to degradation processes.

Degradation of soils is deterioration of beneficial properties and fertility of soil as a result of impact of environmental or anthropogenic factors (Molchak et al., 1998).

The main types of soil degradation are (Bridges, et al., 1979):

- physical degradation (over-compaction, de-segregation, compressor erosion, etc);
- erosion (soil dislodging, washout, alluviation) and deflation;
- waterlogging, groundwater flooding , flooding;
- exhaustion (de-humification, acidification, alkalinization, trophic impoverishment, secondary salinization, sodification);
- contamination with heavy metals, pesticides, oil products, other organic and biological pollutants, radionuclides.

As for over-densification, according to the materials (Baliuk et al., 2010), there is a slight threat of over-compaction to soils of the Polesia part of the Oblast, which may be explained by lower intensity of use and light mechanical composition. Soils of the southern (forest-steppe) part of the Oblast were observed to be under moderate and high threats of over-compaction.

An unfavourable situation is also observed for the content of humus in the soils of Volyn Olast. Over the recent decades, there a tendency has been observed toward decrease in humus content in soils, explained by both natural processes (first of all, erosion-deflation) and compression of humus in the process of intense agricultural activities. According to the materials of the National Report on the condition of soil fertility (Baliuk et al., 2010), for the recent 40 years, average annual losses of humus in Polesia accounted for 0.1-0.2 T/ha, in the forest-steppe – 0.8-1.0 T/ha, in the steppe – 0.4-0.5 T/ha. Average content of humus

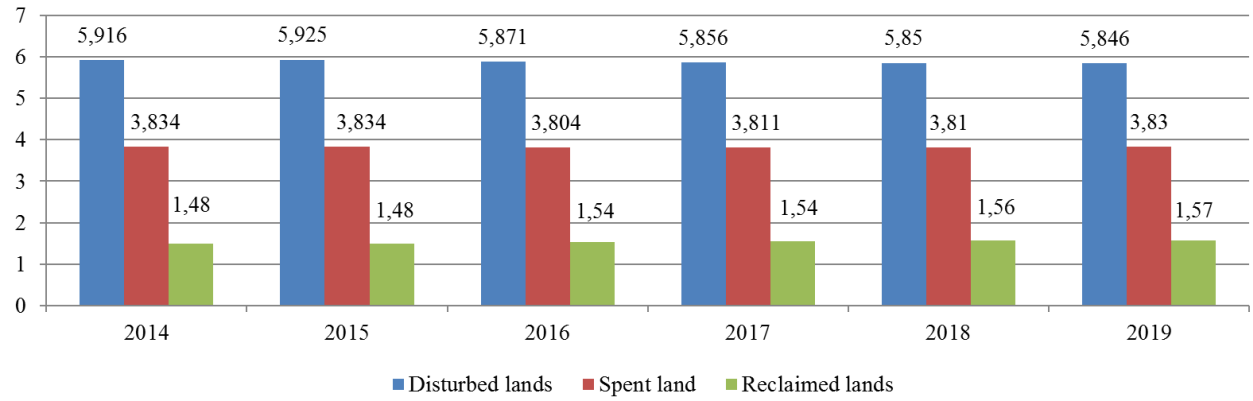

Fig. 2. Dynamics of the area of disturbed, exhausted and recultivated lands in Volyn Oblast, thous ha (according to the materials of the Main Management of State Cadaster in Volyn Oblast)

in soils of the Oblast equals 1.56%. This places Volyn on the bottom rank for humus content in our country. According to the research (Baliuk et al., 2010), Volyn Oblast is the only Oblast in the gradation of the lowest level of humus (less than 2%).

According to the materials of the National Report on the condition of soil fertility, by acidity, the soils of the greater part of Volyn Oblast are in the gradation of pH = 4.5-5.5, i.e. acidic soils (Baliuk et al., 2010).

An important indicator that characterizes the territory from the ecological perspective is presence of open areas without vegetative cover, including gullies, rocky places and sands. Based on multitemporal analysis of the structure of land use, certain specifics were determined: within the Polesia part of Volyn Oblast, there prevail territories that have been preserved in their natural condition, particularly forests and forest-covered territories, meadows and pastures; in southern forest-steppe districts, there dominate anthropogenically altered lands – lands of agricultural allocation. The greatest share of open lands with no vegetative cover (over 1%) is in Volodymyr-Volynskyi and Kamin-Kashyr districts.

Soil degradation in Volyn Oblast was to the highest degree caused by manifestations of erosion and deflation. The territory with manifestations of water erosion comprises Volodymyr-Volynskyi, Ivanychi, Lokachi, Horohiv, Lutsk and Kivertsi districts. The amount of eroded agricultural lands in each district by 1991 has greatly increased since 1968. For example, it was 14.8 against 7.3 thousand ha in Volodymyr-Volynskyi, 13.8 against 4.4 thous ha in Ivanychi, 21.5 against 9.9 thous ha in Lokachi, 42.2 against 21.8 thous ha in Horohiv, 32.8 against 21.4 thous ha in Lutsk, and 10.2 against 7.1 thous ha in Kivertsi. The percentage of eroded soils of the total area of arable land within Volyn Oblast varies. Therefore, partially, in Volodymyr-Volynskyi and Lokachi districts, it ranges 11-30 %, in Ivanychi and, partially, Horohiv – 1-10 %, and ultimately, partially, Horohiv, Lutsk and Kivertsi – 31-50% (Fesyuk et al., 2016).

Annually, 5 T of soil is dislodged from 1 ha in the Polesia zone, 15-20 T/ha in Volodymyr-Volynskyi, Ivanuchi, and Kivertsi districts, and 30-40 T/ha in Lokachi, Lutsk and Horohiv districts (Shevchuk et al., 1999).

Deflatable soils in the Oblast accounted for 258.2 thous ha, including 33.2 thous ha in Kovel district, 27.7 thou ha in Turiisk, 21.9 thou ha in Rozhyshche, 20.1 thous ha in Stara Vyzhivka, 19.9 thou ha in Liuboml, 19.4 thous ha in Ratne, 19.2 thous ha in Kamin-Kashyrskyi, 16.5 thous ha in Manevychi, 17.0 thous ha in Liubeshiv, 16.4 thous ha in Volodymyr-Volynskyi, 4.6 thous ha in Ivanychi, 6.7 thous ha in Lutsk, 7.2 thous ha in Horohiv and 7.8 thous ha in Lokachi district (Polanskyj, 2015).

Since then, the situation has obviously changed. No monitoring of eroded and deflated lands is currently being performed in the Oblast. Statistical reports about the condition of lands contain terms such as disturbed, exhausted, low-productive and degraded lands.

As of 2019, there were 5,846.51 hectares of disturbed lands in Volyn Oblast (Fig. 2). The greatest areas are in Horohic district – 20% of the overall parameter for the Oblast, Kovel – 18%, Turiisk – 12%, Manevychi – 9%, Stara Vyzhivka – 8%, Kamin-Kashyrskyi and Ivanychi – 7% in each. Reasons for disturbance of the lands are different (Rehionalna dopovid, 2019).

It would also be interesting to compare the areas of degrading soils in the Oblast in 1996 and 2019 in terms of administrative districts. According to the materials of the Main Management of the State Cadaster in Volyn Oblast, in 2019, compared with 1996, the area of the degraded soils (including eroded and deflated) in Volyn Oblast decreased 376-fold (116 thou ha to 308 ha). Areas of degraded soils decreased the

most in Horohiv district – 1,356 times (40,570 ha in 1996 and 29.9 ha in 2019) and Lutsk district – 1,335 times (24,030 ha in 1996 and 18 ha in 2019). In other districts, the decrease equaled 37-357 times. Such difference between the areas is obviously due not to the successes of recultivating and ameliorative measures, but rather the fact that the reports about the condition of land resources stopped reflecting degraded (mostly eroded) soils. In order to evaluate the structure of disturbed and degraded soils, it is necessary to perform scientific research on soil, assessing the degree of soil dislodgement or deflation of soils, etc. Such studies in the Oblast have not been carried out since 1996. Until then, there was a program of monitoring degraded soils, measures of which have been implemented by the Volyn Institute of Land Management and Oblast Soil Fertility.

The level of waterlogging of soils in Volyn is one of the highest across our country. Therefore, in particular, 41.9% of the territory of the Oblast is occupied by marshes, waterlogged and overwet lands (Table 1). Within the Oblast, there are large amounts of peat (Fig. 3). Therefore, those engaged in agriculture have an interest in its extraction. There is an especially strong interest in industrial peat and production of peat-bricks, which is increasing due to the necessity of diversification of use of energy sources and maximum replacement of gas in the structure of the oil-energy balance.

The consequences of peat extraction and drainage reclamation are the reasons for the emergence of peat fires, which have a catastrophic impact in Volyn Oblast. The main cause of the fires is burning of dry areas in pastures and hay fields against the background of decrease in the level of groundwater and dry climate over the recent years. The mass media and social network have started an active campaign against burning dry grass and leaves, which unfortunately is not that effective so far.

Over the period of 2015-19, the State Emergency Service of Ukraine in Volyn Oblast recorded 219 cases of peat fires. A total area of 280.43 ha has been burnt . The largest areas of burned peat lands were observed

Table 1. Specific weight of waterlogged lands and land in the marshland fund (Zinchuk et al., 2019)

Region	Total area, thous ha					Area of the marshland fund, thous ha			
	lands in total		including marshes, overwet lands		% waterlogged	overall	including drained gross	including drained net	% of use
	in total	in agriculture	in total	in agriculture					
Polisia	1,450.3	726.3	786.3	635.3	46.3	675.9	396.1	379.2	58
Overall in the Oblast	2,014.4	1,058.7	845.2	690.8	41.9	731.8	435.0	416.6	59

Also, within the Oblast, 191 ameliorative systems operate. The area of dried lands equals 416.6 thou ha (Table 2). The area of ameliorative agricultural lands is 346.7 thous ha. Ceramic drainage pipes dry 236.6 thou ha. The area of polder system is 47.9 thou ha. Length of the open network of the canals equals 18.5 thous km (inter-agricultural – 4.6 thous km and intra-agricultural – 13.9 thous km) (Zuzuk et al., 2012).

The main problems of dried territories are: overdrying of sites, pyrogenic formations (burning out of peatlands), secondary waterlogging, karst development, emission of CO_2, erosion, overgrowing and siltification of ameliorative channels, ploughing of soils immediately adjacent to the canals (Shevchuk et al., 1999).

Another anthropogenic factor of disturbance and degradation of soils in Volyn Oblast is peat extraction. in Kamin-Kashyrskyi – 137.9 ha (49.17% of the overall parameter for the Oblast), Liubeshiv – 26.72 ha (9.53%), Manevychi – 20.35 ha (7.26%), Rozhyshche – 16.22 ha (5.78%), Stara Vyzhivka – 19.7 ha (7%), Kovel – 12.47 ha (4.45%), Shatsk – 11.9 ha (4.24%),

Table 2. Drained lands in Volyn Oblast and their distribution (ha) (Zuzuk et al., 2012)

Region	Overall area , net	Of net area		
		mineral soils	peat-marshy	
			Всього overall	Area with depth of peat over 1 m
Polisia	374.648	262.426	112.222	22.033
In total across the Oblast	416.541	291.501	125.040	24.463

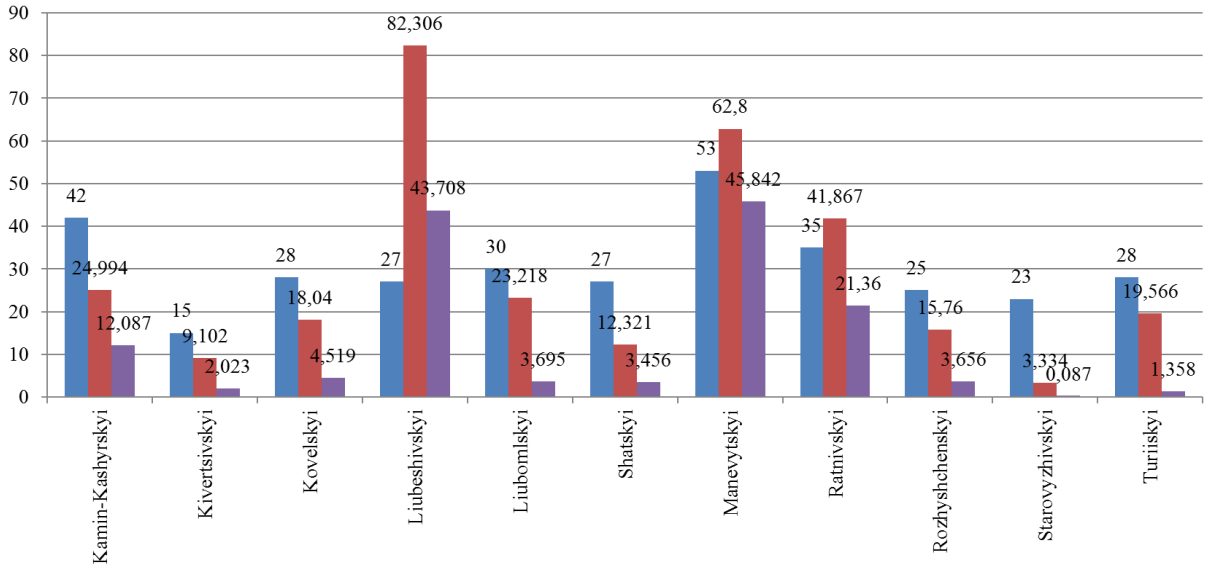

Fig. 3. Peat reserves in districts of Volyn Oblast (Rehionalna dopovid, 2019)

Volodymyr-Volynskyi – 9.67 ha (3.45%), Liuboml – 6.74 ha (2.4%), Ratne – 10.71 ha (3.82%), and other districts – less than 1% (Fesyk et al., 2020).

Peat fires are becoming a significant ecological problem that threatens not only the ecological condition of soils but also safety of life of the population. Pyrogenic formations occupy large areas, worsening conditions for agriculture, sometimes posing a threat to territories and objects of the nature reserve fund. Climatic tendencies of the recent years lead to increase in the number of peat fires and their negative consequences, including destruction of fertile soils, decrease in biodiversity, degradation of landscapes, deterioration of the health of the population, impairment of the carbon cycle and decrease in emission of greenhouse gases. Therefore, it is necessary to prevent peat fires and reduce their negative impacts in the future, as well as to use, restore and recultivate burned peatlands.

Prevention of peat fires requires bilateral regulation of the water regime within the ameliorative system, alkalinization of peat soils, increasing their fertility, sanding of dried peat soils. Also, it is important to carry out such measures as monitoring of burned peatlands and prevention of ignitions in the natural ecosystems.

For the purpose of further use, restoration and recultivation of burned peatlands, it is important to make a timely inventory-check the burned peatlands, assess economic and ecological damage, develop a plan of further use of the territory, determine the priorities of development and propose agricultural and nature-protection measures (Fesyuk et al., 2020).

Peat extraction damages soils and requires their recultivation. No such recultivation is taking place in the Oblast (Fig. 4).

Nonetheless, measures for improvement of low-productive lands in Volyn Oblast are being implemented. Those measures are called ameliorative and include hydrotechnical, biological, forest, agrotechnical, chemical amelioration. As of 2019, the leading lands according to improved areas are (Fig. 5): Turiisk district – 18% of the overall parameter for the Oblast, Kamin-Kashyrskyi – 10%, Liuboml, Stara Vyzhivka – 9% in each, Lokachi – 8%, Lutsk – 7%, Manevychi, Ratne district – 6% in each (Rehionalna dopovid, 2019).

At the same time, the extent of soil improvements do not satisfy the existing need . Therefore, the area of the lands that need improvement in the administrative districts of Volyn Oblast is much larger than the areas where the ameliorative land improvement has been made (Fig. 5). The largest areas of the lands that need to be improved are in the following districts: Turiisk (3,170 ha, 33% of the overall area in the Oblast), Ratne (2,801 ha, 30% of the overall area in the Oblast), Kamin-Kashyrskyi (2,030 ha, 21% of the overall area in the Oblast). Together with Lutsk district (541 ha, 6% of the overall area in the Oblast), these districts make up 90% of the area of the lands that need improvement. Unfortunately, statistical reports on the condition of lands made by the Service for the State Cadaster in Volyn Oblast describe no structure of causes of deterioration of the lands, disturbed lands and measures for their improvement.

Therefore, in the conditions of extensive agricultural land use, agrochemical and agrophysical or agricultural degradation of soils take place. Agrochemical degradation is characteristic of acidification of soil, decrease in phosphorus, potassium, and humus. Studies of agrochemical condition of soils, performed in the Oblast, allow monitoring of the contents of those

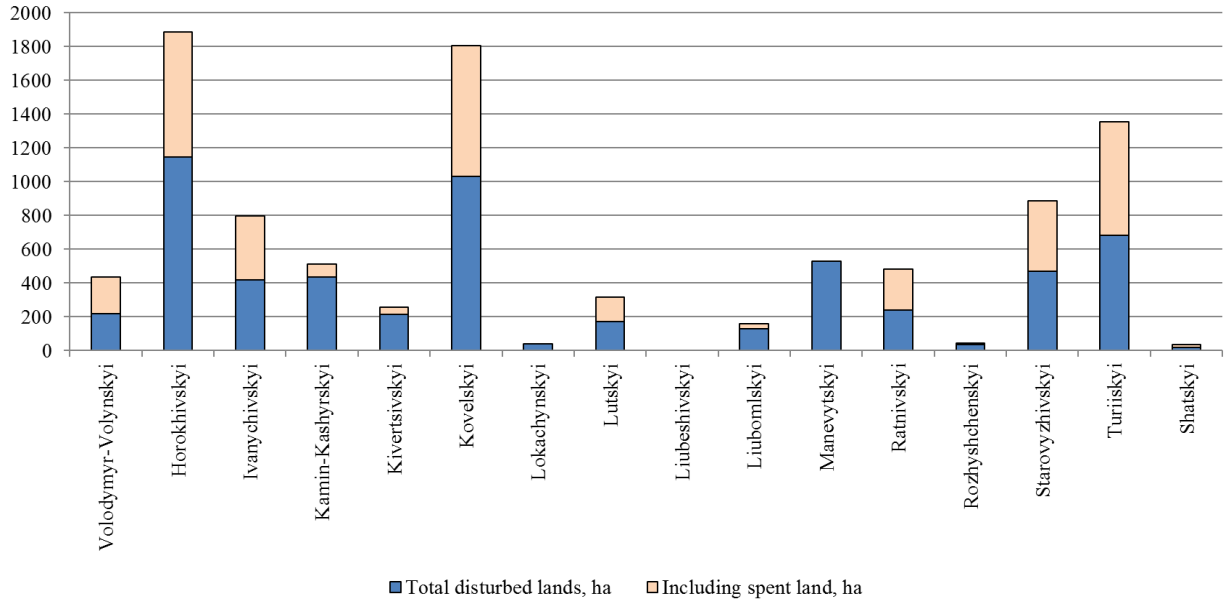

Fig. 4. Areas of disturbed lands in administrative districts of Volyn Oblast as of 2019 (according to the materials of the Main Management of State Cadaster in Volyn Oblast)

elements of fertility. Because the soil cover in the Oblast has been developed mostly by low-humus soils of light granulometric composition, which determined their low capacity of absorption and buffer property, transformation of the fertility parameters may occur in short periods. Agricultural degradation leads to deterioration in the composition of soil layer, deterioration of water-air regime, physical conditions

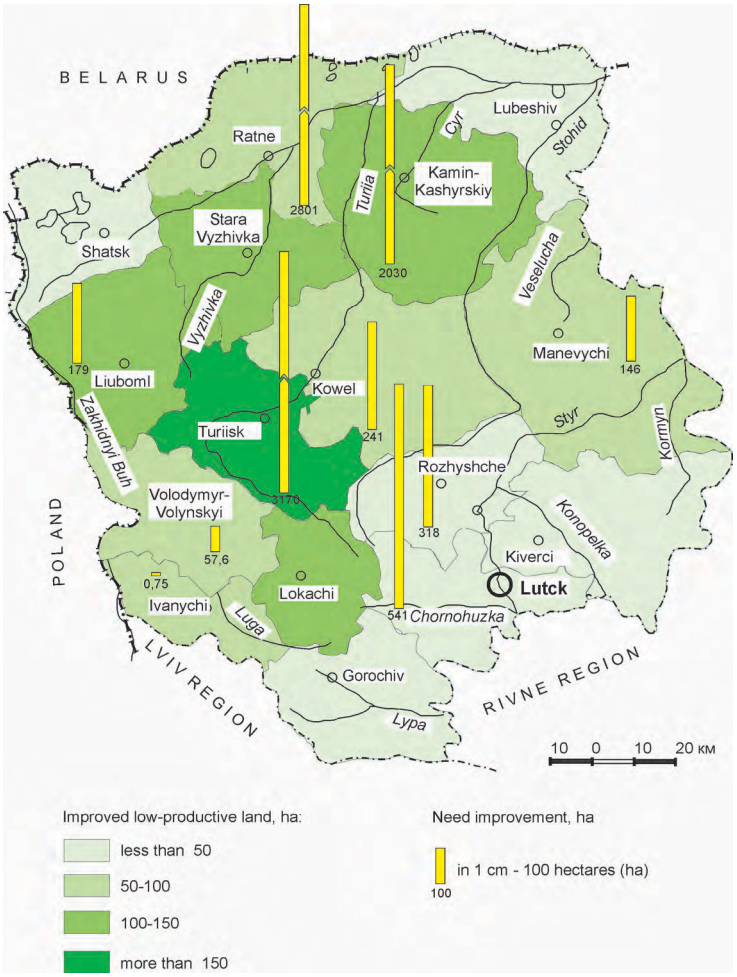

Fig. 5. Improvement of low-productive lands in Volyn Oblast as of 2019 (according to the materials of the Main Management of State Cadaster in Volyn Oblast)

Table 3. Summarised data on conservation of lands in Volyn Oblast as of 2019 (according to the materials of the Main Management of the State Cadaster in Volyn Oblast)

№	Administrative district	Lands taken under conservation since 2002	Lands that need conservation	Including		
				Those in private ownership	In state ownership	Degraded lands
1	Volodymyr-Volynskyi	88.14	544.60	0.00	544.60	307.85
2	Horohiv	104.8	132.52	0	132.52	29.9
3	Ivanychi	106.9	287.26	90.76	196.5	28.1
4	Kamin-Kashyrskyi	88.45	380.7	0	380.7	0
5	Kivertsi	316.32	511.9	0	511.9	57.4
6	Kovel	284.1	1,146.52	0	1,146.52	0
7	Lokachi	108.932	630	0	630	170
8	Lutsk	334.05	356.4	0	356.4	18
9	Liubeshiv	108.4	101.15	0	101.15	18
10	Liuboml	161.3	435.1	0	435.1	0
11	Manevychi	191.2	486.2	264.9	221.3	0
12	Ratne	89.5	291.2	0	291.2	0
13	Rozhyshche	179.3	244	0	244	16
14	Stara Vyzhivka	42	277.8	0	277.8	0
15	Turiisk	399.01	857.43	2.4	855.03	0
16	Shatsk	10	356.9	142	214.9	142
	In the Oblast	2,612.402	7,039.6807	500.06	6,539.603	787.25

of existing of soil biota and plants. All of this leads to erosive processes.

Agroecological monitoring of soils in Volyn Oblast was conducted by the Volyn Office of State Institution Soils Protection Institute of Ukraine (Derzhgruntohorona), State Institution Volyn Oblast Laboratory Center of Ministry of Healthcare of Ukraine and State Ecological Inspection in Volyn Oblast. Density of ^{137}Cs contamination in the agricultural lands is within 1 Ci/km^2, content of ^{90}Sr – up to 0.02 Ci/km^2. In the territory of the Oblast, during 2019, 411 samples of soil were collected for the monitoring of contamination of agricultural lands with residual amounts of stable starch-organic pesticides (DDT, HCH and 2,4-D). Out of 131 analyzed samples, no excess of TLV according to the residual content of DDT was found. Maximum content equaled 0.0027 mg/kg at the threshold limit value of 0.1 mg/kg. As for DDT preparation, there remains a general tendency toward decrease in the level of contamination of soils and decrease in the amount of excesses in limit threshold values. According to the content of HCH (total amount of isomers), out of 98 analyzed samples, no excesses of limit threshold values were found. Maximum content was 0.001 mg/kg at TLV of 0.1 mg/kg. Regarding HCH, no changes in detection of isomers were found over the recent years. No contamination of soils with 2,4-D (amine salt) was recorded during 2019. Content of each preparation in soils for the recent years have rapidly decreased (Rehionalna dopovid, 2019).

Conclusions

Analysis of geographic distribution of the main types of soils in Volyn Oblast reveals that a threat of physical degradation (over-compaction, desegregation, compressor erosion, etc) is insignificant.

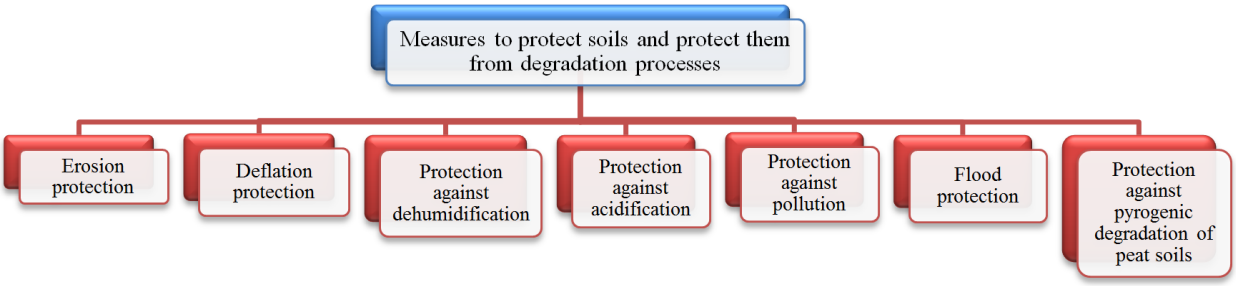

Fig. 6. Complex of measures for protection of soils in Volyn Oblast and protection of them against degradation

The reasons for this are light mechanical composition of soils in the most part of the Oblast, and also improvement of soil-processing machines, which are having less impact on soils.

Other types of soil degradation are manifested to a lesser extent. Therefore, it is necessary to develop a complex of measures of protection of soils and their protection against degradation processes. The protection should include the following groups of measures (Fig. 6).

The priority measures of preventing degradation of soils and restoration of disturbed soils are:

- restoration of marshes, waterlogged and overwet lands in order to preserve biodiversity, reduce the effects of climate change, increase moisture in the territory, improve the hydrologic regime of the surface waters and their quality;
- limiting the use of peatlands for extraction of peat, flooding and protection against peat fires;
- increasing the extent of forest areas in the region in order to improve the moisture balance in the territories, prevent the development of degradation processes in soils (erosion, deflation), increasing the efficiency of protection of forests against fires and pests;
- creating a landscape-adaptive system of arable farming with contour-ameliorative organization of the territory in the districts of developed water erosion and stimulating traditional horticulture as a factor of sustainable development of local communities;
- ecologically substantiating the use of organic and mineral fertilizers, poisonous chemicals, preparations for protecting plants;
- implementing organic farming so as to improve food safety, protect soils against chemical contamination;
- conducting soil monitoring, including not only agrochemical monitoring, but also monitoring of the condition of soils, especially degraded soils.

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Spring flood frequency analysis in the Southern Buh River Basin, Ukraine

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Abstract. The river floods are among the most dangerous natural disasters in the world. Each year, the spring floods cause the significant material damage in the different countries, including Ukraine. Knowledge of trends in such floods, as well as their probabilistic forecast, is of great scientific and practical importance. In last decades, the decreasing phase of cyclical fluctuations of the maximum runoff of spring floods has been observed on the plain rivers of Ukraine, including the Southern Bug River. In addition, there is an increase in air temperature. So, the actual task is the determine the modern probable maximum discharges estimates of spring floods in the Southern Buh River Basin as well as their comparison with the estimates that were computed earlier. It gives an opportunity to reveal possible changes of the statistical characteristics and values of the probable maximum discharges, to analyze and to discuss the reasons for these changes. For the investigation, we used the time series of the maximum discharges of spring floods for 21 gauging stations in the Southern Buh River Basin since the beginning of the observations and till 2015. The method of the regression on the variable that is based on the data of analogues rivers was used to bringing up the duration of the time series and restoration of the gaps. In the study, the hydro-genetic methods for estimation of the homogeneity and stationarity of hydrological series, namely the mass curve, the residual mass curve and the combined graphs. The distributions of Kritskyi & Menkel and Pearson type III for the frequency analysis were used. It has been shown in this study that the maximum discharges of spring floods of time series are quasi-homogeneous and quasi-stationary. It is explained the presence in the observation series of only increasing and decreasing phases of cyclical fluctuations, their considerable duration, as well as the significant variability of the maximal flow. The series of maximal runoff of spring floods are very asymmetric, which significantly complicates the selection of analytical distribution curves. The updated current parameters of the maximal spring flood runoff have not changed significantly. It can be assumed that such characteristics have already become stable over time, as the series of maximal runoff of spring floods already have phases of increasing and decreasing of long-term cyclic fluctuations.

Keywords: spring floods, stationarity, homogeneity, frequency analyses, cyclical fluctuations

Аналіз ймовірнісних характеристик весняних паводків у басейні річки Південний Буг, Україна

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Анотація. У світі весняні повені на річках – одне з найнебезпечніших стихійних явищ. Щорічно весняні повені завдають значних матеріальних збитків у різних країнах світу, у тому числі, і в Україні. Важливе наукове і практичне значення має знання тенденцій таких повеней, а також їхній імовірнісний прогноз. В останні десятиліття на рівнинних річках України, до яких відноситься і річка Південний Буг, спостерігається маловодна фаза циклічних коливань максимального стоку весняної повені. Окрім того, спостерігається підвищення температури повітря. Отже, актуальним завданням є визначення сучасних ймовірних характеристик максимальних витрат весняної повені в басейні річки Південний Буг, а також їхнє порівняння з оцінками, які було розраховано раніше. Це дозволить виявити можливі зміни статистичних характеристик максимальних витрат весняної повені, проаналізувати та обговорити причини цих змін. Для дослідження використано ряди спостережень максимальних витрат весняної повені для 21 гідрологічного поста в басейні річки Південний Буг з початку спостережень по 2015 р. Для отримання більш достовірних оцінок ряди спостережень було приведено до багаторічного періоду та по можливості відновлено пропуски методом парної регресії. Для оцінки однорідності і стаціонарності рядів спостережень використано гідролого-генетичні методи, а саме сумарну та інтегральну криву відхилень, суміщені хронологічні графіки. Для апроксимації емпіричних точок використано розподіл Крицького-Менкеля та розподіл III типу Пірсона. У дослідженні пока-

зано, що ряди максимальних витрат води весняної повені є квазіоднорідними та квазістаціонарними, оскільки мають тільки незавершені фази (підйому та спаду) довготривалих циклічних коливань. Ряди максимального стоку весняної повені є дуже асиметричними, що суттєво ускладнює побудову аналітичних кривих розподілу. Уточнені сучасні параметри максимального стоку весняної повені суттєво не змінились. Можна припустити, що такі характеристики вже стали стабільними з часом, оскільки ряди спостережень мають фази збільшення і зменшення довгострокових циклічних коливань.

Ключові слова: весняна повінь, стаціонарність, однорідність, ймовірність, циклічні коливання

Introduction

In the world, the extreme floods on the rivers cause considerable and prolonged flooding of the densely populated territories, which cause to damage a myriad of infrastructures such as buildings, roads, bridges, and barrages and sometimes also losses of human lives. The extreme floods are among the costliest natural hazards (Doe, 2006; Razmi et al., 2017; Blöschl et al., 2019). Since the natural disaster as extreme floods is the basis for planning and design of various hydraulic structures, hydrological forecasting, flood risk reflection characteristics such as trends of extreme floods and its changes, and its formation conditions, the probable maximal flood and its characteristics have a great practical importance. The determining of the probable maximal flood is the practical importance, especially for the planning, design, and operation of hydrotechnical structures (Apel et al., 2004; Blöschl et al., 2013; Okoli et al., 2019).

During the 20th century, many scientists developed the methodological approaches to the definition of flood estimates, which remain relevant today. Therefore, the statistical approaches, hydrometeorological methods, empirical formulas, different regionalization methods are usually used to flood estimates (Blöschl et al., 2013; Saghafian, 2014; Odry and Arnaud, 2017). At the same time, such research may have the related difficulties due to low precision of extreme flood discharge measurements and estimates, using comparatively short time series of observed flood data, limited data availability, as well as temporal variation in the data series due to variability in climate and to environmental changes, etc. Hence, the important task is obtaining reliable flood estimates. This can be achieved by using appropriate methodological approaches (McKerchar and Macky, 2001; Kjeldsen, 2015; Okoli et al., 2019).

In Ukraine, on the plain rivers the dangerous floods are observed during the spring period (Grebin, 2010; Gorbachova, 2015; Shakirzanova, 2015; Khrystyuk et al., 2017). In this paper, the spring flood estimates was carried out for the Southern Buh River Basin. The research for this river is actual because the river has significant importance for hydro-energy sector and agriculture. Thus, Southern Buh River Basin has 6929 ponds and 200 water reservoirs (Palamarchuk and Zakorchevna, 2006). In the different years, these reservoirs can accumulate from 20 to 70% of the local flow. Water river is widely used for irrigation, especially in drought years (Vyshnevskyi, 2000). The frequency approach is widely used for flood estimates in Ukraine. Typically, the statistic estimates are the updated every 5 years. This approach allows the use of modern data and, accordingly, to receive more reliable and accurate flood estimates.

The aim of this study is to determine the modern probable maximal discharges estimates of spring floods in the Southern Buh River Basin as well as their comparison with the estimates that were computed earlier. It gives an opportunity to reveal possible changes of the statistical characteristics and values of the probable maximal discharges, to analyze and to discuss the reasons for these changes.

The tasks of the research include:

– the use of the method of linear regression for the restoration of the data of observations in different years;

– the investigation of the homogeneity and stationarity of the observation series on based the graphical methods;

– the determination of 1% maximum discharges of spring flood of the rivers.

Materials and Methods

Southern Buh River is the second-longest river after the Dnipro River in Ukraine. It is the longest river that flowing exclusively through the territory of Ukraine – its length is 806 km. The basin river is on the Volyn-Podillia and Dnipro Uplands, as well as in the Black Sea lowland for the lower part of the basin. Its crosses three natural zones: forest, forest-steppe, and steppe. Catchment covers 10.6% of the territory of Ukraine. Southern Buh River Basin has the pear-shaped form: at the top part it is narrowed; in the middle and lower parts the basin is sharply asymmetrical (Fig. 1). Southern Buh River is plain river, because the average height of its catchment in the upper part is 300-320 m, in the lower part is 5-20 m, the average slope of water surface is 0.40% (Kaganer, 1969).

The atmosphere circulation is carrying out an important role for the formation of the basin climate. It is associated with the movement of an air masses from the Atlantic, Arctic, and Mediterranean. Moderate

continental climate is typical for the river basin. Precipitation gradually decreases from the source to the mouth of the river. (Bauzha and Gorbachova, 2017). The summer rains (except for the strong) do not form a surface runoff at some catchments of steppe zone due to the intensive infiltration of rainwater into the soil and significant evaporation from river catchment. Furthermore, such rivers almost do not have an underground supply and in the summer-autumn period it dries up. In winter period, such rivers are usually frozen (Gorbachova and Khrystyuk, 2018). Southern Buh River basin is characterized by a clearly pronounced spring flood, during which it is forming from 35 to 60% of annual streamflow (Shakirzanova, 2015).

The Southern Buh Basin has extremely high anthropogenic loads. Hence, more than 8 000 artificial reservoirs were created in the basin, their total volume is close to 1.5 km³, which is almost equal to the runoff in the dry year of probability 95%. Its water is widely used for hydro-energy sector, industrial and municipal water supply, agriculture, irrigation, shipping, tourism, etc. (Bauzha and Gorbachova, 2017).

In this study we used the series of observations of 21 gauging stations of the Southern Buh River Basin (Fig. 1). The catchment areas are changing in the greater limits – from 92.5 to 46200 km². The period of observation on these rivers is from 14 (Southern Buh River – Selythse village) to 102 (Southern Buh River – Oleksandrivka village) years (since the beginning of the observations and till 2015) (Table 1).

To verify the reliability of observations data on the maximum discharges of the spring flood it was used the historical information. On several rivers, the observations were not conducted for some years. Some data series were with errors or have short duration of observed flood data.

The method of the regression on the variable that is based on the data of analogues rivers was used to bringing up the duration of the time series and restoration of the gaps. This method recommended for using as by «Guide to Hydrological Practices» WMO (2009), as and by the national guideline of Ukraine (BNR, 1983). It is carrying out provided that:

$$R \geq 0.7,\ l \geq 10,\ k/\sigma_k \geq 2 \qquad (1)$$

where R is the correlation coefficient between discharge values of the corrected and analogue gauging stations; l is a number of joint observation years of corrected and analogue gauging stations; k is the regression coefficient; $\boldsymbol{\sigma}_k$ is the standard deviation of regression coefficient.

The determining probable characteristics of time series can be carried out only based on the homogeneous and stationary data. Nowadays, two methodi-

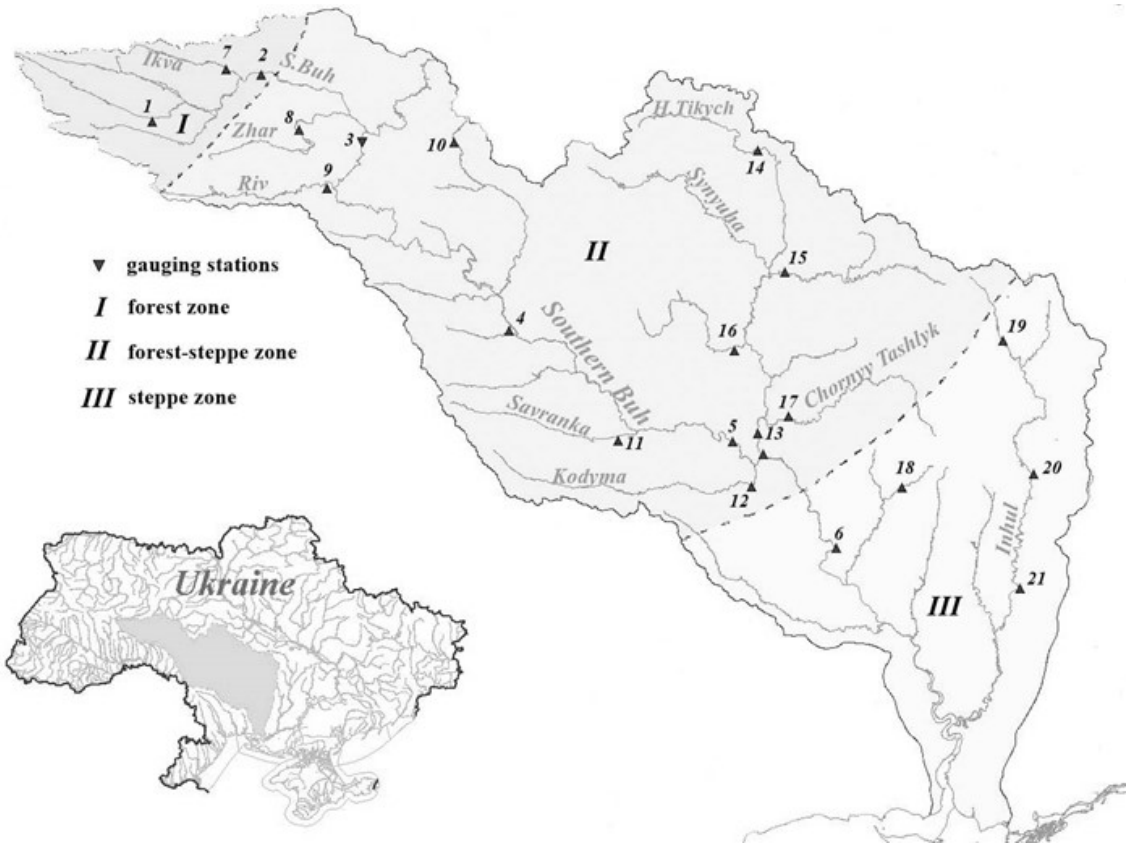

Fig. 1. Scheme of the Southern Buh River Basin and location of the 21 water gauging stations (numbering of stations is based on Table 1)

Table 1. Basin characteristics of gauging stations of the Southern Buh River

No	River	Location of the gauging station	Catchment area (km^2)	Study period and its duration, years
1	Southern Buh	Pyrohivtsi village	827	1964-2015 / 52
2	Southern Buh	Lelitka village	4000	1926-43, 1945-46, 1964-2015 / 72
3	Southern Buh	Selyshche village	9100	2002-2015 / 14
4	Southern Buh	Trostyanchyk village	17400	1930-41, 1946-94, 1996-2015 / 81
5	Southern Buh	Pidhir'ya village	24600	1926-43, 1958-2015 / 76
6	Southern Buh	Oleksandrivka village	46200	1914-2015 / 102
7	Ikva	Stara Synyava village	439	1946-93, 1996-2015 / 68
8	Zhar	Lityn village	692	1931-88, 1990-94, 1996-2015 / 82
9	Riv	Demydivka village	1130	1916-18, 1922-41,1945-88, 1990-94, 1996-2015 / 91
10	Sob	Zoziv village	92.5	1945-88, 1990-94, 1996-2006, 2008, 2010-13, 2015 / 66
11	Savranka	Osychky village	1740	1936-39, 1945-2015 / 75
12	Kodyma	Katerynka village	2390	1931, 1933-41, 1945-88, 1990-2015 / 80
13	Synyuha	Synyuhyn Brid village	16700	1925-31, 1933-89, 1991-2015 / 89
14	Hnylyy Tikych	Lysyanka village	1450	1945-2015 / 71
15	Velyka Vys	Yampil village	2820	1925-1941, 1943, 1945-91, 1993-2015 / 87
16	Yatran'	Pokotylove village	2140	1955-2010 / 61
17	Chornyy Tashlyk	Tarasivka village	2230	1933-43, 1945-88, 1990-2015 / 81
18	Mertvovid	Kryva Pustosh village	252	1949-88, 1991-94, 1996-2015 / 64
19	Inhul	Kropyvnytskyi city	840	1945-81, 1983-88, 1992-2006, 2008-12, 2014-15 / 65
20	Inhul	Sednivka village	4770	1954-2015 / 62
21	Inhul	Novogorozhene village	6670	1931-1941, 1945-2015 / 82

cal approaches detecting changes in the hydrological series of observations that are widely used worldwide: deterministic and statistical (Kundzewicz and Robson, 2004; WMO-No. 168, 2009; Gorbachova, 2014). In the paper, Kundzewicz and Robson (2004) it is showed that the hydrological series are characterized by some features (they are non-normal, seasonal, and serially correlated). Therefore, the statistical criteria to analyze changes of hydrological series of observations should be used only after their transformation, particularly resampling methods should be made. The graphical method and historical data are used to confirm the results of the statistical criteria.

In this paper, the deterministic approach based on graphical methods for estimation of the homogeneity and stationarity of hydrological series are used. These methods include correlation graphs, frequency of values, histograms, mass curves, double mass curves, residual mass curves, chronological charts, and etc. (Chow et al., 1988). During the 20th century the methodical approaches of using graphical methods were developed. Thus, Rippl (1883) invented and proposed to use the mass curve and residual mass curve for the design of the reservoirs and Merriam (1937) is the author of the double mass curve that he used for a research of hydrometeorological series change. In the papers, Gorbachova (2014, 2016) showed that with the complex use of certain graphical (hydro-genetic) methods can successfully carry out the assessment of homogeneity and stationarity of hydrological series. The mass and residual mass curves, and combined graphs of hydrological characteristics were proposed for the complex analysis of observation data. This methodological approach has already been used to investigation the homogeneity and stationarity of streamflow of Ukrainian rivers (Gorbachova et al., 2013; Gorbachova, 2015; Zabolotnia et al., 2019).

The mass curve is used to detect the influence of anthropogenic factors (hydraulic structures, canals) and of climate change (the presence of trends in the data series). The generation of runoff in the study area is homogeneous, and vice versa when the mass curve is not detected "hopping", "outliers" or unidirectional deviation. The mass curve is defined with the following formula:

$$Q = \sum_{t=1}^{T} Q(t) \quad (2)$$

where Q is the total discharge of river for time period T; $Q(t)$ is the discharge of t^{th} year.

The residual mass curve was used for the assessment of the observation series stationarity. The analysis allows the definition of the stationarity of data series, the sustainability of the mean value of

the hydrological characteristic over a long period of time. The mean value of the time series is stable in the presence of at least one dry and wet phase of a long-term cyclical fluctuations of time series. The residual mass curve is defined by Andreyanov's formula (1959):

$$f(t) = \frac{\sum_{t=1}^{T}(k(t)-1)}{C_v} \quad (3)$$

where C_v is the variation coefficient of time series; $k(t) = Q(t)/Q_0$ is the modular coefficient; $Q(t)$ and Q_0 is the discharge of t^{th} year and mean discharge for the period T.

Combined graphs of hydrological characteristics allow the definition of the synchrony/asynchrony of long-term fluctuations in different rivers within the one hydrological homogeneous area. In turn, the synchronous fluctuations are indicated on the homogeneous climatic conditions of runoff formation.

The Kritskyi & Menkel, Pearson type III and Gumbel distributions for the frequency analysis were used (Kritskyi & Menkel, 1940; WMO, 2009; BNR, 1983; Chow et al., 1988). The empirical probability distribution is defined by the formula (BNR, 1983):

$$P_m = (m|n+1)100\ \%, \quad (4)$$

where ***m*** is ordinal number of hydrological series members that arranged in the decreasing order; ***n*** is the total number of hydrological series members.

Statistical parameters of the analytical probability distribution, namely the mean discharge of the data series, the variation, and skewness coefficients are defined by the method of moment and method of maximal likelihood according to methodical approaches that were showed in the WMO (2009).

The fitting criterion χ^2 to check the results of analytical curve approximation of empirical points was used (Chow et al., 1988).

Results and their analysis

In accordance with formula (2), in the Southern Bug River basin for the 21 gauging stations the graphs of the mass curve of maximal discharges of spring floods were created. Examples of such curves for some rivers are shown in the Fig. 2.

The analysis of these graphs shows that the observations series are inhomogeneous, because a point of inflection is on them, after which the tendency of maximal discharges changes. At the same time, this type curves indicates the absence of unidirectional stable trends of maximal discharges of spring floods of the Southern Bug River basin. Such tendencies are typical also for other plain rivers of Ukraine (Shakirzanova, 2015; Gorbachova et al., 2016; Zabolotnia et al., 2019). Such observations series have the mass curve of convex type. The residual mass curves were created to identify the reasons for such a tendency of maximal discharges of spring flood of the rivers (Fig. 3). Their analysis showed that for the period 1970-1980 for all rivers was the transition from the increasing to decreasing phases of the long-term cyclical fluctuation. The decreasing phase continues to this day and its completion cannot be predicted. The different phases of cyclic fluctuations are observed in the

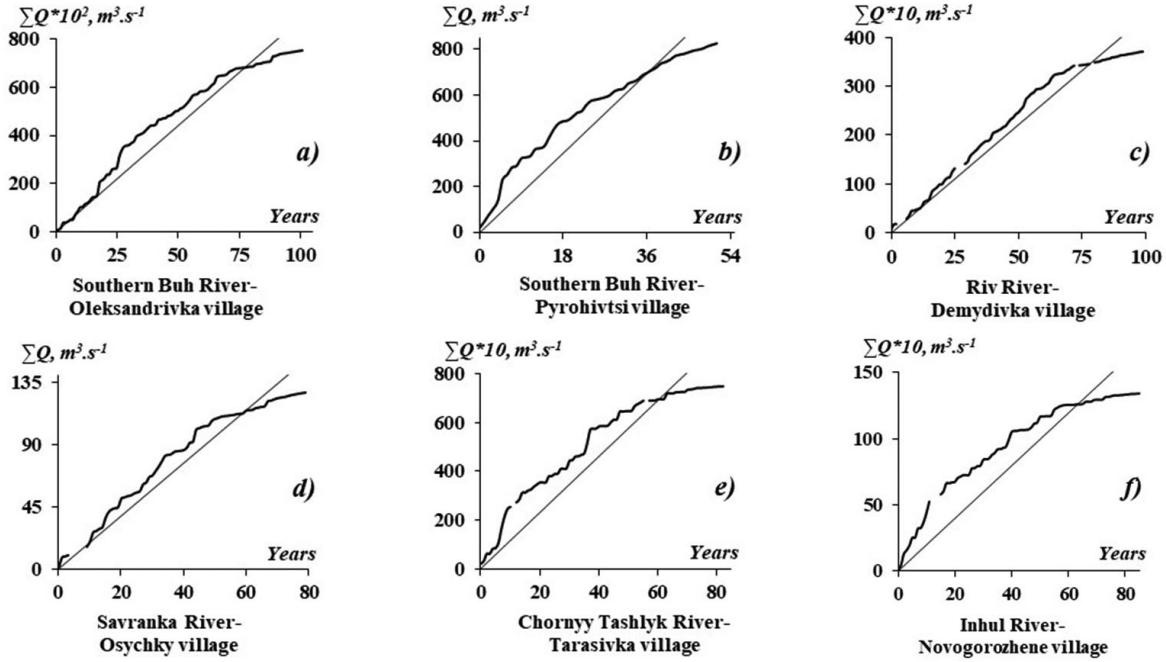

Fig. 2. Some mass curves of the maximal discharges of spring floods of the Southern Buh River Basin

various directional changes of streamflow (Pekarova et al., 2003; Gorbachova, 2015). Also, these phases have a significant difference in the mean values (Gorbachova, 2015). Furthermore, the maximum flow of rivers has considerable variability (its values are several times higher than the values of average annual and minimum flow). The feature of the maximum flow of spring flood of plain rivers is the long duration of cyclical fluctuations phases. For example, at the Southern Buh River hydrological station on Oleksandrivka village the data series of maximal spring flood (the observations have been carried out since 1914), have not yet completed a decreasing phase that began in 1970 (Fig. 3). This series of observations also do not have the complete increasing phase of fluctuations since observations began at a time when the increasing phase was already in progress. Consequently, at the Southern Buh River hydrological station on Oleksandrivka village the maximal flow of spring floods with the duration of observation at 102 years (1914-2015), does not have a full cycle of long-term fluctuations.

plain rivers. For mountain rivers, the mass curves have the sinuous type. In the study (Shakirzanova, 2015) it is shown that in the Southern Buh River Basin the climatic factors of spring floods have long-term cyclical fluctuations. The cyclical fluctuations of climatic factors of the formation of spring floods of rivers are also shown in the papers (Khrystyuk, 2013; Khrystyuk et al., 2017). The classification of hydrographs by similar shapes in them was carried out and it was shown that the presence of similar in shape hydrographs in the time series of classes indicates that from time to time the similar formation conditions of water flow at the catchment area repeats due to cyclicity of climatic and, as a consequence, of hydrological processes. In the study (Khrystiuk et al., 2020) the cyclicity of spring floods based on the classification of hydrographs by the facet method in the Southern Buh River Basin is showed.

The absence of a full cycle of long-term fluctuations in the observation series of the maximal flow of spring floods of rivers makes such data an unrep-

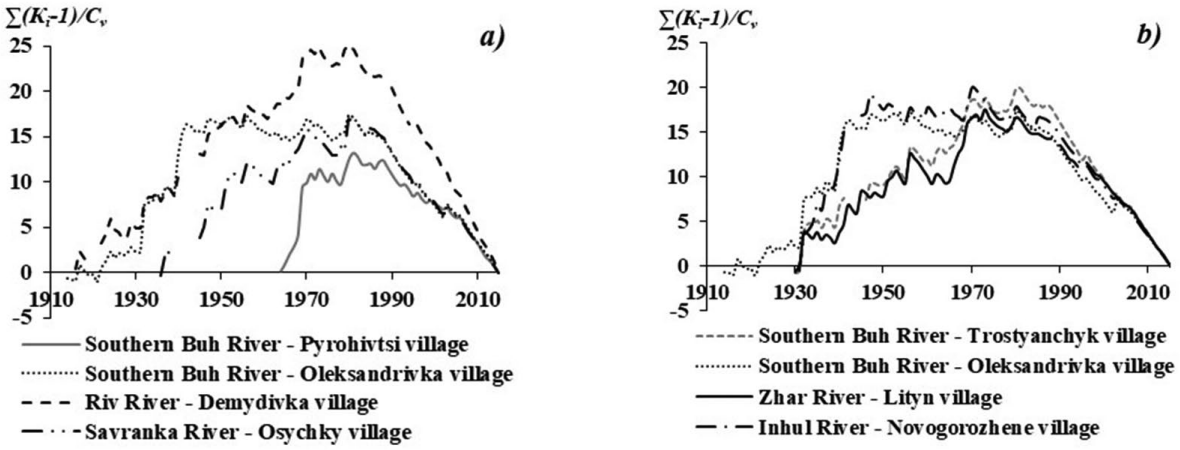

Fig. 3. Some the residual mass curves of the maximum flow of spring floods in the Southern Buh River Basin

Therefore, the presence in the observation series of maximal flow of spring floods of plain rivers in only increasing and decreasing phases of cyclical fluctuations, their considerable duration, as well as the significant variability of maximal flow are forming the convex type of mass curves. Also, a mass curve type has a temporary character and occurs when a combined analysis of different phases of long-term cyclical fluctuations, namely only increasing and decreasing phases. The observation series can be classified as quasi-homogeneous. The conclusions are indirectly confirmed by the analysis of the maximal flow of spring floods of mountain rivers. Such studies (Gorbachova and Barandich, 2016; Zabolotnia et al., 2019) is shown that the phases of cyclic fluctuations of mountain rivers have a much shorter duration than

resentative for the correct determination of stable mean value (Andreyanov, 1959). The many scientists identify such series as non-stationary. Especially when only statistical criteria are used to analyze the homogeneity and stationarity of the data series (Kundzewicz and Robson, 2004; Gorbachova and Bauzha, 2013). An example of the mean value change of observation series depending on the presence or absence of a representative period was shown in paper (Gorbachova, 2015). At the present, in the Southern Buh River Basin the observation series of maximum flow of spring floods can be attributed to temporarily quasi-stationary. Therefore, it is essential to update the statistical characteristics every 5 years.

The basin of the Southern Buh River, the conditions for the formation of the maximal flow of spring

floods are homogeneous, because at all hydrological stations the fluctuations of the maximal flow of spring floods are synchronous and syn-phase (Fig. 3). It also shows that the anthropogenic impact does not have a significant effect on the maximal flow of spring floods because rivers with natural flow have the same tendency as the rivers with the hydraulic structures. It also facilitates the selection of rivers of analogues. For short series of observations, it is necessary (if possible) to carry out them the increase duration. This will allow such series to have the information about extreme floods that were observed in the increasing phase of long-term cyclical fluctuations in the Southern Buh River Basin. For example, these are the same data series as for Southern Buh River – Pyrohivtsi village (Fig. 3a) and for Southern Buh River – Selyshche village (Table 1).

In accordance with the requirements to calculations (1), the increased duration and restoration of the gaps in the time series by the method of regression on the variable based on the data of analogue rivers were carried out. An analysis of the results shown that in the time series remained some gaps, but their percentage was significantly decreased (Table 2). In the Southern Buh River Basin there are difficulties with the choice of analogue rivers because observations do not cover small rivers and some tributaries (Gorbachova and Khrystyuk, 2018).

Hence, at the Southern Buh River water gauging station on the Oleksandrivka village, the time series has the longest duration without gaps (102 years). This station is the closing water gauging station on the Southern Buh River, consequently, its catchment area is the largest in basin (Fig. 1, Table 1). However, it cannot be an analogue for the time series that were obtained from catchments with small areas. All other time series have gaps in observations due to military actions, reconstruction, etc. The restored time series allows obtaining the more reliable calculated statistical characteristics of the maximal discharges of spring floods in the Southern Buh river basin, which are shown in the Table 2. However, we have some difficulties with the selection of the analytical curves when approximating the empirical points of spring floods in the Southern Buh river basin. We found that the distributions Kritskyi & Menkel and Pearson type III can be used for plotting analytical curves (Fig. 4 and Table 3).

The Gumbel distribution is generalized extreme value distribution. However, in the Southern Buh River Basin the Gumbel distribution cannot be used to generate analytical curves, because the lower part of such curves is in the range of negative values. The Pearson type III distribution also could not be used for some series of observations for a similar reason. Therefore, basically the analytical curves of Kritskyi & Menkel distribution to determine the values of maximal discharges of spring floods with 1% probability were used. Although, these curves also do not correspond very well the empirical points according to the analysis by fitting criterion χ^2 (Table 3). This situation can be explained by the fact that the observation series of spring floods are very asymmetric, because it has only a few extreme discharges. For short series (for example, it has only one extreme discharge), it is generally impossible to select the analytical curve without restoring the historical discharges. These are such series of observations as for water gauging stations of the Southern Buh – Pyrohivtsi village and the Sob – Zoziv village.

Discussion

The last frequency analysis of observation data for the maximal discharges of spring floods of the Southern Buh River Basin was carried out in the paper of Gorbachova and Khrystyuk, 2018. In this paper, the calculation was carried out for the data to 2010 and were shown that values of maximal discharges of spring floods with 1% probability have the tendency to decrease in relation to the calculations which was completed according to the data to 1980. A comparative analysis of the results of this study with the results introduced in the paper of Gorbachova et al. (2018) showed that the values of maximal discharges of spring floods with 1% probability as well as its statistical characteristics not significantly changed (Table 3, columns 6, 7, 8, and 10). Consequently, such a parameter as the mean values of maximal discharges of spring floods already became stable over time. It is ensured by the presence in the time series of the increase and decrease phases of long-term cyclical fluctuations (Fig. 3). Thus, the analysis of cyclic fluctuations of the maximal flow is especially important when the frequency analyses are carried out.

Conclusions

The research presents the results of the spring floods estimates of the Southern Buh River Basin. The analysis of the homogeneity and stationarity of the maximal discharges of spring floods showed that time series are quasi-homogeneous and quasi-stationary. It is explained by the features of the maximal flow of spring floods of plain rivers, namely presence in the observation series only increasing and decreasing phases of cyclical fluctuations, their considerable duration, as well as the significant variability of maximal flow.

Table 2. The maximal discharges of spring floods of 1% probability in the Southern Buh River Basin

№	River	Location of the gauging station	Calculated period, years	Percentage of restored/missed data	Statistical parameters			Parameter definition method	$Q_{1\%}$, m^3 s^{-1}
					Q_{mean}, m^3 s^{-1}	C_v	C_s/C_v		
1	Southern Buh	Pyrohivtsi village	(1916-2015)	36/12	24.3/25.5	0.80/0.76	2.31/2.30	MLE	93.4/92.7
2	Southern Buh	Lelitka village	(1917-2015)	14/13	140/122	1.15/0.85	3.11/2.37	MLE	783/687
3	Southern Buh	Selyshche village	(1914-2015)	85/1	272	1.12	2.51	MOM	1479
4	Southern Buh	Trostyanchyk village	(1916-2015)	11/8	418/422	1.02/0.94	2.49/2.25	MLE	2036/1877
5	Southern Buh	Pidhir'ya village	(1915-2015)	17/8	470/442	0.97/0.81	2.42/2.42	MOM	2265/2266
6	Southern Buh	Oleksandrivka village	(1914-2015)	0/0	737/767	1.18/1,17	2.92/3.33	MOM	4400/4340
7	Ikva	Stara Synyava village	(1916-2015)	18/14	21.6/22.1	1.12/1.00	2.31/2.29	MOM	115/105
8	Zhar	Lityn village	(1916-2015)	6/11	23.8/24.5	1.05/1.02	2.64/2.63	MLE	120/121
9	Riv	Demydivka village	(1916-2015)	1/7	40.9/42.0	0.88/0.85	2.05/1.98	MLE	167/165
10	Sob	Zoziv village	(1928-2015)	8/17	6.97/6.18	1.39/1.50	2.50/3.00	MLE	46.4/44.7
11	Savranka	Osychky village	(1915-2015)	17/9	29.3/29.0	1.76/1.50	2.83/3.20	MOM	248/246
12	Kodyma	Katerynka village	(1917-2015)	8/11	34.0/29.1	1.74/1.50	2.50/3.68	MLE	285/290
13	Synyuha	Synyuhyn Brid village	(1915-2015)	7/5	413/420	1.35/1.37	2.22/2.82	MOM	2678/2768
14	Hnylyy Tikych	Lysyanka village	(1917-2015)	17/11	83.8/85.6	1,52/1.37	2.18/2.17	MLE	610/559
15	Velyka Vys	Yampil village	(1917-2015)	5/7	75.4/68.0	1.60/1.58	2.36/2.40	MLE	577/522
16	Yatran'	Pokotylove village	(1917-2015)	25/13	124/129	1.53/1.46	2.19/2.32	MLE	913/906
17	Chornyy Tashlyk	Tarasivka village	(1917-2015)	9/9	105/110	1.39/1.32	2.16/2.07	MLE	696/687
18	Mertvovid	Kryva Pustosh village	(1917-2015)	20/15	21.6/22.1	1.51/1.50	2.10/2.08	MLE	156/158
19	Inhul	Kropyvnytskyi city	(1917-2015)	17/17	52.3/51.5	1.37/1.39	2.15/2.12	MLE	341/341
20	Inhul	Sednivka village	(1917-2015)	24/13	208/220	1.36/1.28	2.20/2.08	MLE	1342/1327
21	Inhul	Novogorozhene village	(1917-2015)	8/9	188/195	1.37/1.31	2.18/2.08	MLE	1228/1214

Note: MLE – Maximum likelihood estimation method, MOM – Method of moments; in columns 6, 7, 8, and 10, the numerator shows the values that were calculated for the data to 2015, the denominator shows the values that were calculated for the data to 2010 (Gorbachova et al., 2018)

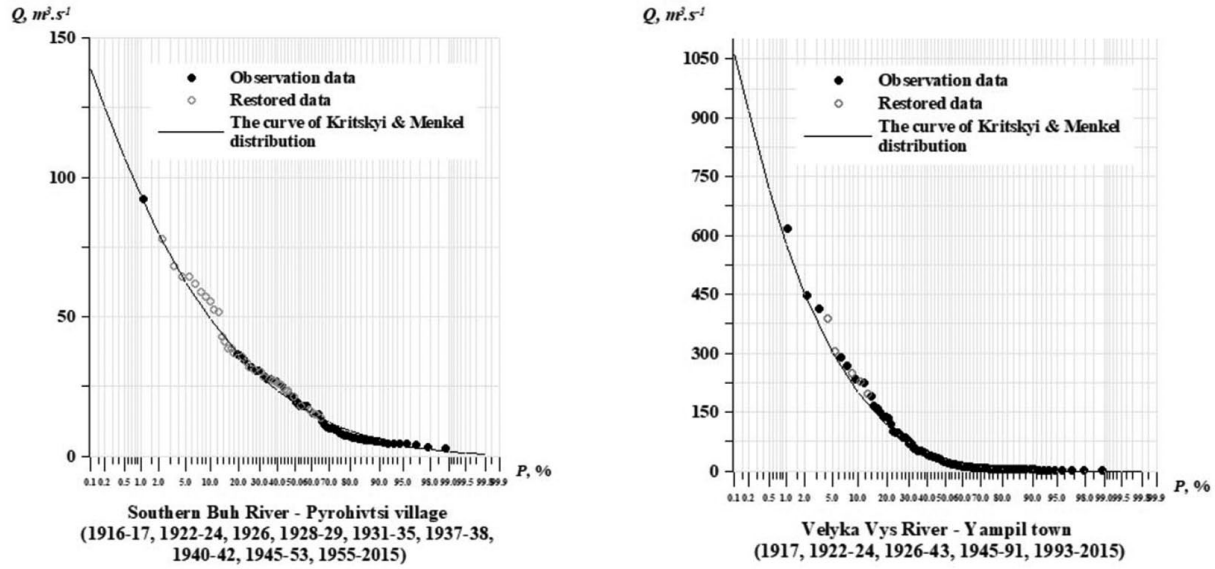

Fig. 4. Probability curves of the maximal discharges of spring floods in the Southern Buh River Basin

The restoring of the gaps in the time series is especially important step in the investigation because it allowed obtaining information about extreme floods that were observed in the increasing phase of long-term cyclical fluctuations of the Southern Buh River Basin. It contributes to obtaining more reliable and stable over time of the statistical characteristics of time series.

In the Southern Buh river basin, we have some difficulties with the selection of the analytical curves when approximating the empirical points of spring floods. Such empirical distributions are very asymmetric due to the presence of only a few extreme discharges. The calculation characteristics of the

Table 3. Check of spring flood series for compliance distribution laws in the Southern Buh River Basin

№	River - gauging station	$\chi^2(\alpha, \nu)$	χ^2	Compliance	Distribution low
1 Southern Buh – Pyrohivtsi village		12.6	7.91	compliant	Krytsky & Menkel
2	Southern Buh – Lelitka village	12.6	18.9	not compliant	Krytsky & Menkel
3	Southern Buh – Selyshche village	12.6	11.2	compliant	Pearson type III
4	Southern Buh – Trostyanchyk village	12.6	21.0	not compliant	Krytsky & Menkel
5	Southern Buh – Pidhir'ya village	12.6	9,04	compliant	Pearson type III
6	Southern Buh – Oleksandrivka village	12.6	48.5	not compliant	Krytsky & Menkel
7	Ikva – Stara Synyava village	12.6	6.56	compliant	Pearson type III
8	Zhar – Lityn village	12.6	9.31	compliant	Krytsky & Menkel
9	Riv – Demydivka village	12.6	11.2	compliant	Krytsky & Menkel
10	Sob – Zoziv village	12.6	29.6	not compliant	Krytsky & Menkel
11	Savranka – Osychky village	12.6	37.1	not compliant	Krytsky & Menkel
12	Kodyma – Katerynka village	12.6	40.4	not compliant	Krytsky & Menkel
13	Synyuha – Synyuhyn Brid village	12.6	10.5	compliant	Pearson type III
14	Hnylyy Tikych – Lysyanka village	12.6	44.7	not compliant	Krytsky & Menkel
15	Velyka Vys – Yampil village	12.6	24.5	not compliant	Krytsky & Menkel
16	Yatran – Pokotylove village	12.6	47.5	not compliant	Krytsky & Menkel
17	Chornyy Tashlyk – Tarasivka village	12.6	27.8	not compliant	Krytsky & Menkel
18	Mertvovid – Kryva Pustosh village	12.6	37.2	not compliant	Krytsky & Menkel
19	Inhul – Kropyvnytskyi city	12.6	12.1	compliant	Krytsky & Menkel
20	Inhul – Sednivka village	12.6	30.3	not compliant	Krytsky & Menkel
21	Inhul – Novogorozhene village	12.6	34.6	not compliant	Krytsky & Menkel

maximal discharges of spring floods already became stable over time. It is ensured by the presence in the time series of the increase and decrease phases of long-term cyclical fluctuations.

The research results can be used by scientific and project organizations for getting more reliable estimations of time series and to plan and design of different hydraulic structures, as well as for regional planning and management of water resources of the Southern Buh River Basin.

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Analysis of zoning schemes of the territory of Ukraine for the purposes of optimization and management of recreational and tourist activities

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Abstract. The purpose of this publication is to analyze the existing set of results of scientific and applied research in the field of recreational and tourist zoning of Ukraine and identify methodological differences in existing schemes for planning the development of recreation and sectoral zoning. To achieve this goal, the study used a content method of analysis of a set of existing theoretical and methodological approaches to zoning, research and development on the organization and functioning of recreational territorial units. Methods of comparative analysis of the data on the formation of the territorial structure of tourist regions, determining the criteria for taxonomic classification of territorial recreational formations allowed to systematize information about existing world zoning systems and recreational and tourist territorial structure of Ukraine. The information base of the study is the regulatory documents, analytical and statistical materials of the WTO, NTO of Ukraine, scientific publications of leading Ukrainian and foreign researchers on zoning, in particular, zoning to manage and optimize tourism and recreational activities. The study involves schemes for the development and allocation of resources for tourism and recreation, zoning schemes in Ukraine, in the field of recreation and tourism, which were carried out in the period from 1960s to 2020s. Numerous schemes of recreational and tourist division of the country's territory and its separate regions indicate the confusion of terminology, approaches, standards and rules for zoning the country. In Ukraine, there are sectoral zoning, which are based on the principles of "zona making" conception, however, most sectoral zonings are not compared and do not correlate. The principles laid down in the implementation of sectoral recreational and tourist zoning are not always coordinated with the regulations that exist in the system of spatial planning. The results of the analysis emphasize the urgency of unification of terminology, certainty with methodological approaches to taxonomic classification and selection of taxa within the country. Today the issues of formation of recreational, tourist, resort spaces for the purposes of efficient and rational nature use and development of a competitive national tourist product are solved without a single coordinated recreational and tourist zoning of the territory of Ukraine.

Keywords. tourism, recreation, taxonomy, taxonomic recreational units, zoning, recreational and tourist zoning

Аналіз схем районування території України для цілей оптимізації та управління рекреаційною і туристською діяльністю

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Анотація. Метою даної публікації є проведення аналізу існуючого масиву результатів наукових та науково-прикладних розробок рекреаційно-туристичного районування території України і виявлення методологічних відмінностей в існуючих схемах планування розвитку рекреації та галузевих районуваннях. Для досягнення мети в дослідженні використано контентний метод аналізу масивів існуючих теоретичних і методологічних підходів районування територій, наукових розробок з питань організації та функціонування рекреаційних територіальних утворень. Методи компаративного аналізу даних, щодо формування територіальної структури туристичних регіонів, визначення критеріальної основи проведення таксономічної класифікації територіальних рекреаційних утворень дозволили систематизувати інформацію про існуючі світові системи зонування та рекреаційно-туристичну територіальну структуру України. Інформаційною базою дослідження слугують нормативні документи, аналітичні та статистичні матеріали ВТО, НТО України, наукові публікації провідних українських та зарубіжних дослідників з питань зонування територій, зокрема, районування з метою управління та оптимізації туристсько-рекреаційною діяльністю. В дослідження залучені схеми розвитку та розміщення ресурсів туризму і рекреації, схеми районувань території України, в галузі рекреації та туризму, які здійснювалися в період з 1960тих по 2020ті роки. Численні схеми рекреаційно-туристичного поділу території країни та її окремих регіонів вказують на заплутаність термінології, підходів, нормативів та правил щодо районування території країни. В Україні є галузеві районування, які базуються на принципах теорії районоут-

ворення, проте, більшість галузевих районувань ніяк між собою не співставлені і не співвідносяться. Принципи, які закладаються при проведенні галузевих рекреаційно-туристичних зонувань не завжди зкоординовані із нормативними документами, що існують в системі територіального планування. Результати аналізу наголошують на нагальності уніфікації термінології, визначеності із методичними підходами таксономічної класифікації та виділення таксонів в межах території країни. На сьогодні питання формування рекреаційного, туристичного, курортного просторів для цілей ефективного і раціонального природокористування та розроблення конкурентоспроможного національного туристичного продукту вирішуються без єдиного узгодженого рекреаційно-туристичного районування території України.

Ключові слова. туризм, рекреація, таксономія, таксономічні рекреаційні одиниці, районування, рекреаційно-туристичне районування

Introduction

Economic transformations in Ukraine, global financial crises, lack of funding for domestic tourism in our country require more efficient use of all opportunities for further rational management of available resources and develop an effective strategy for the industry as a whole.

According to UNWTO, during January-August 2020, international tourist travel decreased by 70% compared to 2019, when there were 1.46 billion tourist trips. The tourism sector has suffered losses of more than 700 billion USD, which is more than eight times higher than the recession caused by the global economic crisis in 2009 (WTObarometerrus, 2020). Military action in the Donbass and the occupation of the Crimean Peninsula led to the reorientation and opening of new tourism destinations, the COVID-19 pandemic showed the importance of domestic tourism. Its development in Ukraine has become increasingly important over the past 10 years.

Today's political-administrative, socio-economic realities in the development of Ukraine allow to review the existing methodological bases used for land division to solve applied problems of recreational geography, in particular, to formulate new approaches to land division for more effective planning of recreation and tourism in the whole country.

Decision-making in formulating strategies for the development of the recreation and tourism industry in Ukraine as a whole and its individual regions should be based on sound project planning of territories, which are expressed in the schemes of zoning and development of territories, including recreation. Particularly relevant issues addressed by zoning schemes are the formation of recreational, tourist and sanatorium spaces for the purposes of efficient and rational use of nature, development of ways for careful use of natural medical and recreational resources through the design of tourism development zones and resorts. In addition, development and zoning schemes become the basis for the development and implementation of a competitive national tourism product.

Methodological issues of determining the tourist, recreational, climatic and recreational potential of territories, typology of recreational areas and special division of territory in the field of tourism and recreation into territorial units are gradually beginning to be covered in development, scientific and applied, normative nature, geography and urban planning, health care, etc. from the 60s - 70s of the 20th century. Researches in the field of recreational division of territories, development of taxonomic recreational classification were carried out by Likhanov B., Preobrajenskij V., Vedenin Yu., Mukhina L. (1975), Panchenko T. (1990, 2005, 2009), Mazurkevich O., Mis`kij V. (1990) Rodichkin I. (1978), Shischenko P. (1989), Stauskas V. (1977), Bejdik O. (1997, 2004, 2009), Mokliak A. (2004), Matsola V. (1997), Danilova N. (1980), Pokolodna M. (2008, 2012) and other autors.

Issues of planning recreational areas in the world, their isolation and functioning in the land use system are revealed in researches and projects since the 1940s, in particular, Wehrwein G., Johnson H. (1948), Jim, C (1989), Hirt S. (2004), Caves R. (2005), Lefcoe, 2005, Hodge G., Gordon D. (2014), Baycan T., Nijkamp P. (2009) and other authors. In these studies, the world's zoning systems are reduced to the two largest groups, namely the American and Western European, which have significant differences. Also, the system of territorial zoning of China is singled out as a system that provides mechanisms for the allocation of particularly valuable lands (including agricultural), Japan, Hong Kong, etc. (C. Y. Jim, 1989, Cheung Darren Man-wai, Tang Bo-Sin, 2016, Hong Kong planning standards and guidelines, 2014). Existing zoning systems are primarily a tool for regional development planning for authorities at various levels and are considered as so-called legal zoning, as they primarily establish and regulate the rights of use of real estate and land resources.

The American zoning system is characterized by the highest degree of independence of local governments, the declaration of policy of strategic planning of socio-economic development is developed in one stage covering the entire territory and all its components (Wehrwein G., Johnson H., 1948, Hirt S., 2004, Lefcoe G., 2005, Hodge G., Gordon D., 2014).

The Western European zoning system is a set of national zoning systems that have certain, sometimes

fundamental, differences. For example, in the United Kingdom, territorial zoning is carried out only by local governments or unitary institutions and is coordinated in accordance with the regional development plan. Issues of planning of protected lands (national parks, reserves) are coordinated by the Organization of National Parks, in particular. Also, there are differences in taxa (classes or categories) of territorial division in different zoning systems (Caves R., 2005, Baycan T., Nijkamp P., 2009).

Analysis of sources related to the world practice of territorial zoning and land management showed that the basic approach to division is the normative method of territorial planning used by local governments (Caves, 2004; Lefcoe, 2005; Hirt, 2014), and the main criteria for zoning types of nature use are selected (recreational, water, forest, agro-, urban and other types of nature use) – "land use form" (Hirt, 2014). In accordance with the type of nature use and the nature of land ownership, users carry out zoning of territories based on the principles of sustainable development of society, term of use, nature and intensity of use, size of taxa, etc. Thus, in the world practice, territorial division (regardless of industry) is the zoning of the territory. Zoning is a method of spatial planning (urban planning, in particular) in which different levels of territorial governance (municipalities, Fish and Wilderness, Forest services or others) divide territorial resources into taxa, called zones (National Research Council, 2009; Hirt, 2014). Each of the taxa has a set of clear rules and regulations aimed at the strategic development of areas subject to zoning and which differs from other zones. During the implementation of zoning, the duration of allocation of zones (temporary, single-use, zones or steel, permanent use, zones, for example, residential, industrial, etc.) is taken into account and indicated. Zones also take into account the possibility of combining several compatible types of nature management, or in the case of zoning based on forms, different rules may regulate the density, size and shape of permitted use regardless the purpose (Hodge, 2014). The planning rules for each zone determine whether planning permission can be granted for a given site design for a specific use or not. Such zoning determines the direct and conditional use of land, and its rules determine the size of land into which the territory can be divided, the form and scale of design decisions. Zoning rules are established to manage the growth and development of areas (including cities) (Rodrigue, 2020).

The current state of zoning in Ukraine is based on the multifaceted definition of the concept and revolves around the legal regulation of zoning processes, tools and mechanisms for nature regulation and management. Numerous existing schemes (in particular, recreational) of the division of the country's territory and its individual regions indicate the confusion and diversification of terminology, approaches, standards and rules for zoning. In addition, in Ukraine there are numerous sectoral zoning, which are based on the principles of the theory of "zone making", however, most sectoral zonings are not compared and do not correlate. In addition, the principles laid down in the conduct of sectoral zoning are not always coordinated with laws and regulations that should regulate the system of spatial planning and often have a different interpretation of zoning. There are significant differences between sectoral zoning and schemes of territorial planning of recreation and tourism in Ukraine during the period of formation and existence of recreational geography, geography of resorts and tourism.

Thus, the general *purpose* of this article is to identify methodological differences in the existing schemes of recreation development planning and tourist and recreational zoning of the territory of Ukraine; clarification and description of basic approaches to zoning the territory of Ukraine for the purposes in order to optimize and manage the recreational and tourist activities. The *object* of this study is the existing, in *the field* of recreational geography and tourism, zoning of Ukraine to analyze zoning schemes of its territory and the allocation of taxonomic territorial units in order to optimize and manage the development of recreational and tourist activities.

Materials and methods of research

The information base of the study is legislative, normative documents, analytical and statistical materials of the World Tourism Organization, the National Tourism Organization of Ukraine, scientific publications of leading Ukrainian and foreign researchers on zoning, in particular, zoning to manage and optimize tourism and recreation. The study involves schemes for the development and allocation of resources for tourism and recreation, zoning schemes in Ukraine, in the field of recreation and tourism, which were carried out in the period from the 1960s to 2020s.

To achieve the goal of this study used methods of scientific analysis and synthesis, in particular, content method of analysis of geographic information in the study of existing theoretical and methodological approaches to zoning, research on the organization and functioning of recreational territorial entities, methods of comparative analysis of information, in particular, comparison and generalization of data on

the formation of the territorial structure of tourist regions, determination of the criterion basis for taxonomic classification of territorial recreational formations, during the systematization of the obtained data on existing world zoning systems and recreational and tourist territorial structure of Ukraine.

Results and its analysis

The successful development of recreational and tourism activities is due to a number of important factors, including effective audit and assessment of resource potential of territories for tourism and/or recreational activities, rational use of recreational and tourism resources based on clear schemes of spatial differentiation of regional resources, effective policy states in tourism support, etc. In Ukraine, the practice of zoning is defined as a way to regulate the environmental management and the function of territorial management. Ragionalization is carried out in order to optimize and manage recreational and tourism activities, which is coordinated and determined by legislative, normative documents of the regulatory sphere of territorial recreational and tourist planning allows to use the existing recreational and tourist potential of the regions and pursue a clear state policy in tourism and recreation, turning this area into an important source of both business development and filling the local and national budgets.

The best scientific meaning of recreational and tourist zoning is conveyed by Beidyk O.O. (1997), who proposes to consider such special zoning as the allocation of territorial division units (taxa), characterized by the structure of the resource base for the development of recreational activities, the specifics of development of recreational resources, activities in the field of preservation and protection of existing resources of the territory specialization in recreational and tourist services. Sectoral recreational zoning of territories should be aimed at coordinating the recreational and tourism industry with the system of nature management of the region as a whole, the existing features of the regional economy and so on (Bejdik, 1997). In Ukraine, the practice of special zoning is based on the following principles:

- constructiveness, which is determined primarily by the purpose of zoning;
- objectivity, which consists in the clarity of the criteria for allocating units of territorial division, mostly, of different ranks;
- hierarchy, which is determined by the levels of mutually subordinate different ranks of taxa;
- complexity, which consists in the complexity of zoning procedures for the purposes of optimization and management of recreational and tourist activities;

Regarding the regionalization of the territory for recreation and tourism, the domestic scientific literature, depending on the purpose and objectives, uses a branched, non-unified and confusing terminology - “recreational”, “resort”, “resort-recreational”, “tourism”, “tourist-recreational” and “recreational-tourism” etc. The last term, according to the authors, is the most appropriate, because it allows to take into account the specifics of recreation and tourism - the available resource base, differences in physical-geographical and socio-economic features, cultural and historical aspects (ethnography, cultural heritage attributes, etc.), economic potential of the territory, etc. Thus, according to the current scientific interpretations, recreational and tourism zoning is the division of territory into taxonomic levels, characterized by a certain recreational and tourist specialization.

One of the key points of sectoral zoning is the observance of clear subordination and hierarchy in the allocation of taxonomic units of zoning of territories. Different methods of taxonomic classification of recreational territorial formations coexist in the scientific literature. Thus, Shelomov M.P. (1975) identifies the following hierarchical levels: institution, complex, functional area, resort, district, region, country. Kotlyarov E.N. (1978) proposes the following hierarchy of taxonomic recreational units: republic (region) → district → recreational area → recreational subdistrict. Znamenskaya E.A. (1969) proposed another hierarchy of resort formations: sanatorium (resort) institution → resort complex → resort → resort district. The disadvantage of this taxonomy is the use of such concepts as “complex” and “district” when designating the ranks of resort formations. Zorin I.V., in the work “Diversity of territorial and recreational systems and its typification” (1975) proposes to adhere to the taxonomy, which is based on the notion of redistribution of management and service functions, the diversity of recreational activities. Based on the following principles, the author identifies 5 taxonomic levels of recreational territorial entities: enterprise → factory → compound → association → industry.

In our opinion, the most successfully taxonomic levels of recreational territorial formations are presented in the scientific works of Dolishny M.I., Nudelman M.S., Tkachenko K.V. (1984), who proposed the following hierarchy: recreational point → recreational center → recreational node → recreational subdistrict → recreational district. The similarity of the hierarchy of recreational formations is characterized by the development of Shablii

O.I.: recreational point → recreational center → recreational node → recreational area → recreational region → recreational zone (Shablii, 1994).

The combination of the last two taxonomic divisions allows us to propose the following hierarchy of recreational and tourism zoning: recreational and tourism institution → recreational and tourism point → recreational and tourism center → recreational and tourism area → recreational and tourism region, in which:

- Recreational and tourism institution is a single recreational or tourism facility that occupies a limited area (sanatorium, boarding house, recreation center, camp site, camp, etc.). Links to other objects are inconspicuous.

- Recreational and tourism point is a settlement of insignificant area, in which there is at least one recreational and tourism institution and defines one of its important functions.

- Recreational and tourism center is a set of recreational and tourism facilities located within the administrative boundaries of the settlement with a developed infrastructure (transport, services). Recreational and tourism center is characterized by the availability of resources in sufficient quantities for their effective use in the recreational and tourism sphere.

- Recreational and tourism area is an area where the natural recreational and tourism, historical and cultural potential is integrated with the social and economic infrastructure of the given territory.

- Recreational and tourism region is a key unit of zoning, covering several administrative and historical regions, natural areas and so on. This area is characterized by common climatic conditions, terrain, hydrological regime, historically formed settlement system and a single historical and cultural heritage.

A significant number of different zoning schemes of the Ukrainian territory for recreation and tourism coexist in the scientific circulation (presented in the Table 1).

Thus, the first attempts to zoning the territory of our state were made in the 60s of the 20th century. In particular, in the General scheme of location of sanatoriums and the list of resorts and medical areas of Ukraine (1961) for the first time on the territory of the former Soviet Union the resort possibilities of the territory were comprehensively studied and prospects of development of resort industry were defined. (360 settlements have been identified which have all the prerequisites for the development of the sanatorium-resort sphere) (Fig. 1 a).

In 1968, the scheme of placement resorts, places of mass recreation and tourism in Ukraine was a zoning of the territory with the definition of promising areas for the organization of recreational and tourism activities. When identifying the prospects of territories for recreation, it were studied the following: resort areas (in Zakarpattia, Lviv, Ivano-Frankivsk, Chernivtsi, Poltava, Odessa, Zaporizhzhia, Donetsk regions and the Autonomous Republic of Crimea); zones of mass recreation (mainly in the coastal zone of the main Ukrainian river - the Dnipro (middle and lower reaches), the Southern Buh (lower reaches), the Dniester (upper reaches), the Seversky Donets and the Desna); suburban green areas (around regional centers, the largest is around Kyiv); monuments of nature and culture (objects of national importance) (Mis`kii, Panchenko, Mazurkevych, 1990).

Mukhina L.I. (1973) carried out the grading of the natural and geographical provinces of the USSR under the conditions of the organization of summer recreation (beach and bathing spots without sea-shores). The south and south-east of our state received

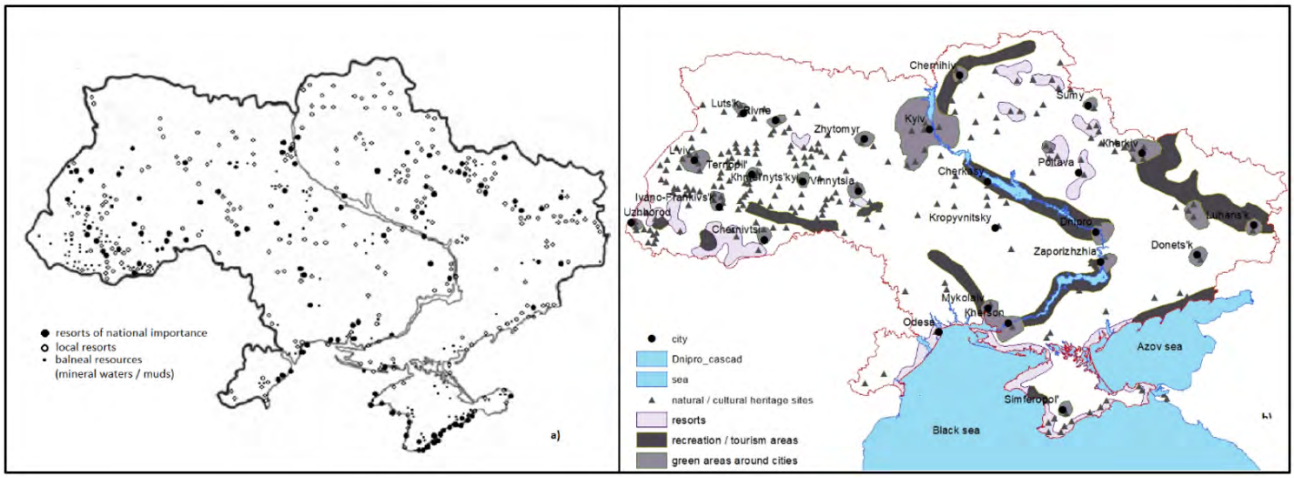

Fig.1 a) Scheme of location of national, local resorts and sources of medicinal mineral waters and muds on the territory of Ukraine (1961); b) Scheme of location of resorts, places of mass recreation and tourism in Ukraine (1968).
Source: made by the authors based on the Mis`kii, Panchenko, Mazurkevych, 1990

Table 1. The main schemes of Ukraine zoning for tourism purpose (all developments in the table are given in the original language)
Source: made by the authors based on the results of their own research

Year	The name of the scheme (in the original language)	Author (-s)
1961	General layout of sanatorium and health institutions and a list of resort and medical areas in Ukraine	Giprograd
1968	Layout of resorts, places of mass recreation and tourism in Ukraine	Urban Planning Institute of Research and Design
1975	Rating of natural-geographical provinces of the USSR under the conditions of organization of summer rest	Muhina L.I.
1975	Recreational zoning of the territory of the USSR	Institute of Geography of the USSR Academy of Sciences (led by Probrazhens`kii V. and Lihanova B.)
1977	Duration of a comfortable period in the USSR for summer recreation and tourism (in days)	Danilova N.A.
1978	Location scheme of regional recreational systems	Rodich`kin I.D.
1979	The scheme of development and placement of resorts, recreation and tourism places, natural parks and reserves in the USSR, including the Ukrainian SSR	Urban Planning Institute of Research and Design
1983	Scheme of perspective development of tourism in the Ukrainian SSR	Giprograd
1983	Regional scheme for the development and placement of resorts, recreation and tourism sites, natural parks and reserves in the Ukrainian SSR	Urban Planning Institute of Research and Design, Giprograd
1985	Recreational zoning of the USSR	Pirozhnik I.I.
1985	Tourist zoning of the USSR	Zorin I.V. and others
1987	Tourism regionalization of the USSR	Krachylo M.P.
1989	Geographical and recreational zoning	Geographical encyclopedia of Ukraine
1989	Recreational and climatic zoning	Kyiv State University - Faculty of Geography
1991	Consolidated scheme of the regional planning of Ukraine. Section: Natural and recreational territories of Ukraine	Giprograd, Urban Planning Institute of Research and Design
1994	Comprehensive recreational zoning of the territory of Ukraine	Shablii O.I.
1996	Tourism zoning of Ukraine	Institute of Tourism of the Ukrainian Trade Unions Faderation (Krachylo M., Popovych S., Fedorenko N.)
1997	Recreational and tourism zoning of Ukraine	Beidyk O. O., Liashenko D.
2001	General scheme of planning of the territory of Ukraine (Development of health and recreational network)	Dipromisto, Urban Planning Institute of Research and Design
2004	Recreational zoning	Lukianova, Tsybukh
2004	Recreational and tourism zoning of Ukraine	Smal` I. I.
2004	Rating resource-recreational zoning of Ukraine	Beidyk O. O.
2004	Tourism zoning	Mokliak
2006	Geospatial organization of recreational economy	Staphiichuk V.I.
2008	Recreational zoning	Masliak P.O.
2008	Tourism and recreational zoning	Pokolodna M.M.

the highest point in this rating, which is 5, on the suitability of natural conditions for the organization of recreational and tourism activities. (Mukhina, 1973)

Since the mid-1960s, scientists have begun to pay considerable attention to the study of territorial recreational systems - as the basic units of development of the recreational economy and the centers of territorial division. Thus, Zorin`s map of "The demand Areas" was compiled (Zorin, 1975). The study was conducted on the basis of a survey of citizens, their preferences and desires to relax in a particular region. Demand was calculated per 1 000 inhabitants. According to this study, the Crimean Peninsula, North-Western and Western regions of Ukraine are characterized as having a low demand − 10-49. The Black Sea coast is characterized by demand − 100-199. The central and eastern regions of Ukraine are characterized as having the highest demand − 200-1000. This was one of the first marketing studies of the tourism in the Soviet Union (Zorin, 1975).

At the same time, one of the first zonings of the territory of the USSR was carried out for the purpose of recreation under the leadership of V. Preobrazhensky and B. Likhanov (1975). The results of the analysis of natural and socio-economic conditions, as well as the results of the study of historically formed recreational enterprises were the basis of recreational zoning. The main criteria for allocating the boundaries of recreational areas in this zoning were the following:

- the degree of the development of the network of recreational systems;
- density of recreational enterprises;
- the role of recreational enterprises in meeting the needs for recreation and health in the country.

Based on this approach in the USSR in 1975, it was proposed to allocate 4 recreational areas. The territory of Ukraine fell into 1 and 2 recreational zones, within which 4 recreational districts were allocated in the territory of Ukraine − Crimean, Azov, Odessa and Dnieper-Dniester, within the last one the Carpathian recreational district was separated (shown in the Figure 2a).

able periods in the Soviet Union in order to organize summer recreation and tourism. According to the results of the study, the duration of the comfort period (temperature range of 22-25 °C) in Ukraine was determined and it was found that the duration of comfort increases from north (45 days) to south (85 days) (Danilova, 1980).

In 1978, I.D. Rodichkin proposed a layout of regional recreational systems (shown in the Figure 2b). According to this scheme on the territory of Ukraine the author identified 9 regional recreational systems: Kyiv-Dniprovs`k, Volyn`, Seversko-Donets`k, Prydniprovs`k, Pryazovs`k, Odesa-Chornomors`k, Dniester-Buz`k, Carpatian and Crimea. It is clear from this scheme that the author has only identified the areas suitable for the development of recreational and tourism activities (Rodichkin, 1978).

The Scheme of the development and location of resorts, places of recreation and tourism, nature parks and reserves (1979) and the Scheme of the perspective development of tourism of the Ukrainian SSR (1983) (Mis`kii, Panchenko, Mazurkevich, 1990) are

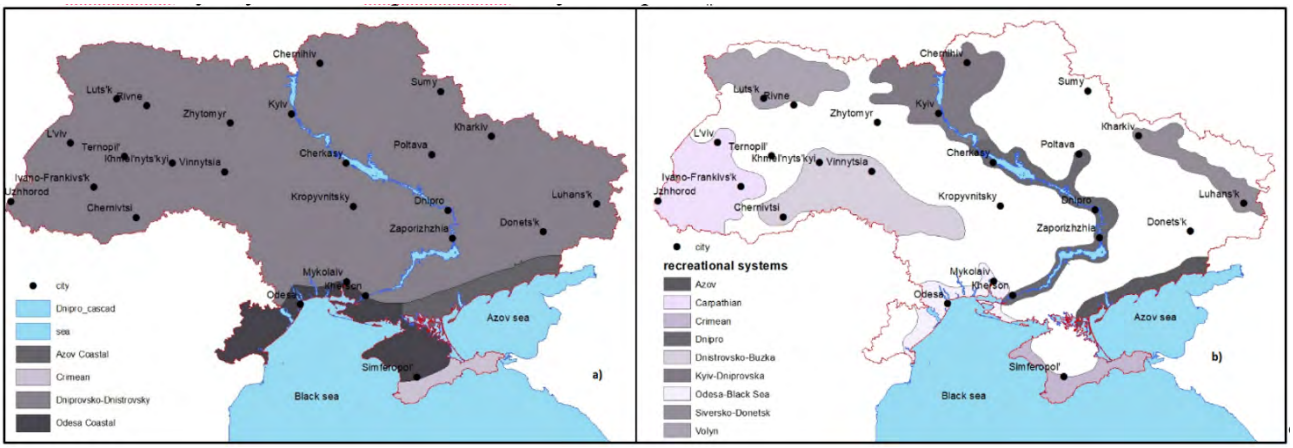

Fig. 2. a) Scheme of recreational zoning within modern Ukraine, 1973; b) Scheme of regional recreational systems of Ukraine, 1978. Source: A) compiled by the authors on the basis of the map "Scheme of recreational zoning of the USSR" on the V. Preobrazhenskii, B. Likhanov., 1975; B) compiled by the authors on the basis of the schema`s of Rodichkin I., 1978

Also, this work presents the characteristics of territorial recreational systems, which coincided with the boundaries of certain areas in Ukraine and differed in a certain specialization. Thus, Odesa, Crimea, Azov and Dnieper-Dniester were characterized by health specialization, and Carpathian − sports and health. The importance of this zoning was that it became the impetus for further studies of territorial differentiation and this zoning was the basis for territorial divisions, according to recreational criteria, until the late 80's of the 20th century. (Preobrazhenskii, Likhanov, 1975) Recreational zoning of V. Preobradzhenskii and B. Likhanov was specified by Pirozhnik I.I. in 1980.

In 1977, N.A. Danilova conducted climatological and recreational studies of the duration of comfort-

also noteworthy. According to T.F. Panchenko, 7 regions and 100 resorts of all-Union significance were allocated on the territory of Ukraine in the scheme of 1979. During such a thorough study in 1983, a comprehensive assessment of tourism resources was carried out and on the basis of estimated data 4 tourism regions (Carpathian, Polissya, Dnipro and Azov-Black Sea) and 35 tourism regions were identified (Panchenko, 2009).

The Kyiv Research Institute of Urban Development with the participation of the Dipromisto Institute (1983) developed a regional scheme for the development and location of resorts, places of recreation and tourism in the Ukrainian SSR (Mis`kii, Panchenko, Mazurkevich, 1990). At that time, the integral resort

and recreational system of the Republic of Ukraine was divided into 5 major territorial systems: Western (8 oblasts - districts), Central (6 oblasts), Southern (4 oblasts), Northeast (4 oblasts) and South-Eastern (3 oblasts). Taxa in the development of the scheme of division of the territory of Ukraine were represented by resort and recreational regions → resort and recreational areas → individual resorts → recreation areas. The largest taxa - resort and recreational regions - were identified on the basis of the most valuable resort and recreational resources, which were concentrated in the same type of natural and geographical systems (including mountains, river basins, sea coasts). By importance, they were divided into regions of union-republican and republican significance (Mis`kii, Panchenko, Mazurkevich, 1990).

Pirozhnik I.I., in 1985, finalized the recreational zoning of Preobrazhensky V. and Likhanov B. with a view to clarifying the boundaries of recreational areas. The key idea of the author was to coordinate recreational zoning, economic zoning and administrative-territorial division. Another important aspect of the revised zoning of 1985 is the analysis of the recreational economy in the context of significant economic areas, highlighting the recreational subregions within them. Accordingly, the author identified the Southern recreational area with 3 subdistricts in the territory of Ukraine − Odessa, Azov and Crimea and the Dnipro-Dniester recreational area. In addition, the author gave a detailed description of recreational subregions (Pirozhnik, 1985).

In the same year, 1985, in the All-Union Research Laboratory for Tourism and Excursions, the tourist zoning of the USSR was developed under the leadership of Zorin I.I. The following were adopted as district-forming features:

1) the degree of development of tourism and its material base;

2) the place of the district in the inter-district division of labor of tourist enterprises;

3) basic tourist functions.

The basis of zoning were 5 tourism zones, which in turn were divided into 31 tourism districts with leading tourist and excursion centers. The study of GNI tourism and excursions was not limited to the development of only a zoning scheme. For each district, the functions of tourism, district specialization, level of development and prospects for development were determined. Subsequently, this development and the results of the study were used in the development of a promising industry scheme for tourism development until 2000. According to the tourism zoning of Zorin I.V. the following districts are distinguished on the territory of Ukraine: Crimean (center - Sevastopol), Ukrainian Primorsky (center - Odessa), Ukrainian-Moldavian (center - Kyiv) and Carpathian (center - Lviv). (Zorin, 1985)

A significant contribution to the methodology of tourist zoning was made by Krachylo M.P., who in 1987 also developed a scheme of tourism zoning of the Soviet Union. Basing on the tourism zoning in 1987, the author identified the proposed wider range of criteria, in particular:

1) the territorial structure of the current state of tourism organization;

2) the share of employees in the tourism industry from the total number of employees;

3) the nature of the links of tourism services with other sectors of the economy;

4) the level of development of the tourism industry;

5) availability of tourist resources;

6) economic and geographical location;

7) modern and long-term needs of the population in tourism services.

On the basis of these criteria in the territory of Ukraine Krachylo M.P. identified 5 tourist areas - Crimean, Azov, Odessa, Dnipro-Dniester and Carpathian (shown in Figure 3a). (Krachylo, 1987)

The zoning of the territory of Ukraine proposed by the specialists of the Faculty of Geography (1989) is based on geographical principles, and the criteria chosen are the physical and geographical parameters of the territory and their spatial differentiation, but climatic and landscape recreational conditions were identified as the key criteria. This zoning was called recreational-climatic and divided the territory of Ukraine into 6 recreational-climatic districts: Western, Central, Eastern, Southern, Crimean and Transcarpathian.

The Ukrainian Geographical Encyclopedia, 1989, offers a comprehensive recreational zoning of the territory of Ukraine. Complex recreational zoning of 1989 represents the division of Ukraine into 4 recreational regions, in particular, the Carpathian, Crimean, Dnipro-Dniester, Azov-Black Sea → 8 recreational areas, namely, Odessa, Priazovs`ky, Feodosiya, Yalta, Evpatoria, Dnipro, Prydniprovs`ky, Prydnistrovs`ky, 7 recreational subdistricts, in particular, Sudak, Yevpatoria, Feodosia, Black Sea, Crimea, Alushta, Yalta. Taxa of recreational regions include subsystems of long-term and short-term rest, sanatorium treatment and tourism, and management subsystems that include services, transport of economic areas. On average, the recreational capacity of the regions in this zoning ranges from 1.5 to 2.0 million vacationers (summer vacation). Recreational regions are due to a spatial combination of features

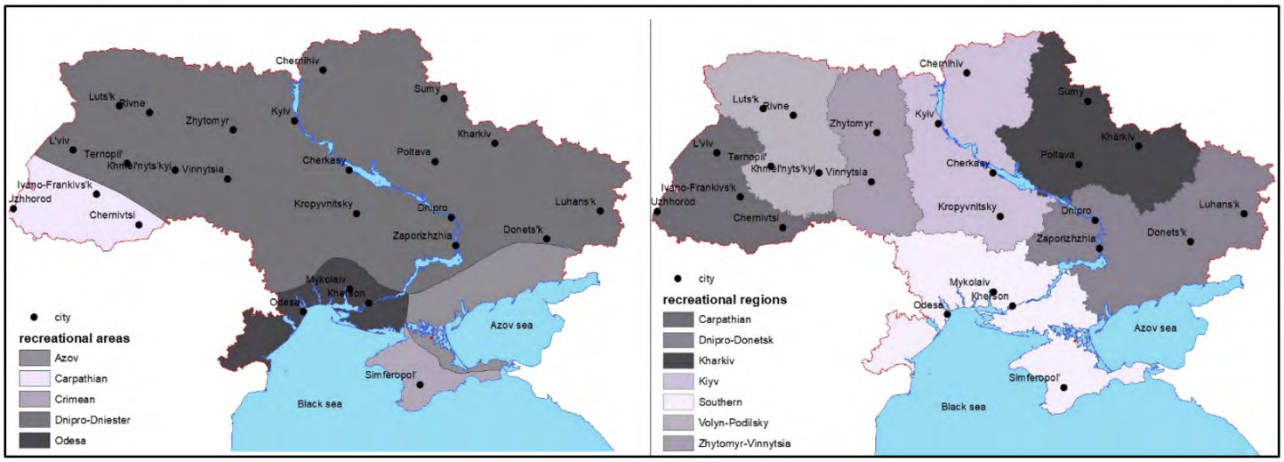

Fig. 3. a) Scheme of tourism zoning within the modern Ukraine, 1987. b) Tourism zoning of Ukraine, 1996
Source: A) compiled by the authors on the basis of the schema`s "Tourist zoning of the USSR. Zones and districts", 1987; B) done by the authors on the basis of the schema`s Krachylo, Popovich`, Fedorenko, 1996

and factors that determine the existence of regions: the presence of recreational landscapes, medical resources, tourism resources, sufficient transport networks and infrastructure, economic and social ties with areas of concentration, etc. (Geographical encyclopedia, 1989).

Shablii O.I. (1994) developed a meaningful comprehensive recreational zoning of the territory of Ukraine based on the availability of recreational resources, analysis of the flow of vacationers, material and technical base. Shablii offered 4 recreational areas: Black Sea-Azov, West-Ukrainian, Central-Ukrainian, Polissya. Recreational zones are proposed to be considered territorial units that are characterized by common natural, historical, cultural, socio-economic resources, typical infrastructural relationships and so on. Recreational areas, in this zoning of Shablii subordinate 9 recreational regions, in particular, the Crimean, Western Black Sea, Eastern Black Sea, Carpathian, Roztochia-Opilia, Prydniprovs`ky, Prydnistrovs`ky, Podilia, Donets`k. Within the Eastern Black Sea region, Berdyans`k district is distinguished, within the Polissya region - Transcarpathian recreational district. (Shablii, 1994).

The tourism zoning of Ukraine (presented in Figure 3 b) proposed in 1996 by the Institute of Tourism of the FPU is based on the study of climatic, historical, cultural, socio-economic conditions and resources, development of tourism in Ukraine and performed for territorial and administrative regions. The authors proposed zoning identified 7 tourist regions: Carpathian, Volyn`-Ternopil`, Zhytomyr-Vinnytsia, Kyiv, Kharkiv, Dnieper-Donets`k and South. (Krachylo, Popovich`, Fedorenko, 1996)

Recreational and tourism zoning of Ukraine in 1997 (presented in the Figure 4a), proposed by Beidyk O.O. and Liashenko O.D. divides the territory into 6 recreational and tourism areas: Carpathian, Polissya-Podilsky, Kyiv-Dnieper, Donetsk-Dnipro, Black Sea and Crimean.

Recreational and tourism zoning of Ukraine (1997) was carried out by the authors in accordance with:

- analysis of the share of recreational areas in the land structure (as a percentage from the area);
- analysis of the number of places in organized recreation facilities;
- analysis of the presence of centers (cores) of districts;
- analysis of recreational and tourism specialization of the territory in the national division and integration of labor;
- analysis of the common areas of use of recreational and tourism resources.

This zoning was also carried out on the basis of the current territorial and administrative division of the country. For territorial-administrative regions of Ukraine, in addition, the following indicators were determined:

a) the share of potential recreational areas in the land structure (up to 20, 20-30, 31-50 and more than 50),

b) the number of places in organized recreation facilities, in this case sanatoriums and boarding houses with treatment and houses and rest boarding houses (1-2, 3-5, 6-10, 11-25 and more than 99 thousand units). (Beidyk, 1997)

Later, in 2004, Beidyk O.O. conducted an assessment of potential and current recreational and tourist resources of Ukraine. Assessment of recreational and tourist potential of territorial-administrative regions of Ukraine was conducted in 7 blocks: geopolitical, natural, natural-anthropogenic, architectural-historical, infrastructural, biosocial and event. The results of a comprehensive analysis and assessment of recreational and tourist resources

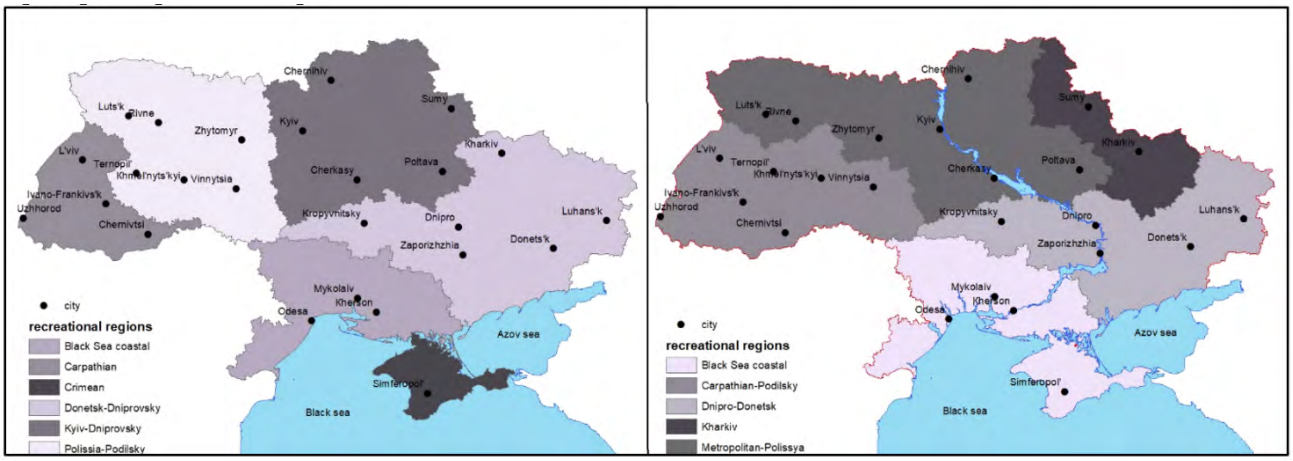

Fig. 4. a) Scheme of recreational and tourism zoning of Ukraine, 1997; b) Scheme of rating recreational and tourism zoning of Ukraine, 2004

Source: A) done by authors based on the schema`s of Beidyk and Liashenko, 1997; B) done by the authors based on the schema`s of Beidyk, 2004

are the basis for ranking regions and their grouping (by rating): very high → high → medium → low → very low. This rating grouping is reflected in the scheme of ranking recreational and tourist zoning of Ukraine (presented in the Figure 4 b). The scheme of ranking recreational and tourism zoning of Ukraine distinguishes 5 districts: Black Sea (core - Odessa, very high rating); Carpathian-Podolsky (core - Lviv, high rating); Polisko-Stolychny (core - Kyiv, average rating); Kharkiv (core - Kharkiv, low) and Prydniprovsko-Donetsk (core - Dnipro, very low). (Beidyk, 2009)

Smal` I.V., in 2004, proposed a scheme of recreational and tourism zoning of Ukraine with the allocation of 5 recreational and tourism macro-districts - Polissya, Western, Central-Eastern, Primorsky and Crimean. The criteria for this zoning are:

- structure and capacity of recreational and tourist potential (natural and socio-historical);
- the presence of elements supporting recreational and tourist framework;
- index of territorial localization of recreational and tourist activity objects;
- results of branch recreational zoning;
- results of groupings of territorial-administrative units of Ukraine (according to the level of development of accommodation establishments);
- intensity of tourist flows within the administrative-territorial units. (Smal`, 2004).

In the study of Mokljak A.V. (2004) tourism zoning should be carried out for the purpose of regional planning and forecasting of tourism development, optimization and management of rational use of tourist resources of territories, etc. (Mokljak, 2004). In his study, the author identified 13 tourism regions within Ukraine:

1) Azov with Mariupol` and Melitopol` subregions in the structure;
2) Volyn` with Lutsk-Volodymyr and Rivne-Kremenets` subregions in the structure;
3) Dnipro with Kyiv and Cherkasy-Kremenchuh subregions in the structure;
4) Dniester with Ivano-Frankivsk-Chernivtsi and Kamyanets-Mohyliv subregions in the structure;
5) Zaporizhzhia independent tourism region;
6) Carpathian with Drohobych, Kolomyia and Transcarpathian subregions in the structure;
7) Crimean with Kerch, Simferopol, Evpatoria-Rozdolnyansky subregions in the structure;
8) Podilsky with Ternopil, Khmelnytsky, Vinnytsia subregions in the structure;
9) Polissya with Kovel and Sarny subregions in the structure;
10) Roztochans`k-Hologors`k with Roztochansky, Holohorsky subregions and the subregion of the city of Lviv in the structure;
11) Slobozhansky region with Izium, Kharkiv, Sumy subregions in the structure;
12) Chernihiv-Sivers`k independent tourism region;
13) Black Sea with Odessa, Mykolayiv, Kherson subregions in structure.

Stafiychuk V.I., in 2006, considered the regional features of the geospatial organization of the recreational economy of Ukraine, but in terms of socio-geographical areas: Volyn`, Carpathian, Podols`k, Capital, Northeast, Central, Dnipro, Donets`k, Black Sea, Crimea. The proposed view of zoning for recreational purposes is quite successful. The scheme proposed by the author is aimed at coordinating the development of the recreational economy with other sectors of the national economy.

The scheme of geospatial organization of recreational economy of Stafiychuk V.I. is designed to ensure the optimal functioning of recreational systems. The defined network of socio-geographical areas most successfully reproduces the territorial differentiation of recreational potential of Ukraine, as administrative areas that fall within public areas are characterized by common features of the current state of the resort economy, development programs, trends and patterns of recreational development. recreational resources (Stafiychuk, 2006).

Maslyak P.O. in the work "Recreational Geography" (Maslyak, 2008) proposed an alternative scheme of recreational zoning, where on the basis of ethnographic, recreational, physical-geographical and socio-economic features and within the administrative division of Ukraine distinguishes the following recreational areas:

1) Southern recreational area, which includes in its territorial structure the coastal territories of Odessa, Mykolaiv, Kherson, Zaporizhzhia and Donetsk regions, coastal and mountainous parts of the Crimea. The southern recreational area subordinates 3 subdistricts: Western, Crimean, Eastern.

2) Carpathian recreational area, includes the territories of Lviv, Ivano-Frankivsk, Zakarpattia and Chernivtsi regions. The Carpathian recreational area subordinates 3 recreational subdistricts: Precarpathians, Carpathians, Transcarpathia.

3) Polissya recreational area covers the northern part of Ukraine.

4) Right-bank upland forest-steppe recreational area, which in ethnographic terms includes Podillya, part of Volyn` and Kyiv region.

5) Left-bank forest-steppe recreational area, which according to the natural landscape is divided into the Dnipro lowland with the Poltava plateau and spurs of the Central European Upland in Kharkiv and Sumy regions.

The steppe recreation area covers the territory from the south of the border with Moldova and to the east to the border with Russia.

In 2008, Pokolodna M.M. proposed a scheme of tourism and recreational zoning of Ukraine. Tourism and recreational zoning was carried out taking into account the following features:

- the degree of development of the recreational industry in the area;
- the nature of tourism specialization;
- the level of tourism and recreational development of the territory;
- common perspective development of the district;
- combinations of tourist resources;
- intensity of tourist flows.

The result of the division were 6 tourist and recreational areas, namely, Carpathian, Polissya-Podols'k, Dnieper, Donetsk-Slobozhans'k, Black Sea, Crimean). This zoning of the territory of Ukraine differs in that the boundaries of taxa correspond to the boundaries of territorial-administrative units and, thus, unite the administrative entities of Ukraine (Pokolodna, 2008).

Conclusion

The analysis indicates significant differences in the methodological basis of taxonomization and separation of recreational territorial units. As a rule, in world practice, formal approaches to the allocation of territorial units have been and are being applied to the implementation of divisions. Territorial allocations are distinguished in accordance with the forms of nature management, taking into account the legal regulations in the field of land use and the relations of the subjects of natural resources use. In Ukraine, until recent times, the theory of zoning prevailed in scientific developments on zoning, and there was a coordination of resource potentials at the level of administrative areas (except for individual developments that coordinated the development of the recreational sphere with the socio-geographical division). In contrast to scientific works, applied engineering and design developments exist in the form of draft planning schemes and were developed according to nominal approaches to the construction of plans and schemes of territorial development in the field of recreation and tourism. Most of these schemes are developed in the form of frame models of recreational and tourism facilities. Recently, given the strong decentralization reform, cluster analysis methods have been used to allocate territorial units for zoning, in accordance with the regulatory rules in the field of land relations on the ground and the compliance of local schemes with the territorial division of the regional and national level. There are significant differences between sectoral zoning and territorial planning schemes for the development of recreation and tourism in Ukraine during the period of formation and existence of recreational geography, geography of resorts and tourism. The existing schemes of recreational and tourism division of the territory of the country and its separate regions indicate the confusion of terminology, approaches, standards and rules for zoning the territory of the country. In addition, in Ukraine there are sectoral zoning, which is based on the principles of the theory of zoning,

however, most sectoral zonings are not compared and do not correlate. The principles laid down in the conduct of sectoral recreational and tourism zoning are not always coordinated with regulations aimed at regulating the system of spatial planning.

Thus, as a result of the analysis of the existing work, in the field of typology and taxonomy of recreational areas, recreational zoning of the territory of Ukraine, the following conclusions can be made:

- the available results of scientific, scientifically applied researches indicate a tangible recreational and tourist potential of our country, which is formed by all available natural, historical, cultural and socio-economic resources;

- in fact, for decades of research activities in the field of recreational and tourism zoning, formed an information basis for the implementation of the target cadaster, in particular, the compilation and lists of discrete tourist and recreational facilities (resorts, monuments of tangible and intangible cultural heritage, including those with protection status, natural monuments and other objects of the NPF), which are supplemented by attributive descriptions and specifications, descriptions and recreational and tourism assessments of integral regional units and tourism frameworks of territories, etc.;

- in fact, all developments in the field of tourist and recreational division of Ukraine exist either in the form of comprehensive zoning schemes with generalizations on the spatial distribution of individual resources and differentiation of areas by recreation and tourism zones or in the form of specialized schemes of state planning documents on strategic directions of tourism and recreation / resorts development, etc.;

- existing zoning developments are quite heterogeneous in the context of generalization of elements of division schemes (schematic allocations of taxa or detailed drawing of the spatial-planning structure of the territory);

- the urgent issue in zoning is the definition of methodological approaches to harmonize the elements of the recreational and tourism sphere with the territorial and economic structure of the country, as well as the decentralization processes taking place in all spheres of the country's activity;

- the results of the analysis allow to emphasize the urgency of unification of terminology, definition of methodological approaches for taxonomic classification and methods of taxon allocation within the country (its regional units) and harmonization of other legal aspects of recreational nature, in particular, land relations in resource use recreation, tourism and resorts, relations in the field of restoration and protection of recreational resources, etc.

Today the issues are: a) formation of recreational, tourist, sanatorium and resort spaces for the purposes of efficient and rational use of nature, b) development of ways of careful use of natural medical and recreational resources through design of tourism development zones and resorts, c) development of competitive national tourist product - are solved and implemented without a single support agreed between specialists in the field of scientific and engineering of spatial planning schemes, recreational and tourism zoning of the territory of Ukraine.

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The green infrastructure within the framework of a compact city concept (by example of Kyiv)

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Abstract. The goal of the study is to determine the actual areas and the geographical distribution of Urban Green Spaces (UGS) in Kyiv; compile and analyse the ratings of the city administrative districts by key UGS indicators and substantiate the level of comfortable living in each district according to the concept of a green compact city. The goal stems from the announcement of an official strategy of transforming Kyiv into a comfortable compact city with an attractive green infrastructure. To achieve this goal, we have calculated a number of major indicators of the modern green infrastructure of Kyiv in all ten city districts. According to the method we developed, we analysed the drawings of the urban development master plan and regulatory documents, and conducted a field survey of significant UGS sites in Kyiv. The data obtained were used to make a UGS map of Kyiv and other thematic maps. For the most accurate calculation of key UGS indicators, we processed several thousand contours in Kyiv's cartographic base. The sizes of Urban Protected Areas (UPA) were found separately, and their share in the total city territory and of each district (Conservation Coefficients) was determined. In so doing, UPA distribution was found to be very irregular, with a total area of 174.9 km^2, or about 21.2% of that of Ukraine's capital. We analysed the ratio of the city population and the areas of green spaces in each Kyiv district. To identify districts with a different UGS coverage, we calculated the Greenness Coefficients (GC) and compiled a rating of Kyiv districts by their level of greenness, using the Greenness Coefficients Index. Significant GC variations in different city districts were substantiated. In contrast to previous studies, we calculated the provision of Kyiv residents with green zones of not merely common usage, but also with those of all other kinds, including UPA. We also calculated the Green space provision per person and compiled ratings of Kyiv districts by the Green Space Provision Index. The results were presented on a relevant map. Based on calculating the share of protected areas in the total UGS area, we found the ratings of Kyiv districts by the Green space legally protected Index. Wherein, we found significant variations among the districts by the ratio of protected areas and green spaces deprived of any legal protection. This increases their vulnerability to projected development attempts. We calculated the Integral Green Space Index (GSI) based on processing all significant UGS indicators of Kyiv. GSI allows for an integral assessment of the condition of the Urban Green Infrastructure (UGI) in Kyiv, and it is the key criterion of its compliance with modern requirements to an ideal compact city. Holosiivskyi District received the highest GSI rating. It is uniformly replete with UGS, which are provided for quality recreation and, at the same time, are protected by environmental legislation. Solomianskyi District received the lowest rating, and almost all the elements of its existing UGI require a cardinal optimisation. As a whole, the indicators we calculated can create an illusion of adequate provision of Kyiv with UGS. Actually, they are distributed very irregularly in the majority of districts. The results of our study are indicative of the presence of many challenging locations that require an extension of existing UGS and the development of new ones pursuant to the principles of compact city planning. Since UGI planning depends on the implementation of the Urban Development Master Plan, it makes sense to include the Green Space Index to the key indicators of the Kyiv Development Strategy. The draft new City General Plan should also be refined with account of the above-mentioned problems.

Keywords: Urban Green Spaces, Urban Green Infrastructure, compact city conception, green space provision per person, Green Space Index, rating of Kyiv districts

Зелена інфраструктура в рамках концепції компактного міста (на прикладі Києва)

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Анотація. Мета дослідження – з'ясувати реальні площі та географічний розподіл міських зелених зон (МЗЗ) Києва, скласти і проаналізувати рейтинги адміністративних районів за основними індикаторами МЗЗ та обґрунтувати рівень комфортності проживання у кожному з них відповідно до концепції компактного зеленого міста. Актуальність дослідження пов'язана з офіційним проголошенням переходу Києва до нової стратегії розвитку в рамках концепції компактного міста з привабливою зеленою інфраструктурою. В процесі виконання поставленої мети розраховано низку важливих показників сучасної зеленої інфраструктури Києва, які в різних районах міста істотно відрізняється. Проаналізовано креслення діючого і проектованого

Генеральних планів міста, нормативні документи, проведено натурне обстеження визначних МЗЗ Києва. На основі отриманих даних створено низку тематичних карт. Окремо визначено площі міських природоохоронних територій (ПОТ) та розраховано їх частку в загальній площі міста і районів (коефіцієнти заповідності). ПОТ загальнодержавного і місцевого значення розподілені містом дуже нерівномірно, а їх загальна площа становить 174,9 км^2, або майже 21,2% столиці України. Також встановлено частку ПОТ у складі зелених зон різного призначення та обґрунтовано значні відмінності районів Києва за рівнем захищеності їх зелених насаджень. З'ясовано співвідношення чисельності населення і площі зелених зон всіх видів у кожному районі Києва. Для ідентифікації районів з різним охопленням МЗЗ використано коефіцієнти озеленення, за якими в кожному районі визначено відповідні індекси. На основі отриманих результатів складено рейтинг районів Києва за рівнем озеленення. Також оцінено забезпеченість кожного мешканця Києва зеленими зонами не лише загального користування, але й усіх інших видів, включаючи ПОТ. Після опрацювання всіх значущих індикаторів визначено інтегральний індекс зелених зон (ІЗЗ) як головний критерій відповідності Києва та його окремих районів сучасним вимогам до компактного зеленого міста. На основі цього складено рейтинг районів, за яким перше місце посів Голосіївський район, найбільш рівномірно насичений зеленими зонами, більшість з яких охороняються законом. Найнижчий рейтинг має Солом'янський район, який значно відстає від решти районів за усіма розрахованими показниками і тому потребує кардинального оновлення майже всієї існуючої зеленої інфраструктури. Результати дослідження певною мірою спростовують уявлення про достатню забезпеченість Києва зеленими зонами та їх захищеність. Наведені розрахунки свідчать про необхідність розширення існуючих і створення нових МЗЗ в багатьох проблемних локаціях відповідно до принципів планування компактного міста.

Ключові слова: міські зелені зони, міська зелена інфраструктура, концепція компактного міста, забезпеченість зеленими зонами на людину, індекс зелених зон, рейтинг районів Києва

Introduction

In the end of the past century, the concept of city sprawl lost its standing and even became an obstacle to sustainable urban development, with discussions still being held. The concepts that are being gradually transformed into a policy of developing green compact cities have got a growing support worldwide. In 2018, roughly 55.3% of the world population (4.22 billion people) lived in urban localities. Of these, 1.7 billion people (23% of the world population) lived in million-plus cities. By 2030, the expected urban population will grow to 60%, with every third person living in a city with a population of at least a half of a million (The World's Cities in 2018). Cities account for roughly 70% of global carbon dioxide gas emission and for the highest concentration of atmospheric pollution and waste. Twenty-seven world metropolitan cities, with a population of over 10 million, produce 12% of the world waste (Gonçalves, 2018). Urbanisation results in depletion and degradation of ecosystems, a declining resistance to climate changes, and a loss of substantial ecosystem services in cities and around them. The adverse consequences of prolonged urbanisation are more pronounced in countries with a low level of economic development and with no strategic planning of urban land usage.

The result of intense search for a model of sustainable urban planning was the green compact city – the ideal one preferred worldwide. It is characterised by closeness, mixed land usage and an attractive green infrastructure. In this case, the significance of urban greening increases considerably, and it becomes a resource for urban development. This means that the natural components of a city become its integral part, capable of overcoming the contradictions and conflicts among all other components, rather than simply being a compensation for the technogenic consequences of urbanisation. Green space is a fundamental part of sustainable city development. It facilitates air cleaning, climate control, and improvement of landscape quality (Tappert et al., 2018).

Until recent times, cities worldwide were urbanised without account for such indicators as air pollution, CO_2 emission, acoustic pollution, and green zones. Currently, they are the priority factors and an essential part of integrated strategies of urban planning. Green urban zones (Pardo, 2019) are valuable assets that are instrumental in reducing healthcare costs, mitigating climate changes, and increasing land productivity and energy effectiveness. Protected areas in big cities, irrespective of the adverse impact of urbanisation on their biodiversity, enjoy certain advantages of their management, in particular, access to political power centres and state financing (McNeely, 2001). In this case, parks, woodlands and other natural territories within city boundaries can be the drivers of urbanisation by attracting population and stimulating housing development around them (Brambilla & Ronchi, 2016).

Urban Green Space (UGS) usually includes all the green space within city boundaries (forests, parks, private orchards, trees and bushes along railway tracks, and so on) irrespective of the form of ownership. The provision of city residents with UGS is usually assessed by several indicators, the key ones are UGS availability, accessibility and attractiveness. Various variants of UGS usage are most often linked to their management features, economic constraints, spatial planning, legal and social norms, and preferences of the residents (Biernacka & Kronenberg, 2019). One of the major practical aspects of UGS development is not the achievement of a particular indicator per capita, but rather the development of dif-

ferent models of green city planning. Limited areas for greenery call for the development of alternative concepts of modern city planning, in particular, the Urban Green Infrastructure (UGI), nature-based solutions, biophilic urbanism (e.g., Singapore), sponge cities (Shanghai in China), forest cities, edible green infrastructure, eco-urbanism and landscape urbanism (Russo & Cirella, 2018).

The main goal of the policy of sustainable development of a compact city is the protection of the urban environment from inevitable degradation in case of urban sprawl. A high quality of living in compact cities can be ensured by development densification with simultaneous preservation of greenery within residential districts and the city as a whole. Accounting for the contradictions between the need of compact development, on the one hand, and preservation of green zones, on the other hand, the landscape planning of such cities uses the concepts of ecosystem services and a green infrastructure. An important principle of planning the UGI of a compact city is its overall integration into the "grey" infrastructure, i.e. housing or other development, roads, utility services, and so on (Artmann et al., 2017). In the event of insufficient greenery, city residents will experience a substantial curtailment of important ecosystem services. Hence, the underpinning of planning green compact cities should be the integration of the concepts of reasonable growth and the urban green infrastructure (Artmann et al., 2019).

Successful implementation of the compact city concept involves an integrated approach to sustainable development, i.e. achieving a trade-off between development densification and the quantitative and qualitative greening of city districts. The goal of development densification is to counteract the adverse consequences of urban sprawl under conditions of ineffective land management. In particular, loss of green spaces due to urban development concentration can be compensated by improving the quality of plantation (Haaland & Bosch, 2015). Urban sprawl will inevitably lead to a growing demand in such ecosystem services as clean air and the opportunity of outdoor recreation because presently these services are provided largely by suburban green zones (Baró et al., 2016).

Nowadays, cities worldwide are investing more and more funds in the UGI. An example of an ideal compact city is Ljubljana, Slovenia. It was the winner of the European Green Capital nomination of 2016. The city has 542 m^2 UGS per resident. Over 46% of the city's territory is covered with natural forests, and all the UGS covers 75% of the city total area (Ljubljana – winner 2016 European Green Capital, 2016). The Portuguese capital Lisbon has become the Green Capital of Europe of 2020, focusing on creating an UGI and associated greenery chains. In Lisbon, 76% of the residents live within 300-metre access to UGS (European Commission: Lisbon is the 2020 European Green Capital Award winner). Urban forests are the basis of the UGI, and they improve the environmental footprint of a city. Apart from woodlands, urban forests include city and district parks, private greenery, groups of trees and separately standing trees in squares, sports grounds, parking spaces, streets, and so on. With proper management, forests facilitate an increasing resilience of city landscapes. The ecosystem approach to their management is focused to maximising carbon capture from the atmosphere (Salbitano et al., 2016). For instance, London's UGI includes over 1.5 million trees and bushes in parks, gardens, forests and open spaces, which provide the residents with important ecosystem services. The cost of these services within city boundaries is estimated at about 60 million pounds sterling annually (Rogers et al., 2015).

The majority studies' results demonstrate that the distribution of greenery is closely linked to the geographic location and the city's historical development. With no single method for determining population provision with UGS, a variety of indicators is used, and their number is increasing (Le Texier et al., 2018). UGS is an important part of the public space of a city and often it is the only opportunity for urban residents to have accessible daily contact with the nature. Planning the UGI is still a relatively new instrument of the European Union's policy, whereas it has just started to originate in Ukraine. Studies dedicated to modern approaches to urban environment greening are also scarce. In practice, neither the UGS concept, nor the UGI are used. The current classification of greenery also fails to contribute to implementing advanced urbanistic concepts (Yukhnovskyi & Zibtseva, 2018). Positive changes have occurred over the past two years: The First All-Ukrainian Forum "The Green Infrastructure of Ukraine's Cities" was held and the first interactive map for planting trees was presented in Kyiv.

The ***purpose of the study*** is to determine the actual areas and the geographical distribution of UGS, analyse the ratings of Kyiv's administrative districts by key UGS indicators and substantiate the level of comfortable living in each of them according to the results obtained within the framework of the concept of a compact and green city.

Material and methods

Kyiv was chosen as the subject of the study not only because it is the capital and the biggest city

in Ukraine. Kyiv's territory is confined to the strip of contact of two landscape zones and the Dnipro River valley. Landscapes of the mixed forest type are common in the northern, north-western and western parts of the city. They are predominantly elevated terrace plains and slopes with turf-podzolic and turf soils that was formed under pine and oak-pine forests. The remaining city territory is covered with landscapes of the broadleaved woodland type. They are elevated accumulation-denudation loess plains and slopes with grey and dark-grey soils formed under fresh oak groves. Kyiv's left bank is abundant in old terrace alluvial plains with turf-podzolic soils formed under dry and fresh coniferous forests. In the north and south, the city's territory is traversed by inundated and insular landscapes with sod and meadow soils under grass-mixed cereal meadows.

In 2017, Kyiv was acknowledged the greenest European capital among metropolitan cities with a population of over 2 million. By the Normalized Difference Vegetation Index (0.389), Kyiv was far ahead of Berlin (0.246) that was placed second by the Capital Greenness rating (Gärtner, 2017). However, since that time, Kyiv has lost its positions because many green zones were alienated for development. Due to this, the environmental conditions in the city have deteriorated considerably. The official policy of transforming Kyiv to a compact and green city in practice facilitates the legalisation of chaotic development.

Kyiv has a special status in the system of the administrative-territorial structure of Ukraine as the main political, administrative, scientific, and cultural and tourist centre. It is the site of central state government bodies, municipal and regional administrative bodies, and diplomatic missions of foreign states. The city has valuable natural landscapes and an historical-and-cultural legacy of worldwide significance. An important advantage of the city is its geostrategic location on the crossroads of major economic and transport links. At the same time, uncontrollable development of the city territory leads to degradation of valuable natural landscapes and contraction of recreation zones, with the ecological situation being deteriorating dramatically. Exceeding the ultimate amounts of available development resources is creating risks for the preservation of a comfortable urban environment.

The city is divided into ten administrative districts, significantly differing in size (Table 1). The biggest district among them is Holosiyivskyi, and the smallest one is the Pecherskyi district (Fig. 1). Kyiv's permanently settled population as of 01.03.2020 was 2.925.700 and the actual population is 2.966.900 (Ofitsiinyi sait Holovnoho upravlinnia statystyky u m. Kyievi, 2020). Solomianskyi district has the biggest permanent population and Pecherskyi district has the smallest one. The average population density in Solomianskyi district is roughly six times higher than that in the least populated Holosiyivskyi district (Fig. 2). These indicators are extremely important for determining the provision of residents with UGS, which significantly varies in different districts of the city.

The algorithm of our study consists of a chain of consecutive actions focused to achieving the goal (Fig. 3). We analysed the drawings of the effective Kyiv Development Master Plan and the one being elaborated, the regulatory documents of the Kyiv City Council, the registries of public recreation zones, OpenStreetMap (OSM) and Google Map geospatial data, and conducted a field survey of significant UGS sites in Kyiv. This helped create a UGS map of Kyiv, other supplemental maps and fill them with

Table 1. Territorial and demographic indicators of Kyiv and administrative districts (as of 1.03.2020)

Districts of Kyiv	Area, km^2	Population, persons	Average population density, persons per km^2	
Holosiivskyi	155.59	252.553	1.623	Low
Desnianskyi	141.396	366.624	2.592	
Darnytskyi	127.846	340.928	2.667	
Obolonskyi	108.484	316.299	2.915	
Sviatoshynskyi	102.455	336.787	3.287	Medium
Dniprovskyi	68.678	356.982	5.198	High
Podilskyi	34.555	204.871	5.929	
Pecherskyi	19.77	158.468	8.016	Very high
Shevchenkivskyi	26.11	210.959	8.079	
Solomianskyi	40.579	381.218	9.394	
Kyiv (total)	825.463	2.925.689	3.544	

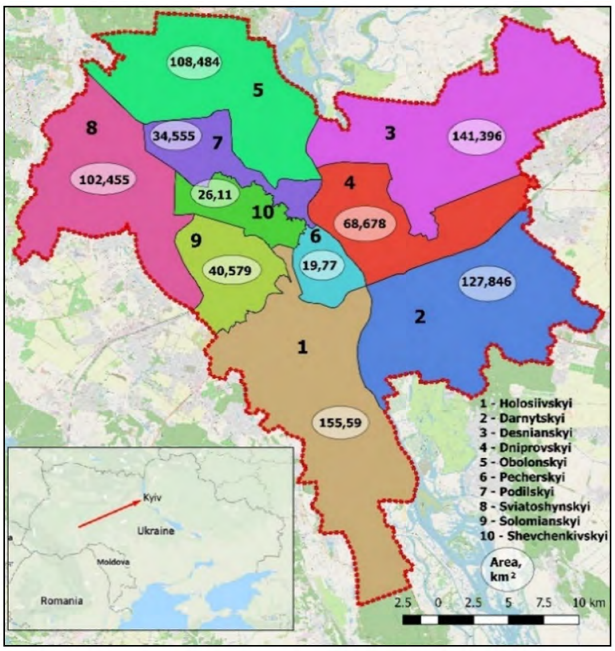

Fig. 1. Administrative districts of the Kyiv city

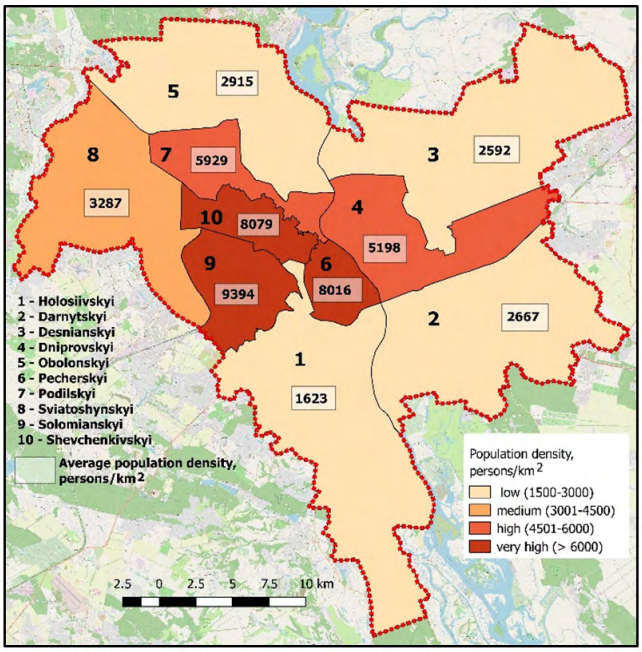

Fig. 2. Population density in the Kyiv city

relevant content. When creating the maps, all the thematic layers of spatial data were uploaded into the QGIS environment reduced to a unique cartographic projection. This is required for correct representation of topological data and accurate calculation of attributive characteristics. The result of overlay analysis was the creation of a polygonal shapefile containing the contours of all UGS within city boundaries, including the territories and sites of the nature reserve fund of statewide and local significance.

Having obtained the cartographic base of Kyiv UGS, we calculated the actual geometric characteristics of the UGS using a Field calculator. Using the collation maps method, this enabled compiling a series of thematic maps with representation of key UGI indicators. The information content of these maps was taken from our own calculations of Kyiv UGS and those of its individual administrative districts.

For the most accurate calculation of key UGS indicators, Greenness Coefficients, Green Space Coefficients, the Green space legally protected and the City Nature Index, we processed 3.548 contours within Kyiv boundaries. The land area of Urban Protected Areas (UPA), a part of the city UGS, was

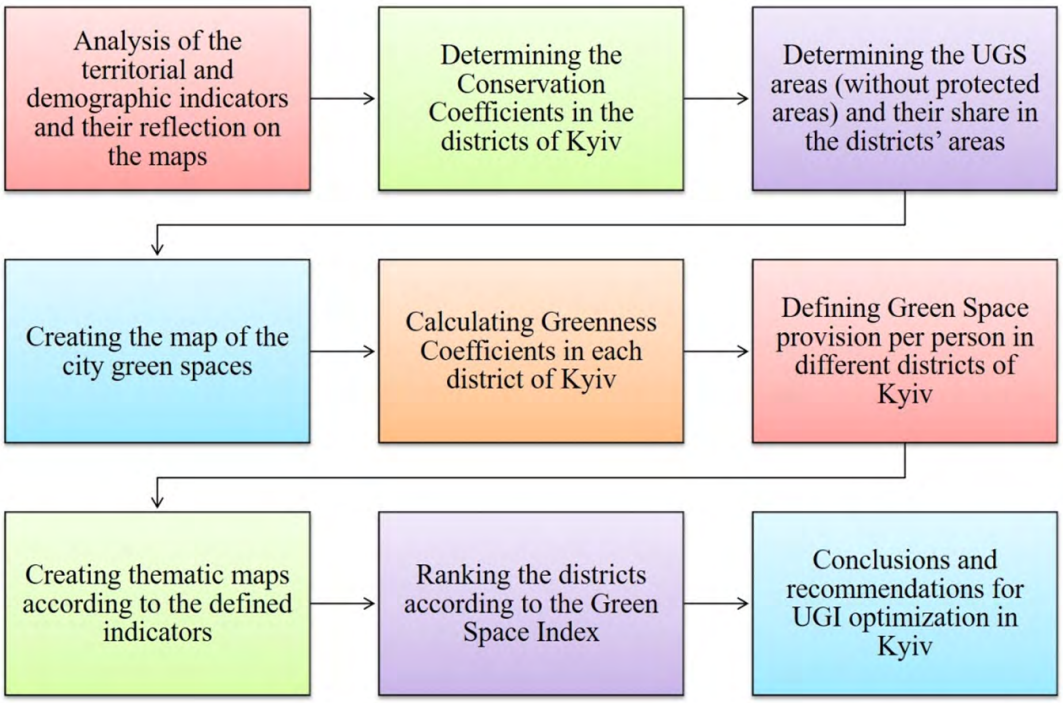

Fig. 3. Research algorithm of the Kyiv Urban Green Infrastructure

determined separately. For this, we calculated 146 contours of varying size (Table 2). UPA of statewide and local significance are distributed across the city very unevenly, with the total area of 174.9 km^2, or about 21.2% of Ukraine's capital area. The main indicators that represent UPA's share in the total area of each district are the Conservation Coefficients.

Table 2. Urban Protected Areas within the Kyiv city

Districts of Kyiv	Area, km^2	UPA, k^{m}2	Number of contours	The average area of the contour, km^2	Conservation Coefficients, %
Solomianskyi	40.579	0.398	6	0.066	0.98
Darnytskyi	127.846	4.007	4	1.002	3.13
Desnianskyi	141.396	4.573	7	0.653	3.23
Dniprovskyi	68.678	5.940	22	0.270	8.65
Shevchenkivskyi	26.110	2.858	23	0.124	10.95
Pecherskyi	19.770	2.317	11	0.211	11.72
Podilskyi	34.555	4.149	18	0.231	12.01
Obolonskyi	108.484	31.53	9	3.503	29.06
Holosiivskyi	155.590	64.108	32	2.003	41.20
Sviatoshynskyi	102.455	55.034	14	3.931	53.72
Kyiv (total)	825.463	174.914	146	1.198	21.19

We also processed 3.402 contours for determining the areas of all kinds of UGS with the exception of protected areas (Table 3). The number of contours and their average areas vary depending on districts' areas. The total area of UGS within Kyiv boundaries is about 277.9 km^2. In different city districts, the UGS size varies drastically. In this case, Greenness Coefficients characterise the UGS share in the entire territory of the districts. It is calculated by dividing the total area of each district by the UGS area in this district, without accounting for the UPA area.

Since UGS are spread across the city very unevenly, their geographic location is of important practical significance. Even under the condition of presence of big areas, UGS can be concentrated only in one part of a district. Districts with different UGS covering are identified using Greenness Coefficients (GC), which characterise the percentage quotient of dividing the UGS area on the total area of Kyiv districts. Then, the Greenness Coefficients Index (GCI) is found for each district. The reference GCI value for the city as a whole is taken to be a unit, and the GCI of each district is found from the formula:

$$GCI_d = \frac{GC_d}{GC_c}, \quad (1)$$

where GCI_d – district GCI, GC_d – district GC, GC_c – total city GC.

Then, district ratings by the greenery level are found. Based on the results obtained, the priority districts for planning an expansion or optimisation of the Kyiv UGI can determined.

Table 3. Urban Green Spaces of the Kyiv city (without UPA)

Districts of Kyiv	Area, km^2	UGS (without UPA), km^2	Number of contours	The average area of the contour, km^2	Greenness Coefficients (without UPA), %
Desnianskyi	141.396	91.400	291	0.314	64.64
Darnytskyi	127.846	76.379	396	0.193	59.74
Dniprovskyi	68.678	26.374	331	0.080	38.40
Obolonskyi	108.484	37.654	413	0.091	34.71
Podilskyi	34.555	6.124	165	0.037	17.72
Solomianskyi	40.579	5.605	432	0.013	13.81
Holosiivskyi	155.590	19.146	461	0.042	12.31
Sviatoshynskyi	102.455	11.069	376	0.029	10.80
Shevchenkivskyi	26.110	2.380	349	0.007	9.12
Pecherskyi	19.770	1.751	188	0.009	8.86
Kyiv (total)	825.463	277.882	3,402	0.082	33.66

The green space provision per a person (GSPP) characterises the ratio of the number of population and the areas of UGS of all kinds in each Kyiv district. This indicator is the quotient of dividing the district UGS area on the permanent number of residents in the same district. Likewise, having accepted the GSPP value as a basic one for the city as a whole, the formula (2) is used to calculate the Green Space Provision Index (GSPI) for each district:

$$GSPI_d = \frac{GSPP_d}{GSPP_c}, \quad (2)$$

where $GSPI_d$ – district GSPI; $GSPP_d$ – district GSPP; $GSPP_c$ – total city GSPP.

Green space legally protected (GSLP) characterises the ratio of available UPA and the total UGS area in different Kyiv districts. GSLP is the percentage quotient of dividing UPA on the total UGS area of a district. Next, the Green space legally protected Index (GSLPI) is found for each district. The reference GSLPI value in the districts is accepted to be this index for the city as a whole. Then GSLPI for each district is found from the formula:

$$GSLPI_d = \frac{GSLP_d}{GSLP_c}, \quad (3)$$

where $GSLPI_d$ – district GSLPI; $GSLP_d$ – district GSLP; $GSLP_c$ – total city GSLP.

Having processed all significant indicators, the integral Green Space Index (GSI) is determined as the key criterion of compliance of Kyiv and of all of its districts with current requirements to a compact and green city. It directly affects the level of comfortable living in the city and in its separate districts. The GSI for each district is found from the formula:

$$GSI_d = GCI_d + GSPI_d + GSLPI_d, \quad (4)$$

where GSI_d – district GSI; GCI_d – district GCI; $GSPI_d$ – district GSPI; $GSLPI_d$ – district GSLPI.

Results and their analysis

According to the Goals of sustainable development in Ukraine, one of the tasks of the goal 11 is providing overall access to urban green zones open to all residents (Sustainable Development Goals in Ukraine, 2016). One of the five key priorities of the Kyiv Development Strategy up to 2025 is an environmentally clean and green city. The latest version of the Strategy has an updated life comfort index with the following indicators: emission of pollutants to the atmosphere, share of disposed waste in their total volume, area of nature reserve lands and provision of residents with green zones of common usage. However, the weight coefficient of the "Eco policy and environmental control" sector in the calculation of the life comfort index is merely 7% (The Kyiv Development Strategy Until 2025 new version, 2018). The condition of Kyiv's green zones and their spatial distribution depends directly on the implementation of the Urban Development Master Plan. Starting from 1958, when Kyiv became a million-plus city, its annual residential growth exceeded 50.000. This made the city a powerful industrial and scientific centre. The most balanced planning document in Kyiv's history was the Master Plan of 1967, according to which urban development was about equally allocated to both Dnipro banks. The last draft Master Plan of Soviet times was not implemented because of the Chernobyl NPP nuclear accident in 1986. It provided for abandoning the concept of the radial-ring urban structure and expanding the city boundaries extensively to the north and south (Palekha, 2017).

After Ukraine had gained independence, the drafting of a new quality Kyiv Development Master Plan continued for ten years. At the time of its approval in 2002, the city area was 835.5 km^2, including a development area of 339.3 km^2 (40.6%). The Master Plan provided for increasing the greenery area of common use by 232.000 ha – from 529.000 to 761.000. Accordingly, its provision for residents had to grow from 20.3 to 28.7 m^2/person in 2020 (Heneralnyi plan mista Kyieva na period do 2020 r. Osnovni polozhennia, 2001). However, during less than ten years, this indicator dropped to 18.5 m^2/person (at a norm of 20 m^2/person). Big greenery zone areas were destroyed for housing development, thereby having curbed the opportunity of developing a compact urban planning structure. Failing to meet many planning indicators and the many violations of Master Plan 2020 stimulated the initiation of a qualitatively other strategy of the capital's spatial development. The chief goal of elaborating a new version of the Master Plan, among other things, was to create a comfortable and safe urban environment. If earlier Kyiv was actively incorporating suburban territories, then now the city's area had to remain unchanging. This meant that "compactness" was to be the underpinning of the principles of sustainable development of the capital. In the new version of the Master Plan, increasing the population's provision with greenery was planned more prudently – from 18.5 to 23.5 m^2/person in 15-20 years (Heneralnyi plan mista Kyieva. Osnovni polozhennia, 2015).

Presently, a new draft of the Kyiv Development Master Plan up to 2040 has been worked out. It has been officially disclosed to the public for discussion.

The draft plan envisages to finally abandon a substantial expansion of the city by incorporating surrounding inhabited localities, and to focus efforts on developing a comfortable compact city based on its resources and potential. By 2040, the plan is to increase UGS areas of common use by 23.000 ha and create 36 new parks and 17 buffer parks, predominantly in new residential districts. The planning also provides for adding eleven new sites to the existing nature reserve fund (NRF) and expand the territory of the Holosiyivskyi National Natural Park (NNP) to 126.000 ha (Ofitsiinyi sait komunalnoi orhanizatsii «Kyivhenplan». Proiekt Heneralnoho planu mista Kyieva, 2020). However, some experts perceive the new project as an attempt to legalise the many new developments and the detailed plans of territories approved in disregard for the Master Plan in effect (Titamyr, 2020). Therefore, before submitting the draft plan for appraisal, prior to its final approval by the Kyiv City Council, it must be reviewed thoroughly.

Since 2005, the Kyiv City Council has been trying to come to a suitable decision on determining the city planning parameters for the formation, functioning and development of an UGS chain. First, a five-year Program of development of the Kyiv green zone was approved and then it was prolonged three times, without ever being executed in full scope. The key tasks of this Program included an inventory of all UGS within city boundaries and a prolongation of the moratorium on alienation of land plots from the territory of the city's green structure. The Program has not been executed to date and the inventory has yet again been prolonged. Common use of UGS in Kyiv include five categories: recreation and entertainment parks, recreation parks, specialty parks, public gardens, and boulevards. In 2018, most parks were located in the Holosiyivskyi (23%) and Dniprovskyi (20%) districts of Kyiv. The smallest number of parks was in the Sviatoshynskyi (3%) and the Podilskyi (1%) districts (Vakulyk, 2018).

The effective Program of ecological well-being of Kyiv for 2019-2021 provides the increasing of the provision of common use of UGS from 22.0 to 23.5 m^2/person (Ofitsiinyi veb-sait Kyivskoi miskoi rady. Pro zatverdzhennia Kompleksnoi miskoi tsilovoi prohramy ekolohichnoho blahopoluchchia mista Kyieva na 2019-2021 roky, 2018). This document states that the area of all kinds of UGS is 565.000 ha, or 67.4% of the city's territory (Table 4). 216.000 ha of it are located within urban development limits. The UGS structure includes 111 parks, 466 public gardens, 59 boulevards and 326.000 ha of urban forest, the territory of which has thirty-seven recreation zones. However, these data turned out to be significantly overstated as compared to the draft Kyiv Development Master Plan data and the indicators that we have calculated in this study.

New state building standards (SBS) were put into effect in Ukraine in 2019. They envisage imposing restrictions on development in green, landscape and recreation zones. "Green lines" should help in determining the areas of all common use of UGS, recreation woods and urban forests, and of NRF sites. In other words, local self-administration bodies should approve the green lines in the master plans of inhabited localities and detailed plans of territories. The structure of common use UGS area, including big parks with an area of over 100 ha and urban forests with an area of over 500 ha, should involve no less than 10% of the total UGS area. The time of transport access to city parks should be within 20 minutes, and to those of district ones, no more than 15 minutes

Table 4. Distribution of green spaces by districts of Kyiv (as of 2018)

Districts of Kyiv	Green spaces area, ha						
	Parks	Small parks	Boulevards	Prospectuses	Squares	Streets	Others
Holosiivskyi	495.4	46.1	61.7	79.1	27.9	71.4	225.8
Darnytskyi	154.5	39.6	1.5	25.8	5.0	68.8	1,044.0
Desnianskyi	504.7	11.4	3.2	27.3	–	73.6	517.4
Dniprovskyi	483.2	30.3	27.0	14.9	1.5	45.9	52.6
Obolonskyi	177.5	117.7	12.8	20.9	–	125.7	100.7
Pecherskyi	211.2	7.2	14.2	–	1.5	59.0	53.7
Podilskyi	173.5	25.6	2.3	18.6	–	50.3	566.1
Sviatoshynskyi	60.3	51.7	13.1	37.3	–	131.6	441.4
Solomianskyi	180.6	53.3	11.3	18.2	-	86.7	205.9
Shevchenkivskyi	379.2	41.7	7.2	2.6	–	93.0	32.8
Kyiv (total)	2,820,1	424.6	154.3	244.7	35.9	806.0	3,240.4

Source: Ofitsiinyi veb-sait Kyivskoi miskoi rady. Pro zatverdzhennia Kompleksnoi miskoi tsilovoi prohramy ekolohichnoho blahopoluchchia mista Kyieva na 2019-2021 roky, 2018

(Derzhavni budivelni normy Ukrainy. Planuvannia ta zabudova terytorii, 2019).

For a detailed analysis of the current condition of UGS in Kyiv and its separate districts, we plotted on the map all the UGS within city boundaries, irrespective of the form of their ownership (Fig. 4). This helped calculate the total UGS area, which is 452.8 km^2, or 54.8% of the entire city territory. We also determined UGS areas and calculated the Greenness Coefficients for each of the ten capital districts (Table 5). As a result, the Greenery level leaders are Park, with an area of 219.4 ha, located on the Dnipro islands among bedroom communities. Sviatoshynskyi district was the runner up by this rating owing to the Sviatoshynsko-Bilychanskyi urban forest. It is the northern branch of the single in Ukraine urban Holosiyivskyi NNP. Obolonskyi district, third by the GCI rating, is the site of the Pushcha-Vodytsia oak-pine forest, part of which has the status of a reserve of statewide significance. Darnytskyi district was the fourth in the ratings of districts by the greenery level, and it is one of the oldest and biggest districts in Kyiv.

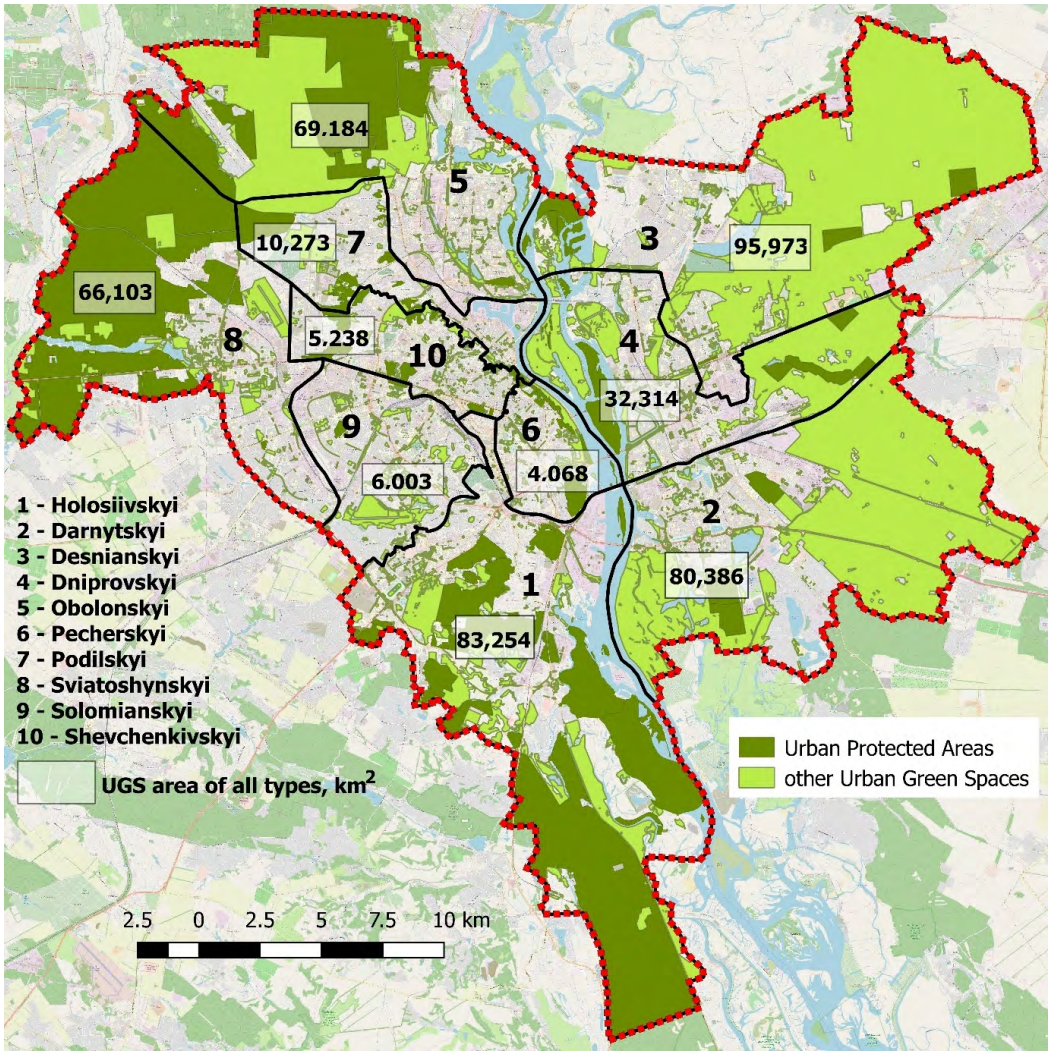

Fig. 4. Urban Green Spaces of the Kyiv city

the Desnianskyi (67.9%), Sviatoshynskyi (64.5%), Obolonskyi (63.8%) and Darnytskyi (62.9%) districts of Kyiv. The smallest greenery level is found in the densely populated Solomianskyi district where the UGS covers only 14.8% of its territory (Fig. 5).

The primacy of Desnianskyi district by the Greenness Coefficients Index is due to the presence on its territory of eleven recreation and entertainment parks, over thirty public gardens and a big urban forest. The biggest and the best known one is Muromets On one side, it is surrounded by a forest, and on the other one, it flanks the Dnipro River. The district has five big parks and the Osokorkivski Luky landscape reserve with an area of 148 ha and unique wetlands. At the same time, Darnytskyi district is distinct from other ones by the presence of densely developed residential blocks and industrial enterprises, in particular, chemical and pharmaceutical ones, which results in its substantial environmental degradation as a whole.

As expected, Solomianskyi district had the lowest GCI, with the main UGS being concentrated in its southern part. The biggest UGS is the Pronivshchyna stow located in the upper reach of the Sovka River. This historical locality has been preserved in a natural ravine, the greater part of which has been developed. In addition, Solomianskyi district is the most densely populated one in Kyiv.

A somewhat different rating of Kyiv districts was found by the Green Space Provision Index. It was calculated with account of UGS of all kinds, including urban forests and UPA in each district (Table 5). Population figures were taken from the official website of the Chief Statistics Department in Kyiv. Holosiyivskyi district has the biggest GSPP (329.65 sqm per a person) because it has the biggest area and the smallest population (Fig. 6). Desnianskyi district was the runner up where each resident is provided, on the average, with 261.78 sqm of green spaces. Darnytskyi district was the third with an index of 235.79 sqm per a person. Obolonskyi district, with the fourth rating, also has a high index. Solomianskyi district has the lowest rating (15.75 sqm per a person), with the densest population and an area about four times smaller than that of the Holosiyivskyi district. Hence, the GSPP in the Solomianskyi district is smaller by more than twenty times.

Table 5. Main indicators and ratings (R) of Urban Green Spaces in the Kyiv city

Districts of Kyiv	UGS, km^2	GC, %	GCI	R	GSPP, sqm/pp	GSPI	R	GSLP, %	GSLPI	R	CGSI	R
Holosiivskyi	83.254	53.51	0.98	5	329.65	2.13	1	77.0	1.99	2	5.10	1
Darnytskyi	80.386	62.88	1.15	4	235.79	1.52	3	4.98	0.13	9	2.80	5
Desnianskyi	95.973	67.88	1.24	1	261.78	1.69	2	4.76	0.12	10	3.05	4
Dniprovskyi	32.314	47.05	0.86	6	90.52	0.58	6	18.38	0.48	7	1.92	8
Obolonskyi	69.184	63.77	1.16	3	218.73	1.41	4	45.57	1.18	5	3.76	3
Pecherskyi	4.068	20.58	0.38	8	25.67	0.17	8	56.96	1.47	3	2.02	6
Podilskyi	10.273	29.73	0.54	7	50.14	0.32	7	40.39	1.05	6	1.91	9
Sviatoshynskyi	66.103	64.52	1.18	2	196.28	1.27	5	83.25	2.16	1	4.60	2
Solomianskyi	6.003	14.79	0.27	10	15.75	0.10	10	6.63	0.17	8	0.54	10
Shevchenkivskyi	5.238	20.06	0.37	9	24.83	0.16	9	54.56	1.41	4	1.94	7
Kyiv (total)	452.796	54.85	1.00		154.77	1.00		38.63	1.00		3.00	

Sviatoshynskyi district is the undisputable leader among Kyiv districts by the Green Space Legally Protected Index. Its protected areas occupy 83.25% of all UGS. It locates the Sviatoshynskyi-Bilychanskyi woodland with an area of 6.463 ha. Since 2014, it has the status of a national natural park of statewide significance. The predominant greenery comprises lucent oak groves, oak-pine and pine forests including many valuable plant species listed in The Red Book of Ukraine (TRBU). The most common TRBU species are *Lilium martagon* L., *Carex umbrosa* Host, *Epipactis helleborine* (L.) Crantz, *Neottia nidus-avis* (L.) Rich) (Pryadko et al, 2014). Besides, the Sviatoshynskyi urban forest, with an area of 240 ha, is located in the Sviatoshynskyi district.

As expected, Holosiyivskyi district was the runner up by the GSLPI rating because the share of protected areas in its UGS structure is 77%. Four of the five branches of the Holosiyivskyi NNP are located in this district: the Lisnyky stow, the Bychok stow, the Teremky stow and the Holosiyivskyi Forest with the total area of 4.525.52 ha. There are rare species included in TRBU and the IUCN Red List, such as the common snowdrop (*Galanthus nivalis* L., 1753), the two-leaf squill (*Scilla bifolia* L., 1753), the violet helleborine (*Epipactis purpurata* Sm., 1828), the broad-leaved helleborine (*Epipactis helleborine* (L.) Crantz, 1769), the martagon lily (*Lilium martagon* L., 1753), etc. (Onyshchenko et al., 2016). The smallest GSLP share belongs to the Darnytskyi (4.98%) and Desnianskyi (4.76%) districts located on Kyiv's left bank. Among right-bank districts, the last place in the rating belongs to Solomianskyi district with a GSLP of 6.63%. In other words, in three Kyiv districts, the UPA share is less than 7% of the total UGS area. This dramatically downplays the perspectives of preserving the natural component of urban landscapes in these districts and worsens their attractiveness in terms of living comfort.

By summarising the processed ratings, we can calculate the integral Green Space Index, allowing for an integrated evaluation of the UGI in all ten Kyiv districts. As evident from Table 5, Holosiyivskyi district received the highest GSI (5.1) and the runner up was Sviatoshynskyi district. Both these districts are

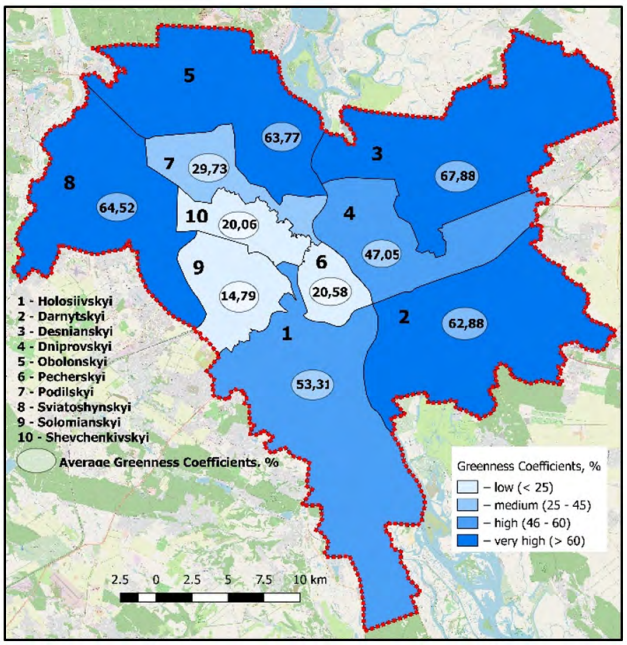

Fig. 5. Greenery levels of Kyiv districts

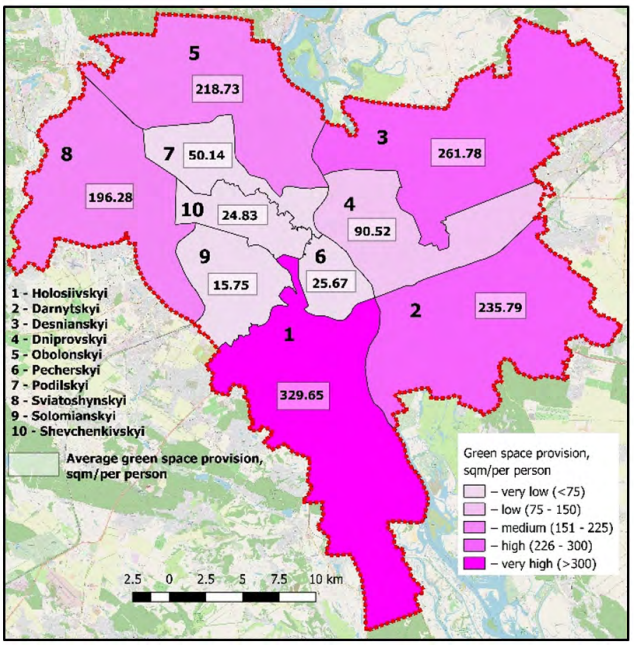

Fig. 6. Green space provision in Kyiv districts

more or less uniformly covered with UGS, which have been developed for quality recreation and, at the same time, are protected by nature conservation laws. A significant share of UGS is located at a 15-minute walking distance from residential communities. Of course, there are certain discrepancies in the provision of UGS for local residents in separate residential districts. Over the previous decade, Holosiyivskyi district is the place where many new housing complexes with dense development and insufficiently developed street greenery are located. Sviatoshynskyi district has a shortage of UGS in some locations in the Mykil'ska and Pivdenna Borshchahivka residential districts, which are burdened with old housing.

The GSI rating of the Obolonskyi, Desnianskyi and Darnytskyi districts was the lowest (from 3.8 to 2.8). Their UGI is fairly developed, though the UGS territorial distribution is uneven by being concentrated primarily in one part of the districts. Therefore, roughly one-half of the residents are deprived of easy access to recreation zones. The UGS in only the Obolonskyi district is arranged quite evenly in all residential neighbourhoods, which are replete with parks, public gardens and boulevards within pedestrian access. Almost all of them are developed for recreation**.** Desnianskyi district, the second largest district by area after Holosiyivskyi district, is distinguished by uneven UGS distribution. Substantial UGS lands are concentrated in its eastern part on Dnipro islands. There are many "grey" zones here, with dense high-rise building development. There is a scarcity of UGS mostly in the Troyeshchyna residential district where, in the first place, it would be expedient to plan new UGS. Darnytskyi district is abundant in urban forests and water bodies; however, many of them are unsuitable for quality recreation. In other words, the UGI is in decay and needs an expansion, especially in the Pozniaky residential district where UGS is most underprovided. Most UGS in the Desnianskyi and Darnytskyi districts have no legislative protection, and can be developed in some time.

Outright, four districts (Pecherskyi, Shevchenkivskyi, Dniprovskyi and Podilskyi) have roughly the same GSI rating (from 2.02 to 1.91). On top of that, the first two districts differ by a very high population density. This means that their UGI is in a poor condition, and only in some locations it is satisfactory. Most residents in these districts have no convenient access to recreation sites, and are made to spend much time to overcome the big distances to UGS. This is like in the Dniprovskyi district where the main UGS is confined to island, riverside and central parts of the district. UGS expansion is especially needed in densely populated residential neighbourhoods that border on industrial zones. The Podilskyi district UGS is concentrated most in its western part, closer to the Dnipro River, whereas the Vynohradar residential district is almost without them. Shevchenkivskyi district is experiencing a critical shortage of UGS, with its bulk being concentrated along its perimeter. The most densely populated central residential districts are particularly short in greenery. Accounting for one of the biggest population densities in Kyiv, expanding the chain of UGS in Shevchenkivskyi district is more challenging than in other districts of the city. In Pecherskyi district, about one-half of all UGS are located

in the M.M. Hryshko National Botanical Garden. The bulk of UGS is concentrated along the Dnipro River and street greenery is inadequate. Expanding existing and developing new UGS is most needed in the Klov stow and in new housing developments, the number of which is growing from year to year.

Solomianskyi district is far behind other Kyiv districts in the GSI (merely 0.54). This is the expected result of its lowest positions in all the ratings we had compiled. Here, a cardinal renovation of almost all existing UGI elements is needed. Expanding and creating new UGS in Solomianskyi district is most critical for the densely developed Vidradnyi residential area with an industrial zone, and for the Chokolivka and Zhuliany residential districts. This district has a critical shortage of UPA, making it impossible to specify conventional "green lines" for developers. In fact, the new Kyiv Development Master Plan draft provides for creating a landscape protected area of local significance in Solomianskyi district called Sovska Balka with an area of 9.7 ha; however, for a long term of 20 years this is insufficient.

Therefore, as is evident, UGS in most Kyiv districts is confined to distant territories close to water bodies and separate woodlands. Their fairly substantial share in the city's overall territory and the calculated Greenness Coefficients are creating an illusion of sufficient provision of the city with UGS. However, our study is indicative of the need to expand existing UGS and create new ones in many locations according to the principles of compact city planning. The new draft Master Plan should be modified with regard for UGI elements requiring priority optimisation.

Conclusions

The ideal of sustainable urban planning today is a compact city with an attractive green infrastructure. UGS in compact cities perform many functions, provide valuable ecosystem services and are accessible for city residents. Following modern trends, the Kyiv administration has declared an environmentally clean and green city as the key priority of the Kyiv development strategy. Instead, UGS are falling victim to competition with other elements of the Kyiv infrastructure, and are used often as reserved space for housing development or other urban development projects. In other words, urban densification leads to UGS loss and contraction of green space provision per capita. The studies conducted point to the practicality of including the Green Space Index in the mix of key indicators used for assessing the comfort of living in Kyiv and in its separate districts.

The realities of creating a compact city call for imposing a moratorium on destroying UGS in areas popular for development, and UGS should be expanded in districts with a low Green Space Index rating. The results of this study should serve for clearly identifying priority "green lines" in different Kyiv districts, which should be approved in the new Master Plan. With account of the shortcomings in the development of the Kyiv UGI (uneven territorial distribution, insufficient provision for the population, misuse, etc.), the regulatory and legal framework should be revised in terms of conducting a geo-ecological assessment of all UGS and the functions they perform. Special emphasis should be placed on optimisation and connectivity of the UPA chain in conditions of inevitable densification of urban territories. Since excess population density in separate Kyiv districts is one of the factors that considerably increase the environmental load on urban landscapes, it is necessary to make an inventory of UGS ecosystem services and perform their integral environmental and economic assessment.

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Ecological consciousness as a factor influencing the sustainable development of European countries

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Abstract. The article is devoted to the study of the influence of ecological public consciousness on the state of perception of ecological problems in European countries and Ukraine. Ecological consciousness is considered as a latent determinant of modern tendencies of realization of the concept of sustainable development in the context of greening of the international economic system. It is noted that in conditions of social uncertainty, people have the effect of «ecological alienation» as a characteristic of the state of perception of environmental problems in the minds of members of modern society. Although the issues of rational use of economic resources, finding ways to green the international economy, preventing man-made risks and the global environmental crisis are the focus of European governments, an effective solution to these issues is not possible without the reliable support of society. After all, the effectiveness of the environmental policy of each state depends on the trends of perception of environmental problems by its citizens. Issues of environmental consciousness are more related to ethical categories, as they have a significant impact on the formation of civic attitudes of the individual regarding the perception of the importance of certain aspects of society. That is why the analysis of the state of ecological consciousness of the inhabitants of European countries and Ukraine was studied according to the results of the 7th wave, 2017-2020 of the comparative study "World Values Survey" (WVS) using comparative and typological analysis. The World Values Survey is the largest non-profit international survey of human beliefs and values, which contributes to the monitoring of the Sustainable Development Goals and the goals set by the UN program for the period after 2015. From the presented data set, the basic empirical components were identified, which, according to the authors, illustrate the European context of the greening of consciousness - the attitude to technologization; the priority of the ecological state of the country over the economic development of society; the state of trust in environmental protection organizations and the level of active civil position on environmental protection. On the basis of the secondary analysis of data, the key modern tendencies of formation of ecological consciousness in the countries of Europe and Ukraine are substantiated: tendency to ecological thinking; formation of ecological culture; economic rationality. The conclusion is made about the expediency of monitoring and forecasting the state of ecological public consciousness as one of the factors regulating global socio-economic processes in European countries and Ukraine. According to the authors, the environmental consciousness of members of society determines the degree of permissible range of orientation of a country to implement environmentally friendly goals of sustainable development. The study of the variability of the dominance of the trends of ecological consciousness mentioned in the article in certain socio-demographic communities allows to create an effective system of social guarantees in providing conditions for effective socio-economic development and maintaining an ecologically healthy living environment, both in Europe as a whole and in individual countries, in particular.

Keywords: public consciousness, effect of «ecological alienation», ecological consciousness, greening of economic system, tendencies of ecological consciousness

Екологічна свідомість як чинник впливу на сталий розвиток європейських країн

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Анотація. Стаття присвячена дослідженню впливу екологічної суспільної свідомості на стан сприйняття екологічних проблем у європейських країнах та Україні. Екологічна свідомість розглядається як латентна детермінанта сучасних тенденцій реалізації концепції сталого розвитку у контексті екологізації міжнародної економічної системи. Зазначається, що в умовах соціальних невизначеностей у людей спостерігається ефект «екологічної відчуженості» як характеристики стану сприйняття екологічних проблем у свідомості членів сучасного соціуму. Не дивлячись на те, що питання раціонального використання економічних ресурсів, пошуку шляхів екологізації міжнародної економіки, запобігання техногенним ризикам та глобальній екологічній

кризі знаходяться у центрі уваги урядів європейських країн, ефективне вирішення цих питань не можливе без надійної підтримки членів суспільства. Адже ефективність екологічної політики кожної держави залежіть від тенденцій сприйняття екологічних проблем її громадянами. Питання екологічної свідомості більшою мірою відносяться до етичних категорій, так як саме вони мають істотний вплив на формування громадянських позицій особистості відносно сприйняття важливості тих або інших аспектів життєдіяльності соціуму. Саме тому, аналіз стану екологічної свідомості мешканців європейських країн та України досліджувався за результатами 7 хвилі, 2017-2020 роки порівняльного дослідження «Світового Дослідження Цінностей» (World Values Survey, WVS) з використанням порівняльного та типологічного аналізу. World Values Survey це найбільше некомерційне міжнародне дослідження людських переконань та цінностей, яке сприяє моніторингу Цілей сталого розвитку та цілей, визначених програмою ООН на період після 2015 року. З представленого масиву даних були визначені базові емпіричні компоненти, які, на думку авторів, ілюструють європейський контекст екологізації свідомості – ставлення до технологізації; пріоритетність екологічного стану країни над економічним розвитком суспільства; стан довіри до організацій охорони навколишнього середовища та рівень активної громадянської позиції щодо охорони навколишнього середовища. На підставі вторинного аналізу даних, обґрунтовані ключові сучасні тенденції сформованості екологічної свідомості в країнах Європи та Україні: схильність до екологічного мислення; формування екологічної культури; економічна раціональність. Робиться висновок про доцільність відстеження та прогнозування стану екологічної суспільної свідомості як одного з чинників регулювання глобальних соціально-економічних процесів у європейських країнах та Україні. На думку авторів, екологічна свідомість членів суспільства визначає ступінь допустимого діапазону орієнтації певної країни на реалізацію екологічно спрямованих цілей сталого розвитку. Дослідження варіативності домінування означених у статті тенденцій екологічної свідомості у певних соціально-демографічних спільнотах дозволяє створити ефективну систему соціальних гарантій у забезпеченні умов для ефективного соціально-економічного розвитку та підтримці екологічно здорового середовища для проживання, як у європейському просторі в цілому, так і у окремих країнах, зокрема.

Ключові слова: суспільна свідомість, ефект «екологічної відчуженості», екологічна свідомість, екологізація економічної системи, тенденції екологічної свідомості

Introduction

The idea to study the European context of ecological consciousness arose after acquainting the authors with the published results of the study «World Research Values» (World Values Survey, WVS) in Europe and Ukraine, which were presented to Ukraine October 27, 2020 with the support of Ukrainian culture Foundation at the initiative of the public organization «Ukrainian Center for European Policy» in partnership with the research agency « Info Sapiens» and the Center for Social Monitoring. WVS is a long-term comparative study, which was founded in 1981 by Professor R. Inglehart of the University of Michigan (USA) is based on the European Values Survey (EVS) and is one of the most widely used and authoritative international studies, covering almost 120 countries. Ukraine joined this study in 1999, when the fourth wave of WVS took place and participated in the following waves (the fifth in 2006, the sixth in 2011 and the seventh in 2020) (Svitove doslidzhennya tsinnostey v Ukrayini, 2020). Some of the questions in this survey relate to environmental issues. When reviewing the results of research in Ukraine, our attention was attracted and answer to question that illustrated the change of perception in the minds of Ukrainian relationship of ecology and economy. Namely, respondents were asked to choose one of the two statements that is closer to them – «The priority should be to protect the environment, even if it will slow economic growth and job losses» or «Economic growth and new jobs should be paramount, even if the environment will suffer from this»). 45% of them chose the environmental protection as a priority in 1999, and 44.1% - in 2020. Economic growth, even due to the deterioration of the environmental situation in 1999, was chosen as a priority by 29%, and in 2020 by 43.9% (Svitove doslidzhennya tsinnostey v Ukrayini, 2020). This made us think about the need for a deeper study of the ecological orientation of the value orientations of members of modern society as an internal factor in the greening of social processes in the country.

The issue of studying environmental issues is not new to world scientific discourse. The experience of recent years has shown that in the process of solving global environmental problems, the impact of institutional changes on nature management is insufficient. That is why, recently, scientists are paying more and more attention to the study of social impact on the environmental consciousness of citizens. Here are a few examples that, in our opinion, illustrate a certain level of global relevance of our issues. American researchers Johnson, Eaton, Mikels-Carrasco, and Case, studying coastal ecosystems in the eastern United States (which have undergone significant changes as a result of human activities), concluded that we should not focus solely on environmental protection without taking into account the «social landscape» of certain areas. It is necessary to create local «environmental communities», based on local culture, social norms, social trust, etc., which will form a certain social cohesion and facilitate the solution of environmental problems. And for this it is necessary to form an ecological culture, because social and ecological systems are interconnected (Johnson, Eaton, Mikels-Carrasco, and Case, 2020). The experience of China is also in-

teresting, where since 2011 the «environmental revolution» course has been taken (according to Zhong, Shi), which, according to researchers, is based not only on the recognition of existing environmental problems by the state and citizens, but also on ecological consciousness of people, which researchers call the «cornerstone» of improving the environmental situation through the consciousness of residents of different regions of the reasons for the deterioration of the situation and personal responsibility for it (Zhong, Shi, 2011). In Germany, ecological consciousness has long been addressed in the Environmental Policy Research Center (Freie Universität Berlin), trying to convey to citizens that solving environmental problems is directly related to the socio-economic well-being of people (Jacob, Quitzow, Bär, 2011) and others.

Our examples make it possible to understand that the world practice of environmental protection is no longer focused so much on overcoming the consequences of damage to the environment, but on finding and implementing mechanisms to prevent the impact of negative human activities on the environment.

We believe that the relevance of the study of latent determinants of economic development increases in periods of social uncertainty, especially when they become global. This is due to the fact that the state of uncertainty is exacerbated by the energy crisis that arises as a result of competition between alternative sources of its production. Climate change, population growth, urbanization, and growing demand for electricity require responsible behavior at all levels of the hierarchy of social organizations and ensuring the sustainable development of relevant systems and structures.

However, there is a paradoxical situation. On the one hand, with the increase in man-made risks in modern societies, threats of a looming environmental disaster, a global environmental crisis, are growing. The issues of rational use of economic resources, finding ways to green the international economy and achieving the goals of sustainable development (Analitychna dopovid' tsentru Razumkova, 2019) are in the center of attention of governments around the world.

On the other hand, it is obvious that the solution of any state or regional environmental problems is impossible without the reliable support of society members. However, the problem is that in the minds of ordinary citizens there is an effect of «environmental alienation» (according to W. Beck) (Sorensen, Christiansen, 2014), when economic development and environmental security are perceived at the level of dichotomy (or / or) W. Beck explains this by the current state of «risk victims». And this is quite justified, because the situation of social uncertainty determines not only the collective social behavior (Yereskova, Mazuryk, Aleksandrova, 2020; Yereskova, Mazuryk, Tymofieieva, 2020), when members of societies need to form a «hierarchy» of their own reactions between social, economic or environmental risks (Bauman, 2000; Maffesoli, 2016; Burluts'ka, 2015). It also determines the desire of members of modern societies not to adhere to certain established principles in public affairs, but to solve each socially determined issue in view of its attractiveness to a particular person. This means that modern man is guided by considerations of expediency and the desire to reach a compromise between different views on socially significant issues. In such situation, it makes sense to pay attention to the level of formation of social and environmental responsibility that has developed in certain societies. It is clear that environmental policy, problems related to environmental protection should be the subject of state environmental activities. The statement of the existence of environmental problems at the state level necessitates specific intervention by interested parties (society, state, government agencies, business communities, social groups), based on social responsibility, environmental law, environmental audit (Natsional'na dopovid' pro stan navkolyshn'oho pryrodn'oho seredovyshcha v Ukrayini, 2020).

In our opinion, one of the leading roles of environmental policy should be played by the ethical factor. Effective environmental policy is characterized by a certain set of environmental values established in a certain society, which have a serious impact on how the citizen percept the importance of their own influence on environmental policy in nation states. There is also a deep connection between the environmental situation and the socio-political organization of society. Social problems are often caused by environmental preconditions in terms of restricting human rights to a quality living environment.

The issues of environmental awareness are more in those categories where civil society institutions are important, as they have a significant impact on the formation of civic positions of the individual and, consequently, the preservation of the integrity of society. The correct perception of ecological culture by social institutions, will allow to green the moral consciousness, change values, because man and society act as elements of a single system «nature-society», outside of which their existence is impossible, but the interests of nature come to the fore, get priority over the interests of society, included in the sphere of morality (Anats'ka, 2020). That is why the *aim of the* article is to define the manifestations of environmental awareness in European societies and Ukraine as an el-

ement of ensuring effective sustainable development. *The scientific novelty* of the approach proposed by the authors is to apply the potential of the methodology of comparative social research to diagnose the state of environmental consciousness as a tool to prevent the threat of irresponsible attitude of the population of European countries to current environmental challenges.

Materials and methods of research

As a methodological basis of our study, we applied a procedural approach (according to P. Shtompka) to social problems, according to which society is perceived not so much as an object, but as a kind of "field of opportunity" of social actors (Sztompka, 2000). We mean that modern societies are tested by constant risks, the main content of which is the need to assess the level of «threats» - economic, social, environmental, etc. for the effective functioning of a country. In other words, members of societies need to streamline their own attitudes and reactions to such external challenges. The information base of our study was the results of the 7th wave (2017-2020) of the comparative cross-cultural study "World Values Survey" (World Values Survey, WVS), which contains empirical data on the distribution of socio-cultural values of residents of European countries and Ukraine. In each country, the survey is conducted on a nationally representative sample of a standardized questionnaire. As for now WVS is the largest non-profit international survey of human beliefs and values, which contributes to the monitoring of the Sustainable Development Goals and the goals set by the UN (United Nations) program for the period after 2015. The main method for the realization of their research goal, the authors of the article chose the secondary analysis of the results of this study, which was able to synthesize the quantitative characteristics of the respondents' answers in the indicators of the formation of environmental consciousness. Typological analysis was used to determine the trend and state in the ecological consciousness of the inhabitants of European countries and Ukraine.

In our opinion, the proposed approach has a universal analytical potential to study the state of formation of environmental consciousness. After all, the idea of fixing and typologizing direct or indirect indicators of the formation of environmental consciousness in a particular country or region, allows you to use both open empirical data (official statistics, survey results, analytical reports, scientific articles, etc.) and targeted social research on perception in the public consciousness of certain environmental problems (or attitudes to them) within the framework of state or public initiatives (including relevant blocks of issues). However, it should be noted, that the method has certain limitations, which are due to the peculiarities of the method of secondary analysis. This method has recently become an increasingly popular means of obtaining social knowledge, as only large research structures are able to conduct large-scale nationwide, cross-cultural surveys. However, it should be borne in mind that secondary (already available) information is data that has been previously collected for purposes other than the one currently being addressed. Therefore, the application of our proposed approach requires researchers of environmental consciousness a certain interdisciplinary understanding of the problem, its multifaceted specifics (system of state regulation and response to environmental challenges, the level of greening the economy, socio-cultural features of certain countries and regions, etc.).

Results and discussions

We are accustomed to the fact that important areas of environmental research are, first of all, environmental policy of political and economic activities, policy of rational and environmentally safe use of nature, and the formation of socio-ecological views is based on creating and concretizing various theories of nature optimization. All this suggests that modern countries are experiencing a period of change in established perceptions of the relationship between human and nature, during which mature fundamentally new ideas that promote consciousness of the need to improve social development through environmentally safety changes.

In a global situation of social uncertainty, it is necessary to form new ethical standards of living, behavior and well-being, which would enable members of society to relate consciously to nature and its resources on the basis of enshrining in the public consciousness of social and environmental responsibility. Due to the fact that under certain conditions, socio-ecological ideas have become a factor in the accelerated development of society, stimulating the active and transformative impact of people on nature.

If consider ecological consciousness as a tendency of the social consciousness evolution, we want to emphasize that we are not talking about some new form or social type of worldview, but only about the reorientation of its structure due to the influence of modern ecological situation on human life. By «environmental consciousness» we mean the spread in the community of ideas that reflect the level of perception by person of its habitat protection. After all, the ecological aspect of the worldview, at all stages of development of human society, was an integral element

of certain spheres of social consciousness, which periodically manifested itself in mass psychology, legal, philosophical views of a certain era. But only in the period of modern science and technology aimed converting the magnitude of human impacts on nature have reached such large proportions that the question of relations between society and the biosphere have to acquire a peculiar environmentally friendly shade all elements of social consciousness. In other words, the reflection of modern environmental problems in the mind cannot, but affect the environment itself. That causes the «growth» of the environmental component in all areas and levels of public consciousness, penetration into ideological concepts and socio-psychological guidelines of individuals.

We understand that the term «greening of consciousness» is quite conditional, but, in our opinion, it can be used as a kind of indicator of the perception of members of modern European societies and Ukraine of the environmental challenges nowadays. In these conditions, the greening of the worldview should be understood as a set of measures that ensure the creation of scientifically sound and humanistically oriented views, which would be shared by the general population, implemented in their daily practices and lifestyles, would ensure the functioning of optimal models of society solving both global problems of today and the task of accelerating scientific, technological and social progress.

In order to focus on the state of environmental consciousness, we have identified from the data set the empirical components that, in our opinion, visualize the manifestations of environmental consciousness: the attitude to technology; the priority of the ecological state of the country over the economic development of society; the state of trust in environmental protection organizations and the level of active citizenship in relation to environmental protection.

Displaying the characteristics of environmental consciousness, we began to determine trends in the attitude of European and Ukrainian people to the further technologicalization of socio-economic development of the country (Table 1).

Table 1. Respondents' assessment of the statement about the need to pay more attention in future to technology development, comparing data of the certain countries. *Source*: [Svitove doslidzhennya tsinnostey v Ukrayini (2020), p. 37]

Country	Answer options (in %)	
	«fine»	«badly»
Germany	74.8	11.1
Greece	65.8	6.7
Romania	62.5	11.5
Ukraine	58.1	2.8

The analysis of the answers made it possible to outline the trends of consciousness of the representatives of certain countries about the need for further development of technologies. It should be noted that the list of countries presented in the Table 1 and other tables (for example, Tables 3 and 4) was not determined by the authors of the article, but was due to the peculiarities of the World Values Survey in individual particular countries, which had the opportunity to According to the «drivers» of the implementation of the World Study in a particular country, were appropriate for their countries. As you can see, the representatives of these countries positively assess the priority of technology development. However, it is worth paying attention to the answers that have a negative focus. We can assume that the people of Germany and Romania are more concerned on the possible dominance of technology over other spheres of life of their societies (social, environmental, etc.) and the possible impact of technology on the environment.

We have identified the priority in the minds of respondents of environmental or economic issues in the development of European societies by analyzing the answers to questions about the ranking of environmental or economic issues (Figure 1).

Empirical evidence has confirmed the existence of the effect of «environmental alienation» in the consciousness of members of modern European societies which we have already mentioned in the introduction. Residents of Lithuania, Poland and Romania showed the greatest effect (clear priority for economic growth). This effect almost doesn't exist in Sweden (a clear priority for solving environmental problems). In other countries (except Bulgaria and Ukraine) there is a steady trend of understanding the importance of the impact of the environment on society. Bulgaria and Ukraine, on the one hand, are also in this trend, but statistical differences between the selected options compared to other countries (Ukraine - 0.2%; Bulgaria - 13.6%) may indicate possible "fluctuations" of public consciousness in the case of deterioration of socio-economic situation in these countries.

It does not need to prove that the indicator of trust of society members in certain social institutions makes it possible to understand the current state and determine the prospects for the country›s development in the appropriate direction. In modern conditions of social uncertainties, this issue becomes especially important, because social distrust is one of the deterrents to the effective and harmonious development of any society. That is why we have identified trust in environmental organizations as one of the components of the environmental awareness state (Table 2).

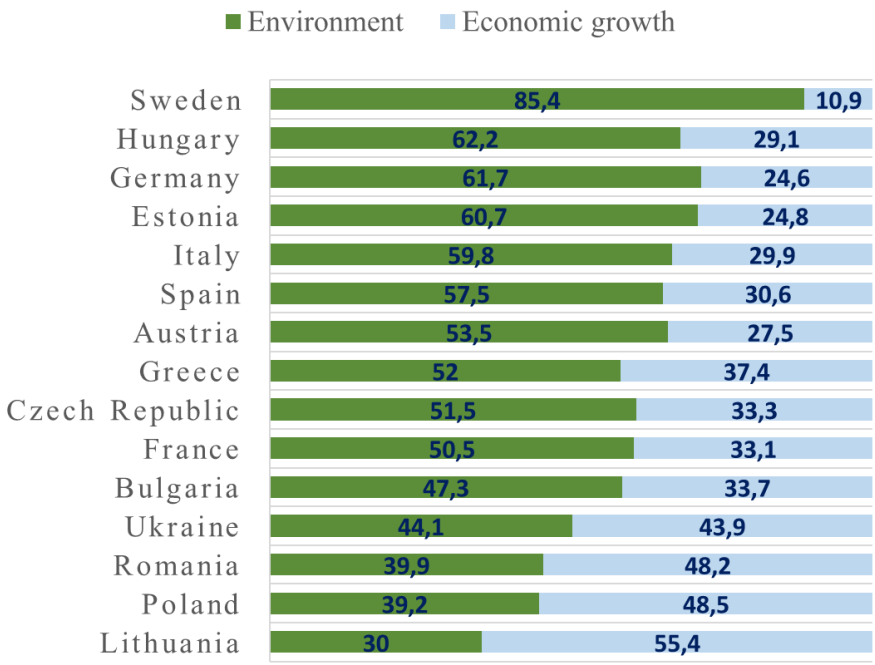

Fig. 1. Respondents' assessment (in %) of the priority of solving environmental problems and economic growth in individual countries and in Ukraine
Source: developed by the authors on the basis of [Svitove doslidzhennya tsinnostey v Ukrayini (2020), p.90]

Table 2. Level of trust in environmental organizations, comparison of Ukrainian and some other countries' data in some of their answers, *Source*: developed by s based [Svitove doslidzhennya tsinnostey v Ukrayini, (2020), p.65-66]

Country	Answer options (in%)		
	Fully trust	Trust to some extent	No trust
Austria	13.0	48.4	6.6
Bulgaria	2.1	18.5	19.0
Greece	4.0	41.5	12.3
Estonia	8.1	49.6	4.1
Spain	12.8	47.4	6.8
Italy	9.6	45.9	9.9
Lithuania	3.3	48.3	4.6
Germany	8.1	52.3	4.9
Poland	6.5	38.0	13.9
Romania	8.5	26.3	20.2
Hungary	10.9	40.5	11.8
Ukraine	3.4	35.2	17.3
France	8.6	52.0	8.3
Czech Republic	4.5	25.1	21.4
Sweden	12.2	57.3	4.0

On the one hand, statistics show the current trend in European countries regarding the perception of environmental organizations as subjects of social influence. However, if we pay attention to the categorical distribution of unambiguously positive and unambiguously negative responses, we can trace the variability of trends in the legitimacy of these organizations in the consciousness of societies' members: 1) perception of organizations as a subject of social impact on society (static gap between categories ≥ 6%) - Sweden, Austria, Spain; 2) situational perception of the organization as a subject of social influence (statistical gap ≤ 4) - Estonia, Germany, Italy, France, Lithuania, Hungary; 3) non-perception of organizations as a subject of social influence (static gap between categories ≥ 6%) - Bulgaria, Greece, Poland, Romania, Ukraine, Czech Republic.

It is well known that the active civil position of members of society in relation to certain problems of the country development affects the formation of vectors of public policy and social norms in society. In our opinion, the results of the World Values Survey on the level of involvement of citizens in environmental organizations (presented by individual countries) provide insight into the prospects for changing trends in public consciousness to gain greater influence in these organizations in European countries (Table 3).

As we can see, the percentage of involvement of citizens of individual countries in activities of environmental organizations is quite low, even if the answers are categorized only by polar options (belong / do not belong). We mean the statistical association of the degree of involvement (active / inactive member).

However, for validation tendencies, whether it

Table 3. The level of involvement of citizens in environmental organizations, comparison of data for particular countries with Ukraine, *Source*: developed by authors based on [Svitove doslidzhennya tsinnostey v Ukrayini (2020), p. 77]

Country	Answer options (in%)		
	I do not belong to the members	Inactive member	Is an active member
Germany	88.4	4.5	7.1
Ukraine	90.5	7.8	1.7
Romania	94.6	4.5	0.9
Greece	96.5	2.5	1.0

concerns only organizations with environmental protection or the low public activity is a definite trend in modern European societies we have monitored the level of manifestation of active citizenship also relation to other organizations (Table 4).

Table 4. The level of civic activity (the degree of participation in various organizations which are able to influence the social and economic life), comparison of particular countries' data with Ukraine, *Source*: developed by authors based on [Svitove doslidzhennya tsinnostey v Ukrayini (2020), p. 76-77]

Country	Answer options (in%)		
	I do not belong to the members	Inactive member	Is an active member
Trade unions			
Germany	86.7	5.2	8.1
Ukraine	87.0	10.9	2.2
Romania	88.8	7.9	3.4
Greece	94.4	3.8	1.8
Political parties			
Germany	93.7	3.0	3.3
Ukraine	91.6	6.1	2.3
Romania	89.6	7.6	2.8
Greece	95.3	3.6	1.1
Professional associations			
Germany	88.8	5.4	5.8
Ukraine	90.3	6.9	2.8
Romania	92.8	4.9	2.3
Greece	94.0	4.1	1.9

A comparative analysis of the dependence of the level of citizenship on the orientation of organizations gave us the opportunity to state that low involvement of citizens in environmental activities in Ukraine and Greece is due to general trends in the attitude of society members to civic activity of organizations, which is 0.9% in Greece and 1.1% in Ukraine). In Germany, in the minds consciousness of citizens, membership in environmental organizations is clearly correlated with membership in trade unions (statistical development of the option "is an active member" is 1%) and professional associations (static gap option "is an active member" is 1.3%), compared to political parties (statistical gap of the option "is an active member" of 3.8% in favor of environmental organizations). In Romania, the low involvement of citizens in environmental organizations, to some extent, illustrates the lack of perception in the public consciousness of these organizations as a subject of social influence on socio-economic development (maximum static gap option "is an active member" is 2.5%).

Summarizing the analyzed empirical components of the European context of greening consciousness, we identified three main trends, formed in European countries and Ukraine, that to varying degrees, allow to further regulate the genesis of this component in the public consciousness of members of societies:

- *tendency to ecological thinking*, which provides awareness of the existence of a direct link between the state of the environment and socio-economic development. It is characterized by the recognition of the priority of the issue of taking into account the peculiarities of the impact of the environment on the life of society. Willingness to change in order to preserve the environment of life. This trend is typical for Sweden;

- *formation of ecological culture*, which determines the consolidation of manifestations of ecological consciousness through individual everyday practices, an element of which is the solution of ecological problems. It is characterized by the formation of a holistic perception of the environment, the establishment and awareness of certain norms of relations between society and the environment, the consolidation in society of beliefs that the protection and preservation of nature is one of the important state-building tasks. However, this does not preclude controversy over the priority of environmental issues. This trend dominates the public consciousness of most European countries (Hungary, Germany, Estonia, Italy, Spain, Austria, Greece, the Czech Republic and France);

- *economic rationality* which affects the seriousness of the perception of the environment state as a factor of the successful development of the country. It is characterized by determining the priority of financial, industrial and technological development of society. This trend is clearly demonstrated by Lithuania, Poland and Romania. Bulgaria and Ukraine balance between this trend and the formation of ecological culture.

So, the environmental consciousness of members of society determines the degree of acceptable range of the country's orientation towards the implementation of environmentally oriented goals of

sustainable development. The study of the variability of the dominance of these trends in environmental consciousness in certain socio-demographic communities allows to create an effective system of social guarantees in providing conditions for effective socio-economic development and maintaining an ecologically healthy living environment, both in Europe as a whole and in particular countries.

Conclusion

The approach to study the environmental consciousness we propose is caused by the reaction of residents of any country on environmental issues arise only from changes in the ecological system, which usually affects either the socio-economic development of society, or the health of society. In conditions of social uncertainty, the consciousness of the majority is dominated by an individual "formula" according to which an average citizen determines the strength and direction of this influence. According to the practice, environmental problems are not always perceived by the majority as a risk (compared to economic ones, for example). This raises the debate about the level of greening of public consciousness and its impact on the international economic system.

Our scientific research in the field of taking into account the state of environmental consciousness in the process of achieving sustainable development goals will contribute not only to understanding the existing interdependencies of modern socio-economic development on latent factors of society's perception of social reality, but also to minimize (and ideally overcome) individualized attitude to environmental issues. After all, today's realities require the formation of ecological consciousness, the main manifestations of which can be considered an understanding of the general laws of coexistence and development of environment and society, recognition of social conditionality of the ecological vector of development and overcoming consumer attitudes to the environment as a source of material benefits.

A balanced combination in the formation of environmental awareness of the trends identified by us (environmental thinking, environmental culture and economic rationality) is the basis not only for environmental protection of social interests of society members, but also to enshrine the principles of environmental responsibility component of daily life in public consciousness. However, we must not forget that a necessary condition for the transformation of environmental consciousness into a factor of a social impact on economic development is the existence of civil society. In other words, it is necessary to create such socially conditioned backgrounds to be sure that the public will be environmentally competent, aimed at improving environmental culture and worldview, assistance in solving both local and international environmental problems.

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The geoecological analysis performed for the geochemical composition of ash and slag waste obtained at Zmiiv thermal power plant

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Abstract. The objective of the study was the composition of ash and slag waste from the Zmiiv TPP (thermal power plant) and the peculiarities of migration of heavy metals (HM) from the place of storage of ash and slag waste into the ecosystem. To achieve this goal, the following tasks were solved: chemical analysis of ash and slag waste of the Zmiiv TPP; identification of the probability of HM migration into the soil environment in the places of ash and slag waste storage. Ash and slag of the Zmiiv TPP contain Cu, Cr, As, Cd, Ni, Pb in quantities several times higher than the threshold limit value (TLV). For ash and slag wastes, the total pollution rate was Zc = 43, which corresponds to a high level. That is, this artificial horizon is dangerous. HMs migrate to groundwater and soils near the ash stockpiles as a result of infiltration of precipitation waters, leaks from water-bearing communications, water filtration through the base of the ash stockpiles of the Zmiiv TPP. To determine soil contamination near the ash stockpiles, we analyzed soil at the distances of 0, 5, 10, 50 and 100 meters. The contents of the HM decreased further away from the stockpiles. At the distance of up to 100 meters from the dump, there were excesses of the threshold limit values for Ni, Cu, As, Cr in the soil. The concentration factor exceeded one for Cr, As, Cu, Cd, Ni. Only at the distance of 100 meters did the contents of Pb and Zn reached the background values. The calculation of the total rate of soil contamination allowed us to classify these soils as moderately dangerous and acceptable. However, the Zn indicator has several significant disadvantages, particularly it does not take into account the differences in the potential hazards of the elements, as well as, most importantly, the synergistic effects of polymetallic pollution. The coefficient of synergistic effect of heavy metals was 26.64 (in the soil of the ash stockpiles), then decreased, but even at the distance of 100 meters it equaled 11.23, i.e. at the distance of 0… 100 m from the ash stockpiles, the overall actions exceed the norm. The study revealed that Cu, Ni, Zn and Cr had low mobility in the soil near the ash stockpiles and therefore accumulated near the stockpiles, which may be explained by neutral and slightly alkaline soil pH values. The ratio of mineral phases and glass varied, but we should note the predominance of aluminosilicates, calcium silicates and glass in the ash and slag wastes. Heavy metal compounds are confined mainly to amorphized clay aggregates and soot-coal ash formation, to a lesser extent to slag glass and even less to grains of quartz sand. Since ash contains such fractions that can be easily carried by the wind, it should be assumed that ingress of HM into the ecosystem occurs by air, which also contributes to air pollution. The solution to the problem of ash and slag waste disposal can be found in their utilization in the production of construction materials, in road construction, but it is necessary to study the composition of ash and slag and the probability of migration of HM depending on the conditions of use.

Key words: geoecological analysis, ash and slag waste, heavy metals, man-made load, ecosystem pollution

Геоекологічний аналіз геохімічного складу золошлакових відходів Зміївської теплоелектростанції

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Анотація. Метою дослідження є аналіз геохімічного складу золошлакових відходів Зміївської теплоелектростанції (ТЕС) та виявлення особливостей міграції важких металів (ВМ) від місця складування золошлакових відходів у екосистему. Для досягнення встановленої мети було вирішено наступні завдання: проведення геохімічного аналізу золошлакових відходів

Зміївської ТЕС; вивчення вірогідності міграції ВМ у ґрунтах місць зберігання золошлакових відходів. Золошлаки Зміївської ТЕС містять Cu, Cr, As, Cd, Ni, Pb у кількостях, що в декілька разів перевищують гранично-допустиму концентрацію (ГДК). Для золошлакових відходів сумарний показник забруднення становить Zc = 43, що відповідає високому рівню. Тобто цей штучно створений горизонт є небезпечним. ВМ мігрують у підземні води і у ґрунти поряд із золовідвалом за рахунок інфільтрації атмосферних опадів, викиди з водопровідних комунікацій, фільтрації вод через основу золовідвалуЗміївської ТЕС. Для визначення забруднення ґрунтів поблизузоловідвалуздійснено аналізи ґрунту на відстані 0…100 метрів.Встановлено, що зменшення концентрації ВМ у ґрунті з відстанню від золошлаковідвалу. На відстані до 100 метрів від відвалу спостерігається перевищення у ґрунті ГДК за вмістом сполук Ni, Cu, As, Cr. Коефіцієнт концентрації перевищує одиницю для Cr, As, Cu, Cd, Ni. Лише на відстані понад 100 метрів вміст Pb та Zn досягає фонових значень.Розрахунок сумарного показника забруднення ґрунтів дозволяє віднести дані ґрунти до помірно небезпечних та допустимих. Однак, є декілька суттєвих недоліків у показника Zc. Насамперед, він не враховує відмінностей потенційної небезпеки хімічних елементів, а також, що найбільш важливо, синергетичні ефекти поліметалічного забруднення.Коефіцієнт синергетичного впливу важких металів становить 26,64 (у грунтізоловідвалу), далі зменшується, але навіть на відстані 100 метрів становить 11,23, тобто на відстані 0…100 м від золошлаковідвалу не виконується умова не перевищення коефіцієнту сумарної дії одиниці.Встановлено, що Cu, Ni, Zn і Cгхарактеризуються низькою рухливістю у ґрунті поблизузоловідвалу, через що вони акумулюються в екосистемі поряд ззоловідвалом, що пояснюється нейтральними і слаболужними значеннями pH ґрунту (pH=8,0…8,5).Співвідношення мінеральних фаз і скла нестійке, проте слід зазначити переважання у золошлакуалюмосиликатів, силікатів кальцію і скла. Сполуки ВМ приурочені в основному до аморфізованих глинистих агрегатів і сажисто-вуглецевим утворенням золи, в меншій мірі до шлакового скла та ще менше до зерен кварцового піску.Оскільки золошлак містить такі фракції, що можуть легко розноситися вітром, слід припустити, що надходження ВМ у екосистему відбувається і повітряним шляхом, що також сприяє забрудненню атмосферного повітря. Вирішення проблеми утилізації золошлакових відходів слідвіднайти у виробництві будівельних матеріалів, у дорожньому будівництві, але необхідно вивчати склад золошлаків і вірогідність міграції ВМ залежно від умов використання.

Ключові слова: золошлакові відходи, важкі метали, техногенне навантаження, забруднення екосистеми

Introduction

The work of TPPs (thermal power plants) generates wastes: ash and slag (heavy fraction) and ash (volatile fracture). Wastes most often are deposited in the open-air. Subject to atmospheric precipitations, the components of ash and slag may migrate into the environment.

Stockpiles of ash occupy large areas, having a negative impact on the environment. A number of studies have focused on danger of ash-and-slag wastes, and the opinions on the subject vary. A number of researchers report the great threat these wastes pose and the possibility of using ash and slag in production of construction materials, road construction, which would reduce the expenditures of raw material, and even propose using them as fertilizers (Bushumov S.A, 2020; Snikkars P.N., 2020; Cristina T. A., 2019). Other researchers draw attention to the environmental pollution with wastes from TPPs (Sokolov A.V., 2019, Ochur-ool A. P., 2019, Turhan Ş., 2020 3-7). Fly ash and ash and slag wastes contain As, Pb, Cr, Cu, Ni, Co, V, Cd, Zn, Se, Mn, Fe, K, Ba, Na, Ca, Mg, Be, F (Pribilova V.M., 2013, Krainiuk E. V., 2004), which may be dangerous to human health (Kornus A., Kornus O., Shyshchuk V., 2020). Ash and slag have high concentrations of zinc, plumbum, cuprum, nickel, vanadium, cadmium, barium, sodium, beryllium, cobalt (Ochur-ool A. P., 2019). There is research confirming significant soil contamination with Ni, Cr with Hg near the stockpiles of ash (Turhan Ş., 2020).

A number of European countries are processing ash and slag wastes, for example Denmark and Germany effectively use ash and slag in production of construction materials. At the same time, the share of recycled ash and slag accounts for up to 100%. For instance, in Germany, it is prohibited to deposit ash and slag wastes. Poland, China and the USA recycle around 60% of generated ash and slag (Snikkars P.N., Zolotova I.Yu., Osokin N.A., 2020).

Provision of the needs of industry and the population requires great resources of electric energy. Therefore, for example, generation of electric energy in Ukraine in 2019 accounted for 141.2 B kW, over a third of this energy was generated by TPPs and CHP (combined heat and power) stations (Statistichnij shhorichnik Ukrainy, 2019).

During the generation of thermal energy, thermal power was 129,045 GCal/year, and the main providers of the thermal energy were thermo-regulating units, heating plants, TPPs and CHPs, the work of which left ash and ash-and-slag waste.

The greatest activity of TPPs is concentrated in eastern Ukraine (Fig. 1). The Zmiiv TPP is among the five largest TPPs, with power over 2,000 MW (Fig. 1, 2).

Objective of the study

The objectives of the study were the composition of ash-and-slag wastes of the Zmiiv TPP and specifics of the migration of heavy metals from place of

Fig. 1. TPPs in Ukraine

1– Zmiiv, 2 – Slovianska, 3 – Vuhlehirska, 4 – Luhansk, 5 – Zuivska, 6 – Starobeshevska, 7 – Kurakhivska, 8 – Prydniprovsk, 9 – Zaporizka, 10 – Kryvyi Rih, 11 – Ladyzhyn, 12 – Trypilska, 13 – Dobrotvir, 14 – Burshtyn

deposition of ash slag wastes to the components of the ecosystem. To achieve the goal, we solved the following tasks: performing geochemical analysis of ash and slag wastes of the Zmiiv TPP; finding probability of migration of HM to soil in places of storage of ash and slag wastes.

The Zmiiv TPP is the leading polluter in Kharkiv Oblast, its impact assessed as 60% of the total pollution in the Oblast (Pribilova V.M., 2013). The TPP has operated since 1960, having the electric capacity of 2,150 MW. The TPP produces 18 B kW per h of electric energy annually. As fuel, the Zmiiv TPP uses low-grade coal with addition of mazut or gas of the Shebelinka gas field. The output of ash and slag accounts for 1.2 M T/year. A total of 200 thous tons is processed annually, 1 M T is stored in the

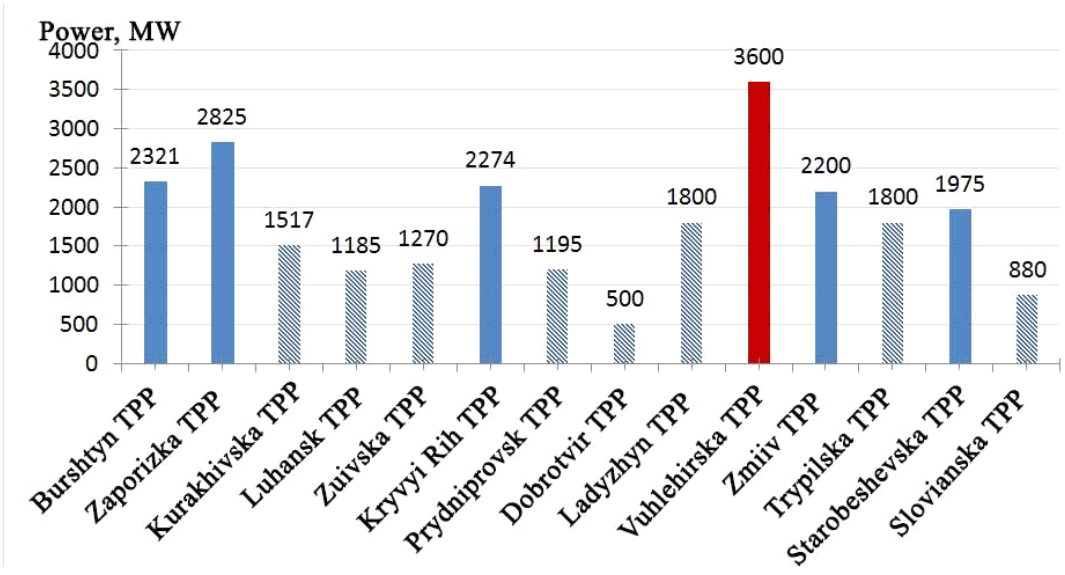

Fig. 2. Power generated by TPPs in Ukraine, MW

Fig. 3. Polygon of ash and slag wastes of the Zmiiv TPP

stockpiles. Currently, the ash stockpiles of the Zmiiv TPP comprise 30 M T of ash and slag. The system of ash and slag removal is hydraulic.

The polygon of ash and slag wastes of the Zmiiv TPP occupies an area of 350 ha (Fig. 3). The ash stockpiles cause a number of ecological problems. Ash and ash and slag wastes are solid non-burned residuals of solid fuel, which are transferred to ash stockpiles. The main mass (965 - 98%) of ash and slag wastes comprises oxides – 45… 60%; CaO – 2.5…9.6%; MgO – 0.5…4.8%; Fe_2O_3 – 4.1-10.6%; Al_2O_3 – 10.1…21.8% i SO_3 – 0.03… 2.7%.

The most important component of ash and slag wastes is SiO_2 (over 40%), which together with Al_2O_3 takes part in formation of calcium aluminosilicates. Up to 15-80% ash and slag wastes are composed of crystalline phase, the rest – poorly soluble quartz, mullites, hematite, magnetite, etc. (Krainiuk E. V., 2004). Furthermore, the ash and slag contain Zn, Tl, Pb, Cr, Mn, Co, Ni, Hg, As, Sb, V, Sr, Ge, B, Be, F and other (Pribilova V.M., 2013).

The stockpiles of the Zmiiv TPP are of a hydrotechnical structure, which also has an effect on the environment (Fig. 4). The stockpiles of the Zmiiv TPP have an impact on groundwater and chemical composition in the area of Lyman village, the Lyman and Chaika Lakes. For the TPP and coal CHP, the storage of wastes, particularly ash and slag, is a relevant ecological problem.

Technogenic load requires constant control of the condition of the components of geological environment, the main of which are soil and water-bearing horizons, for the expedience and efficiency of the environment-protective measures depend on them. Therefore, determining the scales of pollution of constituents of the geological environment, detection of abnormality, designation of ranges of pollution is a relevant task of geological-ecological studies.

Materials and methods

The content of heavy metals in ash, ash and slag wastes and soil was studied using atomic absorption analysis (AAA) on a C-115 spectrometer. For this method, the lower limit of detection was 0.2 μg/mL of extraction solution. Identification was not hindered by the presence of other metals in the samples.

To determine the composition of solid non-organic part of ash and slag, we performed X-ray analysis. Studies were performed on an X-ray diffractometer DRON -1.5 at the regimes of analysis:

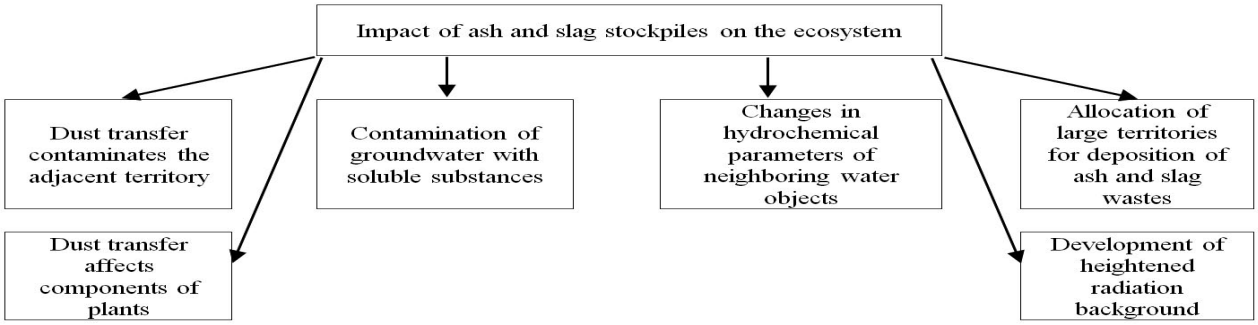

Fig. 4. Impact of ash and slag wastes and deposition sites of ash and slag wastes of TPP on the environment

voltage U = 35kV, power of anode current I anode = 20 mA, velocity of circulation of a sample was 2 degrees/min; the speed of tape of the recorder was 600 mm/h. Copper electrode was used. To avoid β-emission, the analysis was performed using Ni filter and the method of powder diffraction. Specially selected regimes of analysis allowed us to obtain high resolution, especially when examining small amounts of samples.

Results and their analysis

Content of separate toxic elements and heavy metals, determined using AAA method, is presented in Table 1.

Contamination usually is poly-elemental, and so assessment of it requires calculation of parameter of overall contamination (Zc), which reflects the additive sum of the values of concentration coefficients that exceed the background level (Buts, Yu., Krainiuk, O. 2006). Overall parameter of contamination (Z_c) was determined according to formula:

$$Z_c = \sum_1^n K_c - (n-1), \quad (3)$$

n – number of examined chemical elements.

According to the level of Z, the extent of contamination was as follows: moderately dangerous level at Zc < 16; average (allowable) level of contamination at Zc = 16–32; high level at Zc = 32–128; extremely high level at Zc> 128.

Table 1. Chemical composition of ash and slag wastes of the Zmiiv TPP (mean values), mg/kg

	Fe	Cu	Mn	Cr	As	Cd	Ni	Pb	Zn
Concentration of ash and slag, C mg/kg	2800	55.4	34	16	27	0.8	135	16	12
Background content	1510	5.7	792	1.7	1.5	0.3	14.4	13.9	18.7
TLV		3	1500	6	2	3	4	30	23
Coefficient of contamination (excess of TLV), K		18.5	0	2.7	13.5	0.3	33.8	0.5	0.5
Concentration coefficient, Kc	1.9	9.7	0	9.4	18	2.7	9.4	1.2	0.6

Despite the fact that the samples contained Cu, Cr, As, Cd, Ni, Pb in concentrations that were several times higher than the TLV (Table 1), the chemical analysis of the samples of ash and ash and slag wastes of the TPP indicated that these values may be dozens of times higher. Therefore, for example, As in ash may account for up to 58 mg/kg, Ni even up to 56 g/kg, and Cr to 43 g/kg. In those samples, compared with ash and slag wastes of other TPPs, the amounts of Fe and Mn were small (Krainiuk E. V., 2004). We determined that the acidity of aquatic environment equaled pH = 8.8.

For the aforesaid conditions, we determined the coefficient of contamination according to the formula:

$$K = \frac{C_{sample}}{TLV}, \quad (1)$$

where C_{sample} is actual concentration of the metal in the soil (ash and slag wastes).

However, because in this case *K* does not take into account regional specifics of the content of HM, we calculated the concentration coefficient:

$$K_c = \frac{C_{sample}}{C_b}, \quad (2)$$

where C_b is regional background content of element.

For ash and slag wastes, the overall parameter of contamination was Zc = 43, which corresponds to high level. That means that this man-made horizon is dangerous.

Migration of elements from ash and slag wastes is determined by the properties of rocks embedded beneath the ash stockpiles. Within the ash stockpiles, the basis for the ash and slag layer comprises silt loams, but they do not provide complete isolation of groundwater from hydro alluvium. Thus, HM migrate to groundwater and soils around the stockpiles through infiltration of water from atmospheric precipitations, drainage from water communications, filtration of water through the base of ash stockpile of the Zmiiv TPP.

To determine the contamination of soils near ash stockpiles, we analyzed soil at the distance of 0, 5, 10, 50 and 100 meters from the stockpiles.

We determined decrease in concentration of HM in soil further away from the ash and slag stockpiles (Fig. 5). At the distance of 100 meters from the stockpiles, we saw excesses of TLVs of Ni, Cu, As, Cr (Fig. 6). Concentration coefficient was more than 1 for Cr, As, Cu, Cd, Ni. Only at the distance of 100 meters, did the concentrations of Pb and Zn reach the

background values. Increase in Fe concentration at the distance of 100 meters from the ash stockpiles, compared with the sample at the distance of 50 meters, had no pattern, and may be explained by error, for its increase was only 2.4%, or by dust transfer (Fig. 4).

Calculation of total parameter of soil contamination (Fig. 7) allowed us to identify these soils as moderately dangerous and acceptable. However, there are several significant disadvantages to the Zc parameter. In particular, it does not take into account differences between the potential dangers from chemical elements, and also, most importantly, synergic effects of polymetallic contamination.

Coefficient of synergic impact of heavy metals, which was determined using the formula:

$$\sum_1^n \frac{C_i}{TLV_i} \leq 1, \quad (4)$$

equaled 26.64 (in soil of ash stockpiles), further decreased, but even at the distance of 100 meters it was 11.23, i.e. at the distance of 0-100 m from the ash stockpiles, the condition of absence of excess of coefficient of total action of the unit was not satisfied.

Petrographic analysis using the method of immersive preparations determined presence of poorly melted quartz grains in the ash with distinctive parameters of refraction. In the periphery, isotropically with N=1.470–1.490, and in the central part similarly to quartz with N_e=1.554, N_0=1.543. There also occur non-transparent brown ashes with semi-metal gloss of grain of iron hydroxides, and also white, translucent, poorly fibered grains of, probably, wollastonite $CaSiO_3$ з N_q=1.632, N_p=1.619. Often, there occur yellowish brown grains with N_m=1.645 represented probably by compounds of aluminosilicates of iron. Glass is also composed of mostly iron- aluminosilicates with N=1.625–1.638.

Ratio of mineral phases and glass varied, though we have to note the dominance of aluminosilicates, silicates of calcium and glass in ash and slag wastes (Fig. 8).

Compounds of HM are mostly confined to amorphous clayey aggregates and soot-carbon formation of ash, to a lower degree to slag glass and even less to grains of quarzite sand. "Ash: and slag particles: quarzite filling" was in the ratio 8-12: 61-64: 20-31%.

Migration of HM from ash and slag to the components of the ecosystem depends on many factors, one of the essential being the acidity of the environment. Earlier, we examined migration properties of heavy metals by developing concentration logarithmic diagrams (Buts Y., Kraynyuk O., Asotskyi V., 2020; Y. Buts, V. Asotskyi, O. Kraynyuk, 2019; Buts, Y., Asotskyi, V., Kraynyuk, O, 2018; Krainiuk O., ButsYu., 2018; Krainiuk O., ButsYu., Nekos A., 2019). Thus, one may assume that Cu, Ni, Zn and Cr are characterized by low mobility in soil, thus accumulating near the ash stockpiles, which is due to neutral and poorly-alkaline values of soil pH (pH=8,0…8,5).

Usually, the contamination of territory around stockpiles of ash and slag takes place only due to migration of HM from ash and slag, and due to wind transfer of dry ash and slag from the surface of ash stockpiles, dust.

Conclusions

Soils are depositing environments, their condition may be considered an integral parameter of the long term process of contamination of ecosystems. Furthermore, contamination of soils is related to contamination of the troposphere – the layer closest to Earth's surface, surface waters and groundwater.

We determined ash and slag of the Zmiiv TPP to have poorly melted grains of quartz, iron hydroxides, wollastonite, aluminosilicates of iron and slag glass.

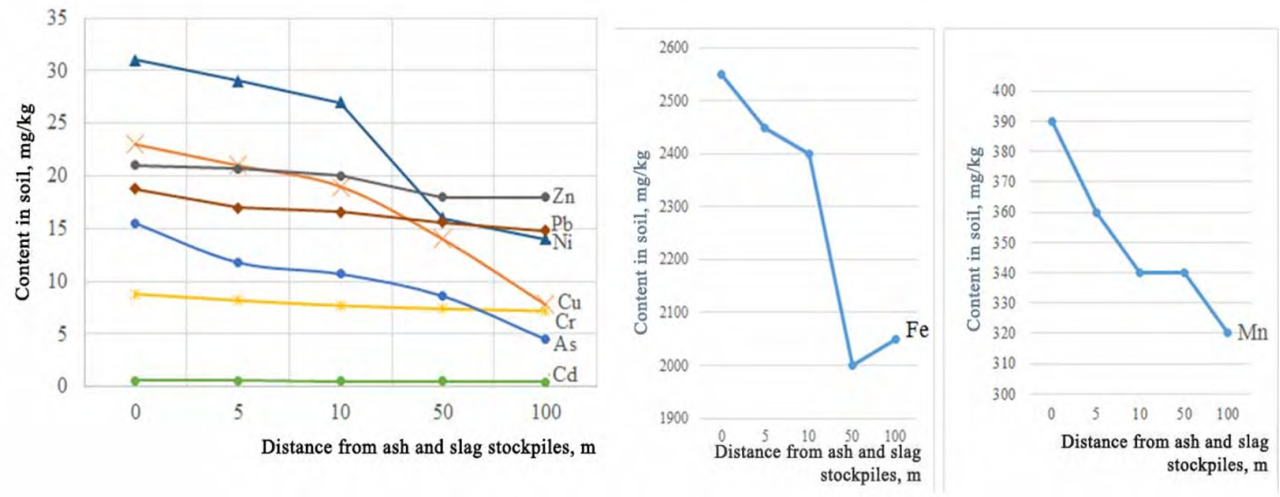

Fig. 5. Dependence of HM content in soil on distance from stockpiles of ash and slag wastes

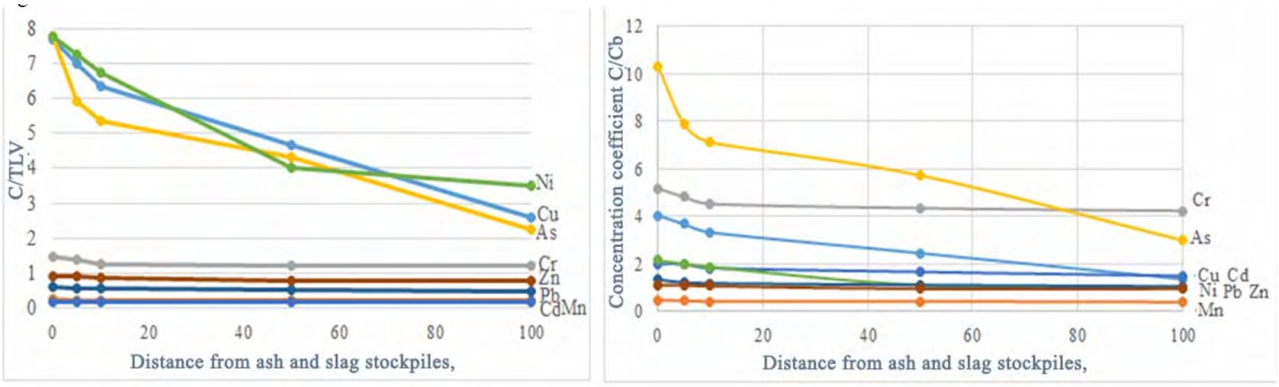

Fig. 6. Dependence of HM content in soil on distance from stockpiles of ash and slag wastes

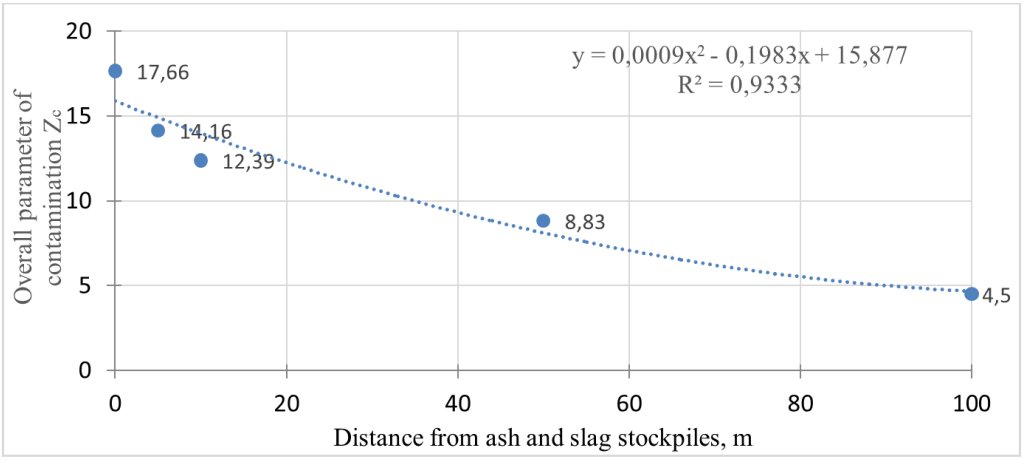

Fig. 7. Dependence of total parameter of contamination of soils on distance from stockpiles of ash and slag

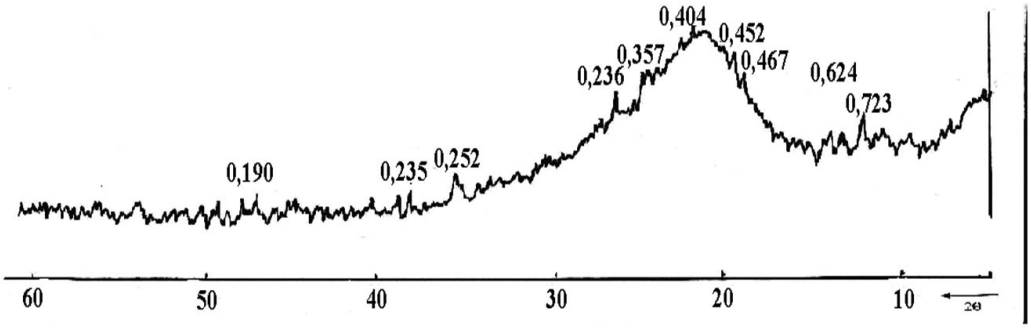

Fig. 8. X-ray diagram of ash and slag wastes of the Zmiiv TPP

Ash and slag of the Zmiiv TPP contain Cu, Cr, As, Cd and Ni in concentrations that several times exceed the TLV.

As the ash and slag wastes of the Zmiiv TPP are deposited, the contaminated water infiltrates, adversely affecting the geochemical properties of the soil and the hydrochemical properties of surface waters and groundwater.

Even, at the distance of 100 meters from the stockpiles, there were observed excesses of TLVs of Ni, Cu, As, Cr in soil. Concentration coefficients exceeded one for Cr, As, Cu, Cd, Ni. Only at the distance of 100 m did the contents of Pb and Zn reach the background values.

Because ash and slag wastes contain such fractions that may be easily transferred by wind, we may presume that introduction of HM to the ecosystem takes place by wind, which also contributes to the pollution of the atmospheric air. The problem of utilization of ash and slag wastes should be solved by producing construction materials, and using them in road building, but the composition of ash and slag and probability of migration of TH depending on conditions of use should be studied.

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Increasing marketing activity of hotel and restaurant business enterprises as a basis for the development of the tourism industry

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Abstract. Modern views on the role and importance of partnership marketing are the basis for the effective strategyormation for the competitiveness of the hotel and restaurant industry and the tourism business in a crisis time of the tourism industry due to the coronavirus pandemic and the effect of restrictive measures. The presented article is aimed at the using modern analytical and methodological tools for assessing the competitive status and marketing activity of the hotel and restaurant enterprises and tourism business in the context of applying the principles of marketing partnerships and its implementation in practice of tourism. The purpose of the article is to develop and implement a model of resource-activity potential management and the formation of a competitive status of hotel and restaurant business enterprises and the development of tourism industry based on marketing of affiliate relations. With the help of the factor analysis it is formed the components and indicators of competitive status of the hotel and restaurant enterprises and tourism business, emphasizing the importance of marketing activity in the field of the service promotion and partnership with stakeholders as a reflection of mobilization and the full use of marketing potential.This methodical approach to assessing the level of competitive status of the enterprises of hotel and restaurant industry and tourism business in the context of the resource and activity support on the implementing principles of the concept of marketing partnerships is proposed. It is established that enterprises have unstable dynamics of the integrated indicator of resource potential and activity, which indicates a lack of attention from managers and managers of the hotel and restaurant business to the formation of partnerships with stakeholders on a long-term basis. The results of the impact modeling of the marketing activity of the hotel and restaurant enterprises and tourism business on the level of their competitive status allowed to propose the measures of managerial influence aimed at solving the problem of increasing competitive status in the difficult conditions of the tourism industry. The practical value is the formation and implementation of the activities aimed at the establishing long-term partnerships with stakeholders in order to form a competitive status of the hotel and restaurant industry and tourism business.

Keywords: partnership marketing, tourism, hotel and restaurant business, tourism business, competitive potential

Підвищення маркетингової активності підприємств готельно-ресторанного бізнесу як підґрунтя розвитку індустрії туризму

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Анотація. Сучасні погляди на роль та значення маркетингу партнерських відноси слугують основою для формування ефективної стратегії конкурентоспроможності підприємств готельно-ресторанного господарства та туристичного бізнесу в умовах кризи туристичної галузі через пандемію коронавірусу та дію обмежувальних заходів. Представлена стаття спрямована на використання сучасного аналітико-методичного інструментарію оцінювання конкурентного статусу та маркетингової

активності підприємств готельно-ресторанного господарства та туристичного бізнесу в контексті реалізації принципів маркетингу партнерських відносин та його впровадженні в практичну діяльність представників туристичної сфери. Метою статті є розробка та впровадження моделі управління ресурсно-діяльнісним потенціалом та формування конкурентного статусу підприємств готельно-ресторанного бізнесу та розвиток індустрії туризму на засадах маркетингу партнерських відносин. За допомогою факторного аналізу сформовано складові та показники оцінки конкурентного статусу підприємств готельно-ресторанного господарства та туристичного бізнесу, що акцентують увагу на важливості маркетингової активності в сфері просування послуг та реалізації партнерських відносин зі стейкхолдерами як відображення результату мобілізації та повноцінного використання маркетингового потенціалу підприємств. Запропоновано методичний підхід до оцінювання рівня конкурентного статусу підприємств готельно-ресторанного господарства та туристичного бізнесу в контексті ресурсно-діяльнісного забезпечення на принципах реалізації концепції маркетингу партнерських відносин. Встановлено, що підприємства мають нестабільну динаміку інтегрального показника ресурсно-діяльнісного потенціалу та активності, що свідчить про недостатню увагу з боку керівників та менеджерів представників готельно-ресторанного бізнесу до формування партнерських відносин зі стейкхолдерами на довгостроковій основі. Результати моделювання впливу маркетингової активності підприємств готельно-ресторанного господарства та туристичного бізнесу на рівень їх конкурентного статусу дозволили запропоновувати заходи управлінського впливу, спрямовані на вирішення завдання підвищення конкурентного статусу в складних умовах функціонування туристичної галузі. Практична цінність полягає у формуванні та реалізації заходів, спрямованих на встановлення довгострокових партнерських відносин зі стейкхолдерами з метою формування конкурентного статусу підприємств готельно-ресторанного господарства та туристичного бізнесу.

Ключові слова: маркетинг партнерських відносин, туризм, готельно-ресторанне господарство, туристичний бізнес, конкурентний потенціал

Introduction

In the context of the intensification of the crisis phenomena at the level of the national economy due to the pandemic and the effect of restrictive measures for the enterprises of the hotel and restaurant industry and the tourism sector of Ukraine, it has become the need to determine the main directions of the development which will ensure not only the expansion of the production scale, but also create the basis for their long-term effective functioning in the interaction with the external environment. This approach requires from the the hotel and restaurant enterprises and tourism business to increase the level of competitiveness, competitive status which are the basic components in the system of planning activities and forming a competitiveness strategy.

The issues of the competitive status formation of the hotel and restaurant enterprises and tourism industry in changing economic conditions, growing instability of the environment and constant transformation processes which dictate the new rules for the market participants require increased attention from scientists (Holliday, 2020).

The concept of marketing partnerships which is based on a radical change in the approaches to the role of relationships with stakeholders and identify the strategic directions for their development allows in today's difficult conditions to identify the further steps to ensure competitiveness and competitive status through the long-term partnerships and areas with all stakeholders. The strategic orientation of the principles of marketing partnerships allows to ensure competitive advantages and a stable competitive status of the enterprises engaged in the provision of tourism services (Honti, 1984; Porter, 1980). Based on the promising areas of the principles implementation of the marketing partnerships in the hotel and restaurant industry and tourism business with the modern tools using of the economic and analytical analysis there is a direct need to assess the competitive status and marketing activity as a basis for the competitive strategy of the hotel and tourism business. establishing long-term partnerships with the stakeholders.

The aim of the article is to develop and implement a model of the resource management and the formation of the competitive status of the hotel and restaurant business and the development of the tourism industry on the basis of the marketing partnerships.

Literature review

In recent decades, many companies world-wide in the various sectors of the national economy, including the hotel and restaurant industry have a tendency to individualize marketing, aimed at the forming partnerships between the producers of goods (services) and their consumers. Partnerships are understood as "long-term mutually beneficial cooperation" between the contractors and "long-term privileged relations" which arise between the producer and consumer of goods by serving each consumer taking into account his specific needs and creating a high degree of loyalty to the producer (Kotler, 2007). Partnership marketing is a strategic collaboration between two or more firms that helps each firm to reach its respective business goals (Gronroos, 2017). In the work (Illiashenko, 2006), partnerships marketing is proposed to understand the process of creating, maintaining and expanding close cooperation with customers, which involves the company's focus on serving each customer individually, taking into account its specific needs and characteristics. Partnership marketing can be defined as a mutually beneficial

marketing relationship between a firm and another organization (Zeithaml, 1996).

The concept of marketing partnerships is based on the fact that it is much harder to win new customers than to increase the degree of loyalty of existing ones. Therefore, the partnership guarantees the hotel and restaurant business a stable economic existence, low risk, the possibility of increasing income and profits, especially in a general decline in demand for travel services due to the coronavirus pandemic and the introduction of restrictive measures to prevent infection (Maxfield, 2009). The effects of the economic recession and the COVID-19 crisis call for more active support for the tourism industry (Gabor, Conţiu, Oltean, 2012). However, in 2019–2020, many new challenges arose related to the effects of the economic recession and the COVID-19 crisis, which reduced the sustainability and performance of the tourism industry (Popova et al., 2020; Kvach, Piatka, Koval, 2020). These circumstances necessitate more active support for the EU tourism industry, taking the form of an independent national policy (Holleran, 2020).

J. H. Gordon in (2001) notes that the concept of marketing partnerships between the producers and consumers in some ways differs from the "classical" concept of marketing. The "Classical" marketing is based on the fact that the manufacturers themselves define and give the consumers value in the form of what they consider a "commodity". The content of the interaction between producers and customers is the exchange of the certain values. In accordance with the concept of partnership marketing, the consumer firms play a leading role in determining the value they want to receive. The seller creates value with the buyer. The total value they receive is distributed among them.

F. Kotler and K. L. Keller in (2007), proposing the concept of holistic marketing; note the need for the marketing relationships with the key market partners and the internal marketing aimed at adopting appropriate marketing principles by all organization employees. They also consider the importance that marketing is socially responsible for the areas of ethics, ecology, laws and society. Thus, they focus their marketing on establishing long-term privileged relationships with all key stakeholders in the organization.

Given the fundamental nature of the theoretical and methodological developments, solving the non-trivial task of the establishing partnerships with stakeholders in the hotel and restaurant industry in order to make effective management decisions requires the modern tools using for assessing the level of their competitive status in the context of the resource and activity support based on the principles of marketing partnerships.

Methodology

With the help of the factor analysis it is formed the components and indicators of competitive status of the hotel and restaurant enterprises and tourism business, emphasizing the importance of marketing activity in the field of the service promotion and partnership with stakeholders as a reflection of mobilization and the full use of marketing potential. To construct a dynamic simulation model of resource-activity potential and the formation of a competitive status of enterprises, a methodological dynamics method is used, which allowed to reflect branched causal relationships between variables. Given the features of system dynamics models, they are an extremely convenient tool for solving the problems of researching competitive status, management of the resource-activity potential of the hotel-restaurant and tourist enterprises based on the implementation of partnership marketing principles.

Results and discussion

Assessment of the enterprises competitive status of the hotel and restaurant industry in the context of the partnership marketing. The enterprises key stakeholders who works at the hotel and restaurant industry traditionally include investors, creditors, enterprise managers, employees, suppliers, consumers (customers of the enterprise), the public and state organizations, as the successful operation of the hotel and restaurant economy depends on the welfare of the economy infrastructure of the region. Relationships with stakeholders are dynamic complex relationships that are constantly changing as the impact and state of the business changes; are determined by the relationship between people, so it is their values that particularly affect the relationship.

The peculiarity of these relations is their focus not only on the supply of goods, but also on the supply of relations (Lew, 2006). According to the ISO / WD 26000 project "Social Responsibility Guide", the category of "stakeholders" includes: non-governmental organizations, local and regional communities, consumers, suppliers, subcontractors, customers, employees, shareholders (Gubanova et al., 2019; Popova et al., 2019). According to Mendelow's model (1991), all stakeholders can be classified according to two variables – their interests and their power: 1) the power of the stakeholder determines his ability to influence the organization; 2) the interest of the stakeholder is determined by his desire to influence the organization. Thus, the stakeholder scheme:

Influence of the stakeholder = Power x Interest.

Thus, the establishment of long-term partnerships with stakeholders allows hotel and restaurant companies to solve the problem of forming the competitive status of the company in changing economic conditions, growing environmental instability and constant transformation processes that dictate new rules for market participants (Makhitha, 2016; Koval et al., 2019; Yankovyi et al., 2020).

Closely related to the concept of the regional stakeholders is the marketing component of hotel and restaurant business which is of great importance, especially in the face of fierce competition in the tourism services market which has intensified in the language of restrictive measures due to the coronavirus pandemic. The effective use of the available marketing opportunities of hotel and restaurant enterprises with the favorable marketing climate and the implementation of the principles of marketing partnerships will provide the additional competitive advantages, increase their competitive potential (Mazaraki, 2015; Gorg, 2000). Competitive position and competitive potential determine the competitive status of hotel and restaurant enterprises which is a prerequisite for achieving a new level of competitive advantage and the desired level of competitiveness in the crisis conditions and partial loss of full-fledged activity during the strengthening of quarantine measures (Richter, 2000).

Therefore, the competitive status is a real characteristic of the hotel and restaurant industry and is defined as the result of more effective than the competitors management of the processes of the formation and use of the competitive advantages and potential, in particular, marketing. Therefore, the competitive status is a real characteristic of the hotel and restaurant industry and is defined as the result of more effective than the competitors management of the processes of the formation and use of the competitive advantages and potential, in particular, marketing (Boiko, 2013; Kaigorodova, 2018). We propose to assess the competitive status of hotel and restaurant enterprises on the basis of our resource and activity potential study which is the internal factor in the formation of competitiveness, as well as the influence of external factors of the marketing environment (the factors of production and infrastructure related the industriesan demand parameters, competitors, relationships with stakeholders) which characterize the resource-active business (McKercher, 2004; Chang, 2016).

Thus, the two-dimensional assessment of the competitive status of hotel and restaurant enterprises in the context of marketing partnerships is based on the assessment of resource potential as a component of competitive status which shows the possibilities of its provision and the resource-active business as a result of using this potential (Mikhno et al., 2021). The study highlighted the local components of the resource-activity potential and the resource-active business of hotel and restaurant industry by the components such as organizational-managerial, marketing, production-personnel, financial-economic, innovation-investment, organization, content and working conditions which allowed to form a system of the indicators for assessing the competitive status of hotel and restaurant businesses in terms of marketing partnerships (Koval, Slobodianiuk, Yankovyi, 2018). Components and indicators for assessing the competitive status of the hotel and restaurant industry and tourism business by the factor load are given in the Table. 1.

The results show that more important in the formation of competitive status among other aspects of hotel and restaurant business and tourism business is their marketing activity in the field of promotion and partnership with stakeholders as a reflection of the mobilization and the full use of marketing potential (Kvach, Koval, Hrymaliuk, 2018).

On this basis the methodological approach to assessing the level of competitive status of the hotel and restaurant enterprises and tourism business in the context of the resource provision on the principles of implementing the concept of marketing partnerships which allowed to determine the integrated indicators of RAP, RAA by the taxonomic analysis for seven hotel enterprises and restaurant business. The calculations were made on the basis of the reporting analysis of the enterprises of the hotel and restaurant industry in Ukraine for the period 2016-2019. It should be noted, that in order to prevent the impact on the image of the investigated objects - enterprises the authors do not «open» their names, but they are submitted under numbers. To get the results tied to the real companies, contact the authors of this study directly.

Assessment of the competitive status of hotel and restaurant enterprises and tourism business includes the following stages:

Stage I. Selection and substantiation of the assessment method – taxonomic (integrated) indicator (according to the criteria of established standards);

Stage II. Determination of reference values and criteria for assessing the enterprises competitive status of the hotel and restaurant enterprises.

2.1 The formation of a matrix of standardized values of the indicators of the enterprises competitive status of hotel and restaurant business. The used method for the standardizing the data is as follows:

Table 1. Assessment indicators of resource-activity potential (RAP) and resource-active business (RAB) hotel and restaurant enterprises and tourist business by the directions.

Aggregate	Directions	Indicators
Resource potential (Possibilities)	Organizational and managerial potential (OMP)	Coefficient of decentralization of organizational management structure (X1)
		Coefficient of quantitative staffing of the management staff (X2)
	Production and personnel potential (PPP)	Coefficient of the equipment use intensity (X3)
		Professional flexibility coefficient (X4)
	Financial and economic potential (FEP)	Accounts payable turnover (X5)
		Accounts receivable turnover (X6)
		Coefficient of cash flows from the financing activities (X8)
Activity potential (Possibilities)	Organization of labor activity (OLA)	Labor distribution coefficient (X9)
		Labor remuneration level (X10)
	Working conditions (WC)	Occupational safety factor (X12)
Resource activity (Final result)	Marketing activity (MA)	The coefficient of effectiveness of advertising and sales incentives, the formation of partnerships with stakeholders (X1)
	Production and personnel activity (PPA)	Capital productivity (X2)
		Labor productivity (X4)
	Financial and economic activity (FEA)	Return on assets (X5)
		The coefficient of financial autonomy (X7)
		Return on the bank borrowed capital (X8)
	Innovation and investment activity (IIA)	Return on the investment expenses (X9)
Business activity (Final result)	Organization of labor activity (OlA)	Distribution possibilities of working time in accordance with individual needs (X10)
	Content of labor activity (ClA)	Influence possibility on the way/method of work (X11)
	Working conditions (WC)	Satisfaction with sanitary and hygienic conditions at work as well as sanitary and household services (X12)
		Satisfaction with the aesthetic working conditions (X13)

$$z_{ij} = \frac{x_{ij} - \bar{x}_{ij}}{\sigma}, \qquad (1)$$

where i – the serial number of the object of observation (from 1 to n);

j – indicator that characterizes the state of the object (from 1 to m);

zij – normalized / standardized feature of the indicator j for the enterprise and;

xij – the actual value of the indicator j in period i;

$\bar{x}_{ij}$ – average value of the indicator;

σ – standard deviation.

$$\sigma = \sqrt{\frac{\sum (x_{ij} - \overline{x_{ij}})^2}{n}}. \qquad (2)$$

The formed matrix of the standardized values of indicators has the following form:

$$z = \begin{pmatrix} z_{11} & z_{12} & \dots z_{ij} \dots & z_{1n} \\ z_{21} & z_{22} & \dots z_{ij} \dots & z_{2n} \\ z_{i1} & z_{i2} & \dots z_{ij} \dots & z_{in} \\ z_{m1} & z_{m2} & \dots z_{mj} \dots & z_{mn} \end{pmatrix}$$

2.2 Differentiation of the features of the matrix of standardized values of the indicators: construction of a vector of the development standard (P_0) of competitive status with the coordinates (x_0) and distribution of the features into the stimulators and destimulators.

$$\begin{cases} z_{oi} = \max z_{oi} & \text{stimulator} \\ z_{oi} = \min z_{oi} & \text{destimulator} \end{cases}$$

2.3 Determining the distance of each object from the reference point. Euclidean distance is used as a measure of distance:

$$C_{i/0} = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_{0j})^2}, \quad (3)$$

де Z_{ij} – standardized value of the *j-th* indicator *i*;

$Z_{\hat{i}j}$ – standardized value of the *j-th* indicator in the reference vector.

2.4 After calculating the Euclidean distance, the following calculations are performed:

average distance between objects ($\bar{C}_o$):

$$\bar{C}_o = \frac{1}{n} \sum_{i=1}^{n} C_{io}; \quad (4)$$

standard deviation (σ_0)

$$\sigma_o = \sqrt{\frac{\sum (C_{io} - \bar{C}_o)^2}{n}} \quad (5)$$

the maximally possible deviation from the standard (C_0):

$$C_o = \bar{C}_o + 2 \cdot \sigma_o; \quad (6)$$

consolidated dynamic indicator of the level of development (d_i)

$$d_i = \frac{C_{io}}{C_o}. \quad (7)$$

Stage III. Assessment of the competitive status of the hotel and restaurant enterprises according to the generalized partial taxonomic indicator.

Determination of the taxonomic (integrated) indicator (Π_i) of the competitive status of the hotel and restaurant enterprises by the components of resource-activity potential and resource-activity activity is carried out according to the formula:

$$\Pi_i = 1 - d_i. \quad (8)$$

Stage IV. Determination of the integrated indicator of the level of competitive status of the enterprises is carried out in a similar way (formulas (1) - (8), onlv the values are used instead of Π_i instead of Z_{ij} (standardized value of the *j-th* indicator).

As a result of calculations, the indicators of the resource and activity potential of the hotel and restaurant enterprises and tourism business were transformed into the unit "Resource and activity potential of the enterprise" (RAP), activity indicators – into the unit "Resource-active business of the enterprise" (RAB) (table. 2).

Table 2. Dynamics of the integrated indicators of resource-activity potential (RAP) and resource-active business (RAB) of the enterprises of the hotel and restaurant enterprises and tourist business

Enter-prise	Years							
	2016		2017		2018		2019	
	RAP	RAP	RAP	RAP	RAP	RAP	RAP	RAP
No1	0.42	0.89	0.89	0.59	0.85	0.80	0.84	0.91
No2	0.34	0.71	0.82	0.70	0.75	0.87	0.77	0.61
No3	0.45	0.65	0.83	0.72	0.64	0.69	0.65	0.56
No4	0.28	0.69	0.71	0.72	0.92	0.74	0.84	0.60
No5	0.41	0.76	0.66	0.72	0.59	0.65	0.53	0.61
No6	0.13	0.19	0.20	0.16	0.25	0.19	0.24	0.23
No7	0.48	0.70	0.68	0.66	0.60	0.65	0.59	0.66

It is established that the constant growth of the general level of RAP and RAA for 2016-2019 years is not observed in any of the studied enterprises of the hotel and restaurant industry and tourism business, ie the enterprises have unstable dynamics of the integrated indicator. The low level of integrated indicators that characterize the components of competitive status was observed in 2016, but in 2017-2019 there was a significant increase in this indicator at the surveyed enterprises. Thus, item No 4 was the maximal value of RAP 0.92 in 2018, which decreased slightly to 0.84 in 2019. A similar trend of dynamics (slight decline/ reduction) were inherent to the analyzed indicators in 2019 compared to 2018, which indicates a lack of attention from leaders and managers of the hotel and restaurant business to the formation of partnerships with stakeholders on a long-term basis.

The proposed approach to assessing the resource-activity potential (RAP) and resource-active business (RAB) of enterprises of the hotel and restaurant industry and tourism business provides the qualitative justification of the values of the result. According to the established scale of intervals, the following levels of resource-activity potential and resource-active business and the characteristics of their competitive status are distinguished: high [73-92] H), adequate [53-72] (A), satisfactory [33-52] (S) and low [13-32] (L)). Thus, the qualitative assessment of the indicators of resource-activity potential (RAP) and resource-active business (RAB) of the hotel and restaurant enterprises, taking into account the marketing component is presented in the Table. 3.

Modeling the impact of the marketing activity of the hotel and restaurant enterprises and tourism

Table 3. Dynamics of the indicators for assessing the level of resource-activity potential (RAP) and resource-active business (RAB) of the enterprises of the hotel and restaurant industry and tourism business by the qualitative characteristics

Enter-prise	Years							
	2016		2017		2018		2019	
	RAP	RAP	RAP	RAP	RAP	RAP	RAP	RAP
No1	S	H	H	A	H	H	H	H
No2	S	A	H	A	H	H	H	A
No3	S	A	H	A	A	A	A	A
No4	L	A	A	A	H	H	H	A
No5	S	H	A	A	A	A	A	A
No6	L	L	L	L	L	L	L	L
No7	S	A	A	A	A	A	A	A

business on the level of their competitive status. The growing speed of the changes in the environment and their low predictability increased competition in the national market, globalization trends of competitive markets and the negative impact of restrictive measures on the market of tourist services determine the feasibility and need for permanent improvement of the internal factors and components of resource potential (RAP) tools for their transformation into resource-active business (RAB) tools of partnership marketing.

Based on the system of the indicators for assessing the resource and activity potential of the studied enterprises of the hotel and restaurant industry and tourism business in the areas listed in the Table 1, the basic conceptual model management of resource and activity potential and the formation of the competitive status of the enterprises of hotel-restaurant and tourist sphere constructed by the author in the PPP Vensim will look as follows (Fig. 1).

The basic model is formed by three main types of variables:

initial coefficients of the activity and potential indicators which are the independent variables and the values of which are set numerically;

the calculated variables that correspond to the integrated assessments of the components of the RAP (RAP) and RAB (RAB), calculated on the basis of the methodology of the integrated rating assessment;

the resulting variables which are the indicators of the state of the system and reflect the integrated estimates of RAP (RAP) and RAB (RAB), the coefficient of transformation of resource-activity potential into activity (kEkc); the overall value of the level of imbalance for all elements of the potential of the enterprises of the hotel and restaurant industry VRRDP (BPrdp).

The basic conceptual model of resource and activity potential management (RAP) and the formation of the competitive status of the hotel and restaurant industry clearly demonstrates the fact that the improvement, including marketing activity (MA) by the hotel and restaurant industry based on the implementation of partner marketing principles and relations and the establishment of long-term mutually beneficial relations with stakeholders allows to solve the problem of increasing competitive status in the difficult conditions of the tourism industry.

The study proposes the measures of managerial influence for the hotel and restaurant industry and tourism business aimed at the increasing certain components of RAP (RAP) and RAB (RAB) in the context of marketing partnerships:

customer flow management based on the attracting both new and maintaining existing ones by meeting their needs and creating the favorable conditions for long-term relationships;

ensuring continuous contact with the customers in order to update their needs and create a unique consumer value based on the high quality service and responsible attitude of the staff to their responsibilities;

cooperation with suppliers and other stakeholders involved in cooperation is based on the development and implementation of joint plans and the strategies aimed at creating joint assets.

Conclusion

The article implements the modern approaches to the implementation of the principles of marketing partnerships in the hotel and restaurant business and tourism business in order to form the effective strategy of competitiveness in the crisis of the tourism industry through the coronavirus pandemic and restrictive measures. The proposed set of tools allows to assess the competitive status and marketing activity of the hotel and restaurant industry and tourism business in the context of the implementation of the principles of marketing partnerships.

The results of the factor analysis allowed to establish the components and indicators of the competitive status of the hotel and restaurant enterprises and tourism business with emphasis on the role of marketing activities in the promoting services and partnerships with stakeholders which characterizes the mobilization result and the full use of the enterprise marketing potential.

Assessing the level of competitive status of the enterprises of the hotel and restaurant industry and tourism business in the context of the resource and activity support based on the principles of marketing concept allowed to establish the levels of the resource and activity potential and resource-active business of the studied enterprises.

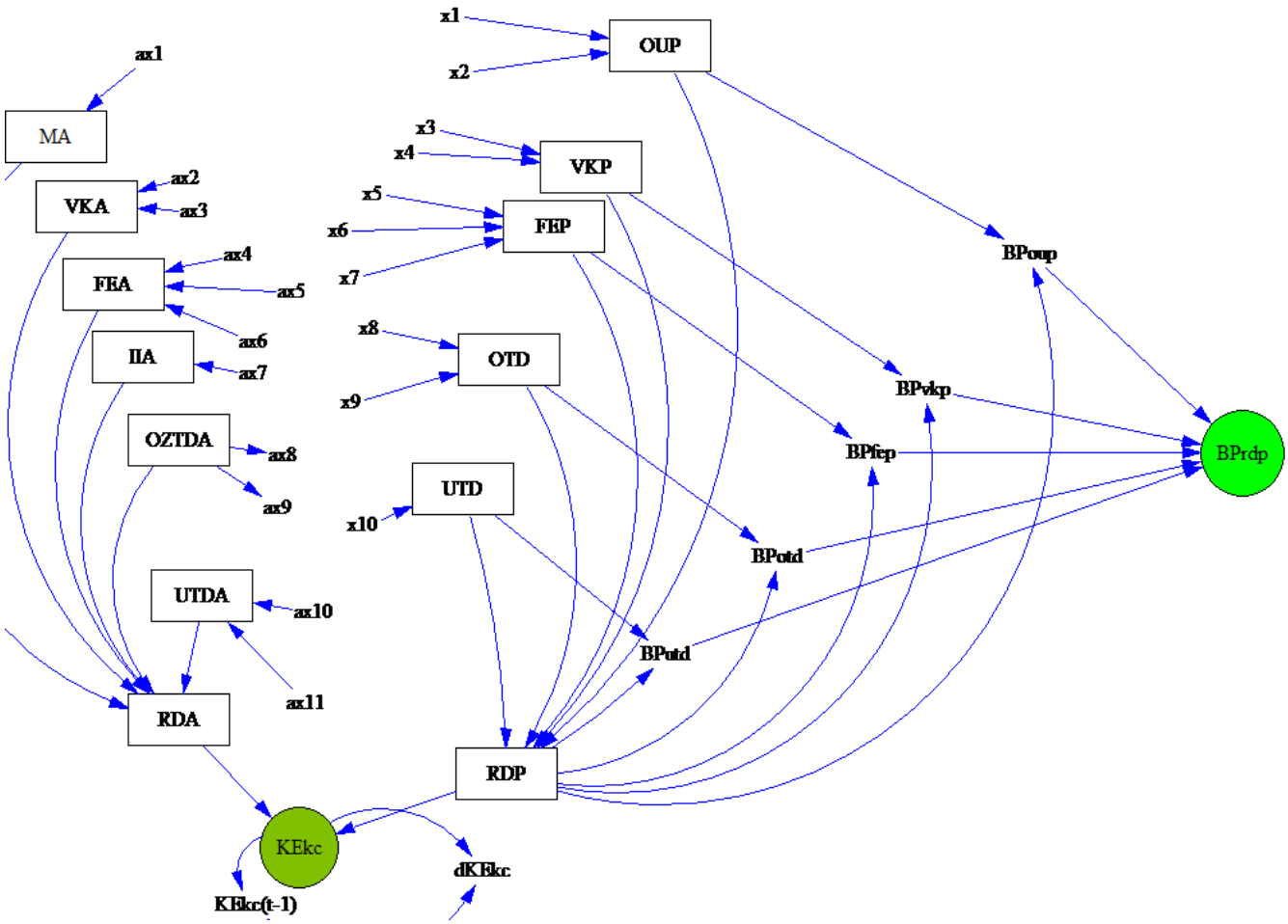

Fig.1. Basic conceptual model of resource and activity potential management (RAP) and formation of competitive status of the hotel and restaurant enterprises and tourism business.

Based on the results of the impact modeling of marketing activity of the hotel and restaurant enterprises and tourism business on the level of their competitive status, the article proposes the measures of management influence aimed at the solving the problem of increasing competitive status in the difficult conditions of the tourism industry. The practical value of the results is the proposals for the formation and implementation of measures aimed at establishing long-term partnerships with stakeholders in order to form a competitive status of the hotel and restaurant industry and tourism business.

Further prospects of the research are to solve the problem of forecasting the relationships structure of the elements and the components of resource-activity potential and resource-active business of the hotel and restaurant enterprises and tourism busines, which will increase the effectiveness of management measures to maintain their competitive status through the formation and use of competitive advantages in the system of partnership marketing.

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Assessment of River Water Inflow into the Sasyk Estuary-Reservoir According to RCP4.5 and RCP8.5 Climate Change Scenarios for 2021-2050

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Abstract. The paper relevancy is determined by the need to substantiate the feasibility of restoring the ecosystem of the Sasyk estuary after its transformation into a reservoir (1978) and the unsuccessful desalination by the Danube waters for irrigation purposes. The paper is aimed at assessment of the possible inflow of fresh water to the Sasyk estuary from the Kohylnyk and Sarata rivers and their role in the formation of fresh water balance in the first half of the 21st century according to the climate change scenarios RCP4.5 and RCP8.5. The main calculation method is the 'climate-runoff' model, which uses meteorological data as input data. Estimates of freshwater inflow into the estuary-reservoir are provided for various calculation periods: before 1989 (before the beginning of significant climate change in the North-Western Black Sea Region); in the period of 1989-2018 according to the hydrometeorological observations; in 2021-2050, according to the averaged data from 14 runs of scenarios RCP4.5 and RCP8.5 under the EVRO-CORDEX project. Estimates of the average long-term values of freshwater inflow in natural conditions and the conditions transformed by water management activity were obtained for each calculation period. It is found that owing to changes in the regional climate for the period of 2021-2050, the total inflow of freshwater from rivers to the estuary in natural conditions will decrease by 23.5 % (by RCP4.5) and by 38.5 % (by RCP8.5) in comparison with the reference period (before 1989). Taking into account the impact of artificial reservoirs, the reduction in the river runoff will be 52.1 % (by RCP4.5) and 64.7 % (by RCP8.5). It is defined, that in case of renaturalization of the Sasyk reservoir into the estuary and the water inflow cut-off from the Danube river, the changes in climatic conditions expected in the first half of the 21st century, combined with water management activity, will result in the increased deficit of annual freshwater balance of the Sasyk reservoir up to 62 % under the RCP4.5 scenario and up to 75 % under the RCP8.5 scenario compared to the period before the emergence of climate change (before 1989). This change must be considered in scientific substantiation of the project on a reversion of the Sasyk Reservoir to the original status of the estuary to ensure such conditions of water exchange with the sea (for compensation of the water balance deficit), which will prevent the long-term trend of salinization.

Keywords: Sasyk estuary, water balance, freshwater inflow, climate change scenarios

Оцінка припливу річкових вод в лиман-водосховище Сасик за кліматичними сценаріями RCP4.5 та RCP8.5 на період 2021-2050 рр.

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Анотація. Актуальність роботи обумовлена необхідністю обгрунтування доцільності відновлення екосистеми морського лиману Сасик після перетворення його на водосховище (1978) та невдалого опріснення дунайськими водами в іригаційних цілях. Мета роботи полягає в оцінці можливого припливу прісних вод до лиману Сасик від річок Когільник і Сарата та їх ролі у формуванні прісного водного балансу в першій половині XXI сторіччя за кліматичними сценаріями RCP4.5 та RCP8.5. Основним методом розрахунків є модель "клімат-стік", яка використовує на вході метеорологічні дані. Оцінки припливу прісних вод до лиману-водосховища надані для різних розрахункових періодів: до 1989 р. (до початку значущих змін клімату на території Північно-Західного Причорномор'я); у період 1989-2018 рр. за даними гідрометеорологічних спостережень; у 2021-2050 рр. за осередненими даними 14 симуляцій сценаріїв RCP4.5 та RCP8.5 проекту EVRO-CORDEX. Оцінки середніх багаторічних величин притоку прісних вод в природних та перетворених водогосподарською діяльністю (побутових) умовах отримані для кожного розрахункового періоду. Установлено, що за рахунок змін регіонального клімату у період 2021-2050 рр., сумарний приплив прісних вод від річок до лиману у природних умовах зменшиться на 23,5 % (за RCP4.5) та на 38,5 % (за RCP8.5) у порівнянні із базовим (до 1989 р.) періодом. При урахуванні впливу штучних водойм зменшення стоку річок буде становити 52,1 % (за RCP4.5) та на 64,7 % (за RCP8.5). Визначено, що у разі ренатуралізації водосховища Сасик в морський лиман та припинення надходження до нього вод р. Дунай, зміни кліматичних умов, які очікуються у першій

половині XXI ст., у поєднанні із водогосподарською діяльністю, призведуть до зростання дефіциту річного прісного водного балансу водосховища Сасик до 62 % за сценарієм RCP4.5 та до 75 % за сценарієм RCP8.5 порівняно з періодом до прояву змін клімату (до 1989 р.). Ці зміни необхідно враховувати при науковому обґрунтуванні проекту повернення водосховища Сасик до первинного статусу морського лиману для забезпечення таких умов водообміну з морем (з метою компенсації дефіциту водного балансу), які унеможливлять виникнення багаторічної тенденції засолення його вод.

Ключові слова: лиман Сасик, водний баланс, приплив прісних вод, кліматичні сценарії

Introduction

The urgency of providing estimates of freshwater inflows into the Sasyk estuary based on climate change scenarios in the 21st century is determined by the directions of the Strategy (IPCC, 2014) to reduce the climate change effects and consequences. This study is related to the existence of risks of the loss of biodiversity and the ecosystem functions and services of the Sasyk water body in the case of its renaturalization into the estuary owing to the reduced freshwater inflow in modern climate conditions and those expected in the 21st century. In the order of the President of Ukraine of 30 September 2019 on 'Sustainable Development Goals of Ukraine for the period up to 2030', "protection and restoration of terrestrial ecosystems and facilitation of their sustainable management…" in paragraph 15 is identified as one of the goals. The main task of this study is to substantiate the feasibility of restoration of the functioning of the Sasyk water body as an estuary, which in the last century for irrigation purposes was converted into a reservoir by separating it from the sea and desalination with the Danube waters. However, satisfactory water mineralization has not been obtained and now it functions as a freshwater ecosystem with low water quality (Tuchkovenko, 2011; Lozovitskyi, 2013; Lyashenko and Zorina-Sakharova, 2016). At present, fishery is the main consumer of ecosystem services.

The research object includes changes in the freshwater inflow from the rivers Kohylnyk and Sarata to the Sasyk reservoir (estuary) depending on climatic conditions and water management activities. The subject of research is the assessment of possible changes in the inflow of freshwater from the rivers Kohylnyk and Sarata into the lake under the climatic conditions of the first half of the 21st century.

The paper is aimed at an assessment of the possible inflow of freshwater to the Sasyk (estuary-reservoir) from the rivers Kohylnyk and Sarata and their role in formation of the freshwater balance of the estuary in the first half of the 21st century under RCP4.5 and RCP8.5 climate change scenarios.

Description of the Object

Historically, the Sasyk estuary was formed in the sea-flooded valley of the Kohylnyk and Sarata rivers and belonged to the closed estuaries at the North-Western Black Sea Region; these estuaries were separated from the sea by isthmuses and spits without permanent channels. The water area of the estuary is a pear-shaped, elongated from north to south, and about 29 km long. The average depth of the estuary reached 1.7 m. The estuary width varied from 3 km to 12 km. The length of the natural sand bar was 14 km, the width – 150-250 m. Water exchange with the sea occurred periodically during the outbreak of the sandbar due to natural factors (storms, and changes in water levels in the estuary and the sea). Mineralization of the Sasyk estuary waters from the late 19th to the first half of the 20th century ranged 12-28 g per dm^3, with the maximum values during periods of isolation of the estuary from the sea (Lyashenko and Zorina-Sakharova, 2016). Since 1958, when the estuary was connected to the sea through the Kundutska Prorva ('deep hole'), water mineralization varied from 2 g per dm^3 in the upper reaches of the estuary, to which the Kohylnyk and Sarata rivers flow, to 18 g per dm^3 in the water zones adjacent to the sandbar. On the coast of the estuary, there was a mud hospital.

In 1978, the Sasyk estuary was artificially separated from the sea by a dam through widening and strengthening the sandbar along which the highway now runs. The main purpose of this construction activity was to create a relatively deep freshwater reservoir on the flat terrain. Salt water was pumped from the estuary into the sea. Fresh water was supplied from the Danube River to the southern part of the estuary via the Danube-Sasyk Canal, 13.5 km long. Thus, the estuary was turned into an artificial lake.

After filling-up with fresh water, the reservoir should have been used for irrigation of agricultural lands at the Danube-Dniester interstream area. Water intake into the main canal of the Danube-Dniester irrigation system was performed in the north of the reservoir (Vyshnevskyi, 2000), whereto the rivers Kohylnyk and Sarata flow (Fig. 1). However, during the last two decades of the past century, a complete desalination of the reservoir did not occur owing to a number of miscalculations in the project. The water quality in the estuary currently remains unsatisfactory: a high mineralization of water is maintained, and the maximum permissible concentrations of chlorides, sulphates, heavy metals, phenols and pesticides

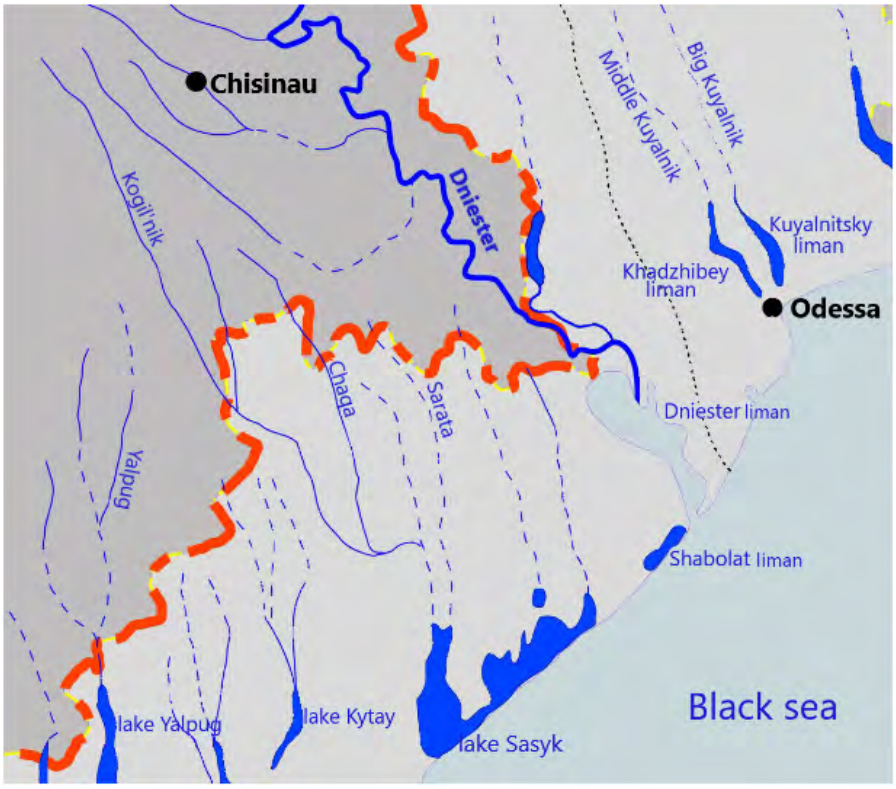

Fig. 1. A schematic map of the geographical location of the Sasyk estuary and its tributaries

in the water are exceeded. The waters of the Sasyk Reservoir are unsuitable both for drinking water supply, municipal and household consumption, and for irrigation. The water body ecosystem is characterized by such environmental problems as siltation, accumulation of contaminated suspended solids that come with the Danube water, accumulation and transformation of toxicants at all levels of the ecosystem, including hydrobionts; water-bloom with blue-green algae and, as a consequence, secondary pollution of the reservoir with organic compounds; accumulation of autochthonic organic matter, which is caused (along with the slow external water exchange) by the large volumes of nutrients coming from the Danube waters. These phenomena negatively affect fish farming, which developed intensively in the first decades of the reservoir's existence. In this regard, the administration of Odessa Oblast, upon the recommendation of research institutions of the National Academy of Sciences of Ukraine, decided to restore the ecosystem of the Sasyk estuary and rehabilitate the adjacent areas (2015). To implement such a solution, a scientific substantiation is needed. In this substantiation, it is important to assess the possible inflow of fresh water into the estuary from the rivers Kohylnyk and Sarata in the future, since the inflow of Danube water into it through the Danube-Sasyk canal will most likely be cut off owing to superfluous maintenance costs on the functioning of the canal and greater pollution of the Danube water compared to the sea water.

Materials and methods

The data of meteorological observations (average long-term monthly values of precipitation and air temperatures for the period from the beginning of observations to 1989) for 24 meteorological stations located within the North-Western Black Sea Region and southern Moldova, the data of meteorological observations in the period of 1989-2018, and forecast values of meteorological characteristics in the period of 2021-2050, 14 ensemble-averaged climate model simulations according to RCP4.5 and RCP8.5 scenarios under the EURO-CORDEX project (Evans, 2011), were used in the paper. The use of ensemble-averaged data results from the assumption that, in the 'average statistical trajectory' for each of the scenarios, the systematic errors of individual models are compensated under averaging (Loboda and Kozlov, 2020).

The method of the determining the annual runoff parameters in natural conditions and the conditions disturbed by water management activity is based on the 'climate-runoff' model, which uses meteorological data and water use indices as the inputs (Loboda, 2005). The model consists of two parts. The first part simulates the natural (undisturbed by hydroeconomic activity) annual runoff, using

meteorological data as the input data. The theoretical basis of the modelling is the equation of water-heat balance for the catchment area in the modification of V.S. Mezentsev, adapted to the conditions of Ukraine (Kaczmarek, 1993). The results of applying this part of the model to the calculations of water resources in Ukraine according to global warming scenarios were released in international publications in the late 1990s (Snizhko et al., 2012). A similar balance approach, presented in the Turk model (Turk, 1954), is used by the Polish hydrologist Z. Kaczmarek (Kaczmarek, 1993) to make forecasts of the changes in annual runoff under conditions of warming in the EU. Scientists S. Snizhko and I. Kuprikov used this model in Ukraine (Snizhko et al., 2012).

The second part of the 'climate-runoff' model is designed to determine municipal (transformed by hydroeconomic activity) runoff. The equations of hydroeconomic balances of the catchment area, given in a probabilistic form, are the theoretical basis of this part (Loboda and Phan Van Chinnh, 2004).

Calculations for the 'climate-runoff' model consist of the following stages. In the first stage, the zonal (climatic) runoff $\bar{Y}_C$ is defined by the isoline map. In the second stage, the natural $\bar{Y}_N$ or $\overline{W}_N$ (undisturbed by hydroeconomic activity) runoff is calculated. For rivers with a constant subterranean supply, natural and zonal runoff coincide. For small and medium-sized rivers, where there is a significant influence of the underlying surface, the coefficients of transition K_{trns} from zonal (climatic) to natural runoff are developed. These coefficients are identified depending on the average altitude (height) of a catchment area H_{trns}. In the third stage, the anthropogenic impact coefficients are calculated according to the data on the scale of hydroeconomic transformations and the climatic conditions. The calculated equations are realizations of the functions of anthropogenic impact. These functions are a generalization of the results of simulation stochastic modelling (Loboda and Gopchenko, 2006).

The 'climate-runoff' model was calibrated and tested on the data for many watersheds of diverse sizes located in various geographical zones of Ukraine. The advantage of the model is that it uses meteorological data at the input. Thus, the model can be applied both to the areas insufficiently studied in hydrological aspects and for making forecasts by climate change scenarios (Gopchenko and Loboda, 2001). The accuracy of identification of the average long-term values of annual climatic (zonal) runoff by the isoline map comprises ±10%.

The methods built on this model are included in the normative documents of the Republic of Moldova in the section on calculations of the annual runoff characteristics in the absence of observational data (ACDTRM, 2012). The 'climate-runoff' model is used for diagnostic calculations and forecasts of a runoff for the rivers, which supply the closed estuaries at the North-Western Black Sea Region, such as Tylihulskyi, Kuyalnytskyi and Khadzhybeiskyi (Tuchkovenko and Loboda, 2014; Loboda and Gopchenko, 2016; Loboda and Gryb, 2017).

To estimate the inflow of fresh water from rivers to the Sasyk estuary-reservoir, the following analytical functions (Gopchenko et al., 2014), which consider the effect of the main factors of water management transformations at the river catchment areas, were used. A coefficient of the influence of additional evaporation from the water surface of artificial reservoirs on the average long-term annual runoff $K'_{\bar{Y}}$ was calculated by the formula:

$$K'_{\bar{Y}} = e^{-\alpha_{\bar{Y}} f_R}, \qquad (1)$$

where f_R is the relative water surface area of artificial reservoirs, %; $\alpha_{\bar{Y}}$ is a coefficient that depends on the rate of annual natural runoff $\overline{Y}_N$.

To quantify the impact of irrigation from the Danube River, a coefficient of anthropogenic impact $K^n_{\bar{Y}}$ is defined by the following expression:

$$K^n_{\bar{Y}} = 1.0 + \alpha_{\bar{Y}} f_R + b_{\bar{Y}} v_0 + d_{\bar{Y}} \xi - m_{\bar{Y}} \eta \ , \qquad (2)$$

where f_R is the relative area of irrigated land in shares from the total catchment area; v_0 is a dimensionless parameter of the soil moisture level, average for the whole vegetation period, at which the development of the relevant crop is optimal (for the studied watersheds is equal to 0.9); ξ is a coefficient of return water from irrigated hydroeconomic areas, depending on their location in relation to the river course, which was set as equal to 1; η is an efficiency of the irrigation system, which was set as equal to 0.75; $\alpha_{\bar{Y}}, b_Y, d_Y, m_Y$ are coefficients that depend on the average long-term runoff $\overline{Y}_N$.

For the North-Western Black Sea Region, the accumulation of surface water in a large number of artificial reservoirs, most of which dry up almost every year, is of great importance.

The coefficient $K_{\bar{Y},F}$ characterizes the losses by filling artificial reservoirs with water and is defined as the ratio:

$$\frac{\overline{W}_N - \overline{W}_F}{\overline{W}_N} = \frac{\overline{W}_{MUN}}{\overline{W}_N} = K_{\bar{Y},F} \ , \qquad (3)$$

where $\overline{W}_N$ is the volume of natural runoff that enters the reservoirs or ponds at the catchment area;

$\overline{W}_F$ is the volume of filling; $K_{\overline{Y},F}$ is a coefficient of losses by filling of artificial reservoirs.

Calculations of the coefficient for the total impact of various anthropogenic factors $K_{\overline{Y},TOT}$ are performed:

when there are two factors indenified by the formula

$$K_{\overline{Y},TOT} = K'_{\overline{Y}} + K_{\overline{Y},F} - 1 \ , \quad (4)$$

when there are three factors indenified by the formula

$$K_{\overline{Y},TOT} = K'_{\overline{Y}} + K_{\overline{Y},F} + K''_{\overline{Y}} - 2 \ . \quad (5)$$

The average long-term value of municipal runoff is identified by the formula

$$\overline{W}_{MUN} = K_{\overline{Y},TOT} \cdot \overline{W}_N \ , \quad (6)$$

Where $\overline{W}_{MUN}$ is the volume of river runoff transformed by water management activity; $\overline{W}_N$ is the volume of natural runoff.

To define the contribution of freshwater inflow to the formation of the water regime at the Sasyk reservoir, in the case of its renaturalization to the initial status of the estuary, the fresh water balance equation was used. Precipitation on the water level of the reservoir and the inflow of freshwater from the catchment area of the estuary with the runoff of rivers are input components of the balance. Evaporation from the water surface of the estuary is the output component. The discrepancy of water balance is calculated by the equation:

$$\delta W = W_P + W_R - W_E \ , \quad (7)$$

where δW is a discrepancy (deficit or surplus) of annual fresh water balance, million m^3 per a year; W_P is a volume of precipitation that fell on the water surface of the estuary, million m^3 per a year; W_R is a volume of water inflow to the estuary with a runoff of the Kohylnyk and Sarata rivers, million m^3 per a year; W_E is a volume of water evaporated from the water surface of the estuary per a year, million m^3 per a year.

Assessment of the annual layer of evaporation from the water surface of the estuary-reservoir at a first approximation was performed by means of the calculation formula (Ivanov, 1954), based on the data on long-term average monthly values of temperature and relative humidity:

$$E = 0.018(25 + T_a)^2 (100 - R) \ , \quad (8)$$

where E is an evaporation layer (mm per a month); T_a is a long-term average monthly air temperature (°C); R is a long-term value of the average monthly relative humidity (%).

Research results and discussion

The catchment area of the Kohylnyk River is 3910 km^2, and this of the Sarata River is 1250 km^2. The average altitudes of the catchments are 130 m and 100 m, respectively. The coefficients of transition from climatic to natural runoff is equal to 0.55 for the Kohylnyk River and 0.46 for the Sarata River.

Estimates of the freshwater inflow into the Sasyk reservoir under natural conditions of runoff formation were performed for diverse calculation periods. The period before 1989 is the baseline. In accordance with the research by V.V. Grebin, the year of 1989 was recognized as a crucial in the pattern of fluctuations in air temperatures over the flat terrain of Ukraine (Grebin, 2010). The period of 1989-2018 corresponds to the beginning of significant climate change. The period of 2021-2050 is considered for two climate change scenarios RCP4.5 and RCP8.5. Each of the scenarios includes 14 runs under the EVRO-CORDEX project. The ensemble-averaged data from simulations are used in the paper.

The prognosticated changes in the average long-term zonal runoff in the period of 2021-2050 according to the RCP4.5 and RCP8.5 climate scenarios (Fig. 2, Fig. 3) allowed us to conclude that there is a tendency to reduction in the water resources of rivers at the Danube-Dniester interfluve, including the Kohylnyk and Sarata rivers, in the future. If the reduction of water resources at these rivers in natural conditions of runoff formation owing to climate change has been only 8 % in the modern period (Table 1), in the coming decades it will reach 23.5 % (RCP4.5) or 38.5 % (RCP8.5).

Estimates of municipal runoff at various calculation intervals were provided using the anthropogenic impact coefficients calculated by equations (1-5). In the last century, the rivers Kohylnyk and Sarata were the part of the Danube-Dniester irrigation system (Lozovitskyi, 2010). The irrigation of agricultural areas with Danube water taken from the Sasyk Reservoir was the main factor in hydroeconomic activity. The coefficient of return water impact $K''_{\overline{Y}}$ was equal to 1.2 for the river Kohylnyk (the relative area of irrigation by Danube waters f_{IR} was 1.3 % of the total catchment area), and 2.8 for the river Sarata (f_{IR} = 6.2 %). The total coefficient of anthropogenic impact $K_{\overline{Y},TOT}$, including irrigation from local runoff and losses by additional evaporation, was 0.99 and 2.7 for each river, respectively. The significant water inflow from the courses of the Kohylnyk and Sarata rivers, owing to irrigation by the Danube waters, had negative features: these waters were mineralized and did not contribute

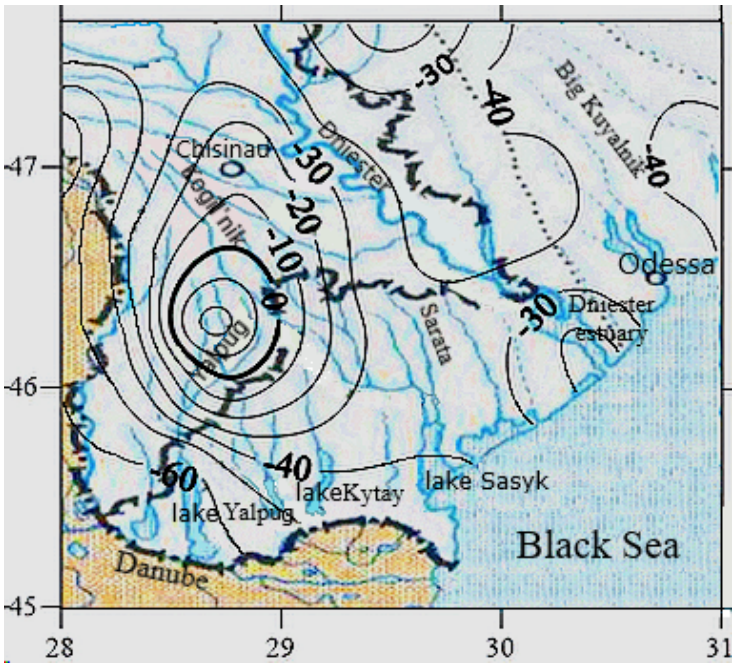

Fig. 2. Changes of the average long-term zonal annual runoff in the space (by the average statistical model of RCP4.5 pathway) for the period of 2021-2050, compared to the basic data before 1989.

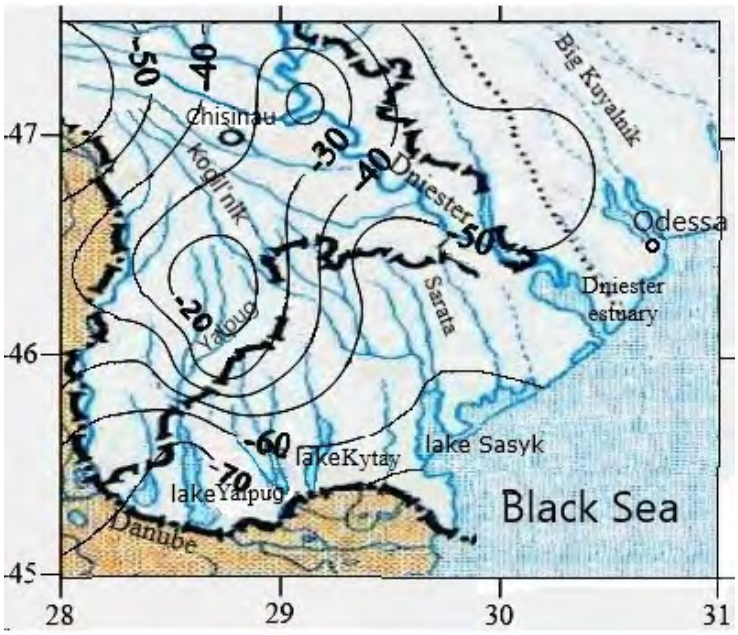

Fig. 3. Changes of the average long-term zonal annual runoff in the space (by the average statistical model of RCP8.5 pathway) for the period of 2021-2050, compared to the basic data before 1989.

to desalination of the estuary (Bloshl et al., 2019).

In the modern period, there is virtually no irrigation of agricultural areas within the Kohylnyk and Sarata catchment areas with Danube waters. According to the Basin Administration for Water Resources of Rivers at the North-Western Black Sea Region and the Lower Danube, the water surface area at the Kohylnyk River catchment area makes up 0.866 thousand ha, the volume of artificial reservoirs is 11.43 million m^3, and the relative water surface area is 0.22 %. At the catchment area of the Sarata River, the total volume of artificial reservoirs equals to 3.89 million m^3, and the relative water surface area is 0.33 %.

The results of identification of the volume of municipal runoff for RCP4.5 and RCP8.5 pathways are given in tables 2 and 3. Analysis of the dynamics of changes in river water inflow in the context of hydroeconomic transformations (Table 4, Fig. 4) showed that the presence of artificial reservoirs within catchment areas intensifies the reduction in water resources at the studied rivers and their capacity to provide the fresh water inflow into the reservoir.

Table 1. Estimates of the average long-term volumes of natural annual runoff, identified by the climate-runoff model, for various calculation periods

River	$\overline{W}_N$, million m³			
	Before 1989, a baseline period	1989-2018	2021-2050 RCP4.5	2021-2050 RCP8.5
Kohylnyk	58.2	53.6	45.1	36.6
Sarata	9.78	8.40	6.90	5.18
Total inflow	68.0	62.0	52.0	41.8
Changes in freshwater inflow, %	-	-8.82	-23.5	-38.5

Table 2. Assessment of the average long-term value of freshwater inflow in the period of 2021-2050 according to the scenario RCP4.5 in the runoff formation conditions disturbed by hydroeconomic activities

River	$\overline{W}_N$, million m³	Volume of artificial reservoirs, million m³	f_R, %	Coefficients of anthropogenic impact $K_{\overline{Y}}$ under various factors of hydroeconomic activity			$\overline{W}_{MUN}$, million m³
				$K_{\overline{Y},F}$	$K'_{\overline{Y}}$	$K_{\overline{Y},TOT}$	
Kohylnyk	43.9	11.4	0.22	0.74	0.95	0.69	30.3
Sarata	6.9	3.89	0.33	0.44	0.90	0.34	2.35
The total inflow							32.6

According to UN recommendations, a more than 50 % reduction in the average long-term annual runoff leads to the destruction of water resources, and a more than 75 % reduction – to their irreversible destruction. Under the development of climatic events by the RCP8.5 scenario while maintaining the current level of anthropogenic pressure, it is possible to lose the rivers Kohylnyk and Sarata as sources of freshwater supply to the Sasyk estuary-reservoir.

In case of the renaturalization of the Sasyk estuary-reservoir and the restoration of its natural status as the estuary, the inflow of Danube water into the water body through the Danube-Sasyk canal will most likely be stopped, since this entails extra costs to ensure operation of the canal and the related hydraulic structures. Therefore, the annual freshwater balance of the estuary will be defined by the equation (7), i.e. without regard to the inflow of Danube waters. According to the results of calculations of its components (Table 5), in the first half of the 21st century there had already been an increase in the water balance deficit from – 9.7 million m³ per a year in the period until 1989 to – 35.2 million m³ per a year in the period of 2000-2018, and its further increase to 62.5 million m³ per year in the period of 2021-2050 is expected under the RCP4.5 scenario and to 74.2 million m³ per year under the RCP8.5 scenario.

It is important to notice that the results obtained are in good agreement with the research of other authors. The paper (Bloshl et al., 2019) shows that according to the data of 1960-2010 a decrease in water runoff comprising 5 % per decade is typical for the studied area. This is accounted for by the increased air temperatures in winter and their transition from negative to positive values. The forecasts of climate change in Ukraine according to 8 global models of the RCP8.5 scenario for the periods of 2041-2070 and 2071-2100 illustrate the continuation of the decreasing trends until the end of the 21st century. In the Danube-Dniester interfluve, the average long-term precipitation will fluctuate during the century within ±10 %. The average annual air temperature will rise up to 4 Celsius degrees in 2041-2070 and up to 5 Celsius degrees in 2071-2100 (Didovets et al., 2020). As a result of rising air temperature and subsequent rise in evaporation and reduction of fresh water inflow from the catchment area, in the Sasyk estuary-reservoir there will be an increase in the deficit of annual freshwater balance, which, according to the estimates given in the Table 5, will comprise 62 % in the period of 2021-2050 under the RCP4.5 scenario and 75 % under the RCP8.5 scenario, compared to the baseline period before 1989. If this deficit is not compensated, there is a long-term trend for reduction in the volume of estuaries, their shallowing and, as a consequence, there is an increase in salinity and deterioration of water quality (the increased concentrations of nutrients and pollutants, the deteriorated oxygen regime, etc.) for traditional types of nature management (Tuchkovenko and Loboda, 2017).

Table 3. Assessment of the average long-term value of freshwater inflow in the period of 2021-2050 according to the scenario RCP8.5 in the runoff formation conditions disturbed by hydroeconomic activities

River	$\overline{W}_N$, million m³	Volume of artificial reservoirs, million m³	f_R, %	Coefficients of anthropogenic impact $K_{\overline{Y}}$ under various factors of hydroeconomic activity			$\overline{W}_{MUN}$, million m³
				$K_{\overline{Y},F}$	$K'_{\overline{Y}}$	$K_{\overline{Y},TOT}$	
Kohylnyk	36.6	11.4	0.22	0.69	0.945	0,64	23,4
Sarata	5.18	3.89	0.33	0.24	0.88	0,12	0,622
The total inflow							24.0

Table 4. Estimates of the average long-term volumes of municipal annual runoff, identified according to the climate-runoff model, for various calculation periods

River	$\overline{W}_N$, million m³				
	Before 1989 with regard to donor irrigation	Until 1989 without regard to donor irrigation	1989-2018	2021-2050 RCP4.5	2021-2050 RCP8.5
Kohylnyk	57.6	44.2	39.7	30.3	23.4
Sarata	26.4	4.99	3.78	2.35	0.622
Total inflow	84.0	49.2	43.5	32.6	24.0

There are two ways to stabilize the hydrological and hydroecological regimes of 'closed' estuaries, to which the Sasyk belongs, in the context of climate change: (1) – restoration of the natural runoff of rivers that supply the estuary with fresh water; (2) – provision of water exchange of the estuary with the sea through artificial connecting canals ('sea-estuary' canals) with a delivery capacity that will ensure the necessary flushing of the estuary with seawater (Tuchkovenko and Loboda, 2017). Comparison of data on the volume of natural (Table 1) and municipal (Table 4) runoff of the Kohylnyk and Sarata rivers, expected in the period of 2021-2050, with the values of the deficit of fresh water balance of the estuary (Table 5) shows that the first way is not capable to solve the problem for the Sasyk estuary. When implementing the second way, it should be taken into consideration that the climate change, which occurred and is expected in

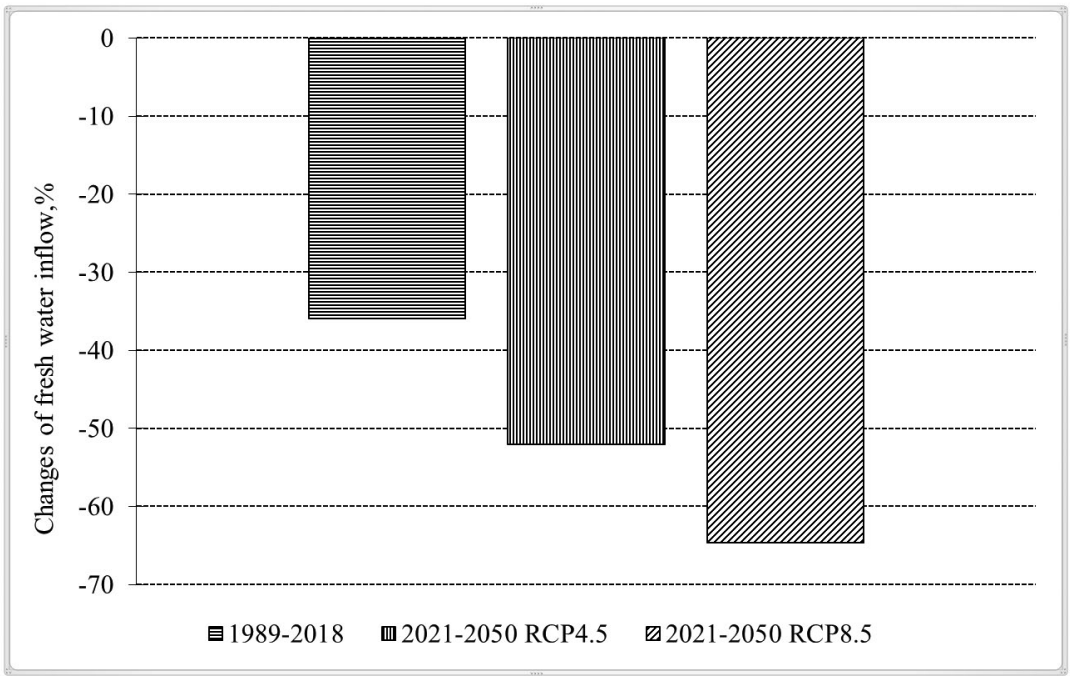

Fig. 4. Changes in the average long-term inflow of fresh water from the Kohylnyk and Sarata rivers into the Sasyk estuary-reservoir under various climatic conditions compared to the baseline period (before 1989)

Table 5. Estimates of the components of the annual freshwater balance of the Sasyk estuary and its deficit for various calculation periods

Item №	Calculation period	W_P, million m³ per a year	W_R, million m³ per a year	W_E, million m³ per a year	δW, million m³ per a year
1	Before 1989	99.3	49.2	158.2	-9.7
2	2000-2018	100.5	34.0	169.7	-35.2
3	2021-2050 RCP4.5 pathway	88.2	32.6	183.3	-62.5
4	2021-2050 RCP8.5 pathway	84.9	24.0	183.1	-74.2

the 21st century, in particular a significant increase in the freshwater balance deficit of the water body, leads to a completely different hydrological situation than that observed before the transformation of the Sasyk estuary into a freshwater reservoir in the seventies of the 20th century. The issue of ensuring the delivery capacity of the 'sea-estuary' artificial canal (canals), which will provide not only compensation for the deficit of freshwater balance of the estuary by seawater, but also the required speed of its flushing, takes on particular relevance. Methodical approaches to finding solution for this problem are considered in (Kushnir and Tuchkovenko, 2020).

Conclusions

1. According to the 'climate-runoff' model developed by OSENU (Odessa State Environmental University), the estimates of freshwater inflow from the Kohylnyk and Sarata rivers to the Sasyk estuary are provided. The current and potential inflows are defined for various climatic conditions and for various factors of hydroeconiomic activity (irrigation due to local runoff, irrigation due to the donor river, losses by additional evaporation from the water surface of artificial water bodies, losses by filling of artificial reservoirs). The meteorological data (average monthly precipitation and air temperatures according to both observational data and climate change scenarios) and information on the scale of water management transformations at the catchment areas are the input to the model. Based on the application of the 'climate-runoff' model, the average long-term parameters of natural and municipal runoff of the Kohylnyk and Sarata rivers are identified for diverse calculation periods, which correspond to certain climatic conditions and predominant factors of hydroeconiomic activity.

2. It is found that in the period of 2021-2050, owing to the expected changes in the regional climate, the total inflow of freshwater from rivers to the estuary-reservoir will decrease by 23.5 % (according to the scenario RCP4.5) and by 38.5 % (according to the RCP8.5 pathway) compared to the baseline period (before 1989). By virtue of the total impact of artificial reservoirs and regional climate change, the total inflow of freshwater from rivers to the reservoir will decrease by 52.1 % (according to RCP4.5) and by 64.7 % (according to RCP8.5) compared to the baseline period of natural runoff (before 1989).

3. It is defined that in case of renaturalization of the Sasyk Lake into the estuary and the water inflow cut-off from the Danube River, the changes in climatic conditions expected in the first half of the 21st century, combined with water management activity, will result in the increased deficit of annual freshwater balance of the Sasyk reservoir up to 62 % under the RCP4.5 scenario and up to 75 % under the RCP8.5 scenario compared to the period before the emergence of climate change (before 1989). This change must be considered in scientific substantiation of the project on a reversion of the Sasyk Reservoir to the original status of the estuary to ensure such conditions of water exchange with the sea (with the aim of compensation of the water balance deficit), which will prevent the long-term trend of salinization of its waters.

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Analysis of the monopolization level of raw material exports of Ukraine

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Abstract. The formation of a competitive national economy of Ukraine is hindered by a weak system of monopoly control. The activities of oligarchic clans stimulated political lobbying, illegal influence on the management of independent enterprises, their raider capture, which led to a slowdown in Ukraine's technical progress, an increase in the hidden economy and a decrease in its efficiency. The current trend of increasing exports of raw materials and the monopolization of major export industries makes Ukraine's economy even more dependent on the activities of several monopolists. The aim of this work was to analyze the level of monopolization of the main Ukrainian export categories – agricultural and iron industry production. Methods of this study were based on analysis of literature of the national authors, systematization and generalization of data of the State Statistics Service of Ukraine, the Antimonopoly Committee of Ukraine and other open sources. The study found that the agricultural sector of the Ukrainian economy has a dual structure – corporate (agricultural holdings) and individual farms (family farms and households), which are characterized by different directions of development. The analysis of the regional presence of agricultural holdings showed that the largest landowners cultivate land plots in almost all regions of Ukraine. At present time in the agro-industrial sector of Ukraine corporate landowners control 18.4% of arable land, exist in the form of vertically integrated holdings specializing in the cultivation of export-oriented crops. The study found that specific location of minerals explains the geographical location of iron industry enterprises in Dnipro, Donetsk, Poltava and Zaporizhia regions. However, the geography of the place of registration of these holdings or their parent companies includes Cyprus, the United Kingdom, the Netherlands and Switzerland. The group of companies Metinvest occupies an informal monopoly position in the market of ore mining and steel production in Ukraine. Thus, the main items of Ukraine's exports are under control or are significantly influenced by a small number of vertically integrated holdings, which may indicate a low level of competition. In these circumstances, one of the most important functions of the state in this area is to maintain a competitive environment and limit monopolies. At the same time, the lack of quality legislation does not allow the state to fully regulate and influence the real situation in the country.

Keywords: agricultural products, export, monopolization, iron industry

Аналіз рівня монополізації сировинного експорту України

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Анотація. Формуванню конкурентоспроможної національної економіки України перешкоджає слабка система контролю монополізації. Діяльність олігархічних кланів стимулювала політичне лобіювання, протизаконний вплив на керівництво незалежних підприємств, їх рейдерське захоплення, що призвело до уповільнення технічного прогресу України, зростання рівня тіньової економіки та зниження її ефективності. Існуюча тенденція до збільшення експорту сировини та монополізація основних галузей експорту ставить економіку України ще в більшу залежність від діяльності кількох монополістів. Метою даної роботи був аналіз рівня монополізації основних галузей експорту України – продукції сільського господарства та чорної металургії. З'ясовано, що аграрному сектору економіки України властива дуальна структура – корпоративні (агрохолдинги) та індивідуальні господарства (сімейні ферми та господарства населення), яким властиві різноспрямовані напрямки розвитку. Аналіз регіональної присутності агрохолдингів показав, що найбільші компанії-землевласники обробляють земельні ділянки майже в усіх областях України. Показано, що на даний момент в агропромисловому секторі України склалася ситуація, за якої корпоративні землевласники контролюють 18,4% оброблюваних земель, існують у вигляді вертикально інтегрованих холдингів, які спеціалізуються на вирощуванні експортно-орієнтованих культур. Показано, що специфіка розташування корисних копалин пояснює географічне розташування підприємств чорної металургії в Дніпропетровській, Донецькій, Полтавській та Запорізькій областях. Проте, географія місця реєстрації цих холдингів або їх материнських компаній, які ведуть основну діяльність в Україні, включає в себе Кіпр, Великобританію, Нідерланди та Швейцарію. Неформальне монопольне

становище на ринку видобутку руди та виробництва сталі в Україні займає група компаній «Метінвест». Таким чином, головні статті експорту України є підконтрольними або підпадають під значний вплив невеликої кількості вертикально інтегрованих холдингів, що може свідчити про низький рівень конкуренції. В даних умовах однією з найголовніших функцій держави в даній сфері є підтримка конкурентного середовища та обмеження монополізму. Водночас, відсутність якісного законодавства не дозволяє державі повною мірою регулювати та впливати на реальну ситуацію в країні.

Ключові слова: продукція сільського господарства, експорт, монополізація, чорна металургія

Introduction

Ensuring the competitiveness of the domestic economy is one of the most pressing issues over the past 30 years. Ukraine remains an outsider in the global competitiveness ranking, lagging far behind in many macroeconomic parameters and in the business environment, market monopolization, institutional and legislative level not only from developed countries but also from countries with transformational economies (Fyliuk, 2015).

The process of monopolization of the economy is controversial. On the one hand, monopolies have more opportunities to develop production, finance research, create and implement innovations. Monopolies are more large enterprises, which are characterized by the highest efficiency and lowest production costs. However, monopolies set monopolistically high prices and in a situation of weakening or lack of competition inhibit scientific and technological progress (Kovalchuk, 2013). State-created monopolies governed by administrative means and monopolies created by oligarchic financial-industrial groups based on the principle of monopoly niches are a real threat to Ukraine's competitiveness. The biggest negative consequences of this situation are the rapid decline in competitive advantage for most industries in the country (Chernelevs`ka, 2014).

The formation of a competitive national economy of Ukraine is also hindered by a weak system of monopoly control. According to the Antimonopoly Committee of Ukraine, the markets of crop and livestock products, certain branches of light industry, construction services, most of financial activity services are characterized as markets with a competitive structure, and markets for mobile services, coke, gasoline, beer have an oligopolistic structure (Krykunova, 2014). The restraint of demonopolization of certain markets in the domestic economy is explained by the use of administrative resources, which significantly complicates the development of competition. Thus, during the years of independence, the Cabinet of Ministers of Ukraine consolidated state assets and created state joint-stock companies in the mining and mining industries, medical and microbiological industry, oil and gas industry, elevator, flour and cereals and fodder industry, as well as 24 companies in the engineering industry (Chernelevs`ka, 2014).

At the same time, there is a growing influence of informal monopolies operating through non-market instruments through the pooling of power and capital (Lahutin, 2012). A significant part of monopolized commodity markets in Ukraine is formed due to natural monopolies in such industries as electricity, communications, transport and utilities (Kovalchuk, 2013). At the same time, the activities of oligarchic clans stimulated political lobbying, illegal influence on the management of independent enterprises, their raider seizure, which led to a slowdown in Ukraine's technical progress, increasing the shadow economy and reducing its efficiency (Taranych, 2019). The country failed to realize an investment and innovation breakthrough, to reform the structure of the economy in the direction of knowledge-intensive industries, which was a consequence of the monopolization of strategically important markets for economic growth and economic security (Fyliuk, 2015).

Since the 1990s, Ukraine's foreign trade has been characterized by excessive dependence on raw material exports. During the period of 2015-2019, the basis of exports was represented by agricultural products (primarily crop production) and ferrous metallurgy, which averaged 57.78% of the total exports of goods (Ukrstat). Given the specifics of these industries, they are characterized by the creation of vertically integrated associations of enterprises, which encourages the consolidation of such associations in one hand. Thus, the current trend towards increasing exports of raw materials and the monopolization of major export industries puts Ukraine's economy even more dependent on the activities of several monopolists.

The purpose of this work was to analyze the level of monopolization of the main exports of Ukraine - agricultural products and ferrous metallurgy.

Materials of the article and methods of research

Analytical and analytical-statistical research methods are used in the work, in particular, analysis of literature of domestic authors, systematization and generalization of data of the State Statistics Service of Ukraine, the Antimonopoly Committee of Ukraine and other open sources.

Results and their analysis

Attracting investment, as one of the main tasks of reforming the agricultural sector, in the conditions of Ukrainian agriculture was realized by the expansion of large capital, and the existing corruption component created a specific model of agriculture. In this structure, it is possible to distinguish two types of producers: corporate (agricultural holdings, vertically integrated structures, business associations, etc.) and individual (farmers and households) (Borodina & Prokopa, 2012).

Since the 2000s, the formation of corporate capitalism and the capitalization of agricultural production has begun in the agricultural sector of Ukraine's economy. This was based on the concentration of agricultural land and the attraction of industrial capital, which became possible as a result of legislative changes in the formation of holding structures, including in the field of production and processing of agricultural products. Holding companies were formed by the acquisition of one business entity by another in the privatization process. At the same time, some enterprises (metallurgical, coal mining, financial industries, etc.) were included in the agro-industrial sector, receiving part of the illiquid property as payment of debt (Ghutorov, 2012).

A comparative analysis of statistical data on sowing results provided by producers of three categories - OSG (personal farms), farmers and holdings - showed that as of June 1, 2019, the total number of companies that reported sowing was 38.451 thousand (table 1). OSG sowed 8.393 million hectares, and legal entities - 19.449 million hectares. Farms in the amount of 38.268 thousand (which was less by 1.133 thousand compared to 2018) managed 15.9 million hectares, which was 81.6% of the total crop area. At the same time, holdings increased the arable land to 3.6 million hectares, which was 18.4%, respectively (AgroPolit.com, 2019).

At the same time, the existing dual structure of the agricultural sector is characterized by different directions of development of its individual parts - corporate and individual farms (family farms and households) have occupied their niches (Borodina & Prokopa, 2012).

Individual farms work in a low-cost and labor-intensive niche - growing potatoes, vegetables, fruits, dairy farming, etc. - and are aimed at meeting the needs of the population and filling the domestic food market. However, it was individual farms that provided production of up to 60% of gross agricultural output throughout the transformation period of the Ukrainian economy. The corporate sector monopolizes resource markets, especially financial ones, sales channels, and produces export-oriented, commercially attractive products. In addition, it has an influence on the formation of state agricultural policy and has access to state support (Borodina & Prokopa, 2012).

This is partially confirmed by statistical data on the dependence of production volumes and the size of the enterprise in the cultivation of major export crops of Ukraine in 2019 (Fig. 1). Thus, enterprises with a sown area of 2.000 hectares produce 41.5% and 36.1% of the total production of cereals, legumes and corn, respectively. In the case of wheat cultivation, this figure is 18.3%. Enterprises with sown areas from 200 ha to 2000 ha grew a total of 66.1% of wheat (Ukrstat).

Table 1. Comparative characteristics of the area of sowing crops by different types of agricultural producers (AgroPolit.com, 2019)

	The size of the crop area, ha	Quantity, pcs	Crop area, ha	% of the total area of crops
Farms	До 500	31097	3047501	15.7
	500-1000	2688	1930809	9.9
	1000-5000	4130	8546973	43.9
	5000-10000	353	2351952	12.1
Holdings	10000-20000	92	1213451	6.2
	20000-50000	59	1748738	9.0
	<more than 50000	9	609267	3.1

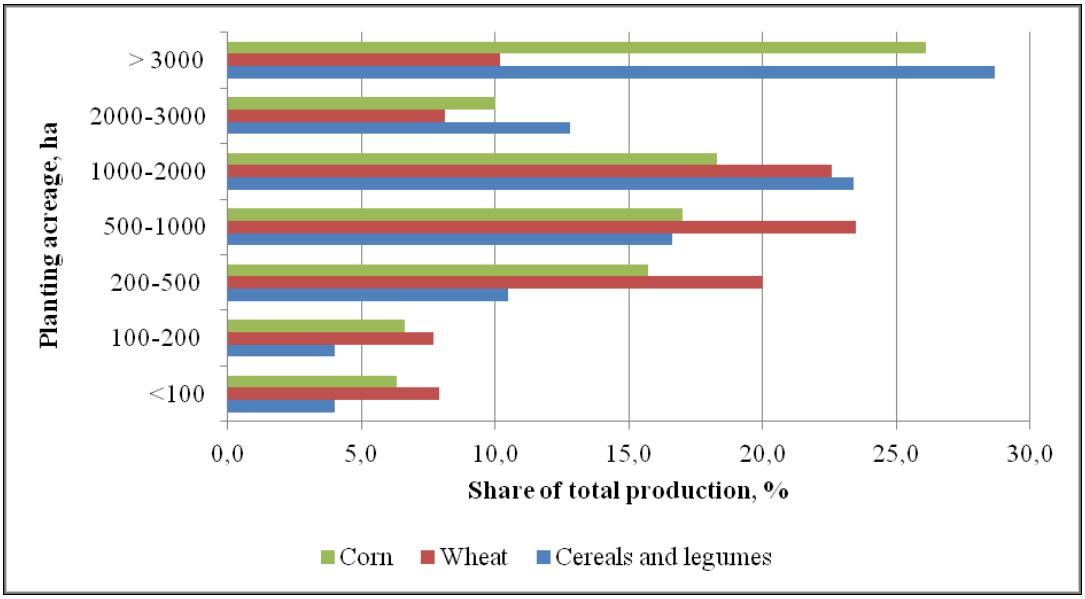

Fig.1. Dependence of production volumes and size of the enterprise when growing major export crops in 2019 (Ukrstat)

In addition, the capabilities of corporate agro-industrial enterprises allow for significant research and implementation of innovative approaches and technologies. Despite the fact that one of the typical features of small sized foreign farms, especially family type, is a higher yield per hectare, in Ukraine the situation is reversed (Fig. 2). According to Ukrstat, in 2019 the yield per 1 hectare grew with the increase in the size of the enterprise. This is less observed in

Analysis of the largest agro-industrial holdings as of 2020 is shown in the table.2. The first ten largest agricultural holdings in Ukraine have a total land bank of 2.660 million hectares, while the first three have 1.400 million hectares (latifundist.com).

The analysis of the regional presence of agricultural holdings showed that the largest landowners cultivate land plots in almost all regions of Ukraine. Some holdings with a land bank of less than

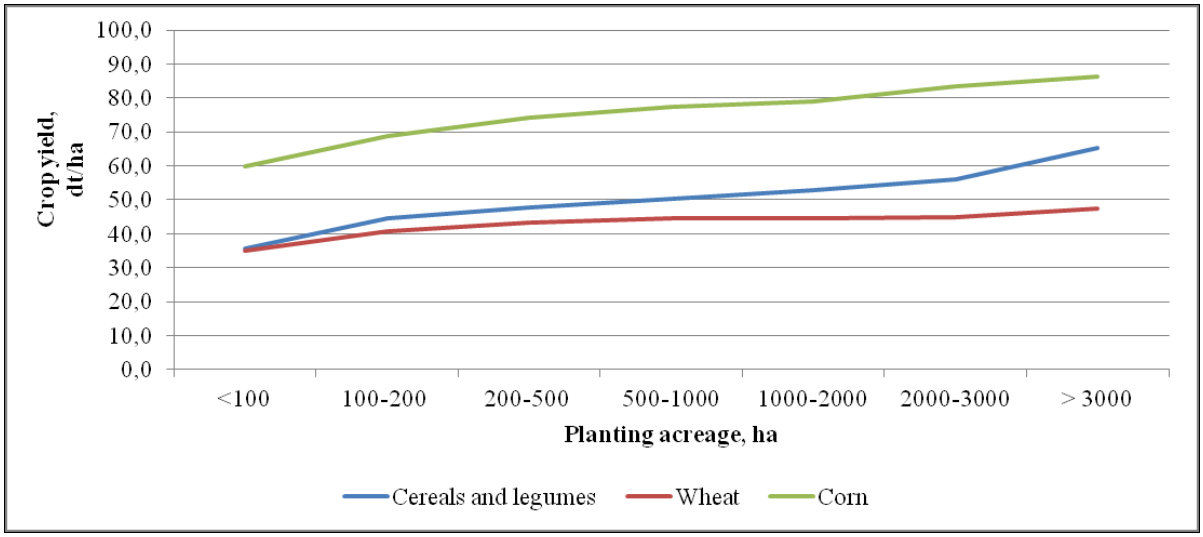

Fig.2. Yield of the main export crops depending on the area of crops of the enterprise in 2019 (Ukrstat)

the example of wheat cultivation, but the yield of corn and grain crops at enterprises larger than 3000 ha is higher by 30.5% and 45.3% (Ukrstat). Agricultural holdings tend to monocultural production, and their focus on foreign markets leads to the displacement of labor-intensive crop and livestock products, imbalance of local agricultural complexes and food markets (Kyrylov, 2014; Gheec, 2010).

200.000 hectares have a certain regional consolidation. For example, Continental Farmers Group's activities are limited to the western region, HarvEast plots are concentrated in Donetsk and two northern regions, Industrial Dairy Company is present in the north-eastern region, and Ukrprominvest cultivates land in the central and south-western regions of Ukraine.

Having analyzed the above, at present in the

Table 2. The largest agro-industrial holdings of Ukraine by land bank, 2020 (latifundist.com)

Name of the holding	Land area, thousand ha	Regional location	Owner
Kernel	530	Ternopil, Odessa, Mykolaiiv, Kirovohrad, Cherkasy, Poltava, Sumy, Chernihiv, Kharkiv, Dnipro, Khmelnytsky regions	Andriy Verevsky
Ukrlandfarming	500	22 regions of Ukraine	Oleg Bakhmatyuk
Myronivsky HP	370	Kyiv, Cherkasy, Poltava, Sumy, Dnipro, Donetsk, Kherson, Vinnytsia, Ivano-Frankivsk regions	Yuri Kosyuk
Agroprosperis	300	Sumy, Chernihiv, Kharkiv, Poltava, Vinnytsia, Zhytomyr, Khmelnytsky, Ternopil, Rivne, Volyn and Lviv regions	"NCH Capital" (George Rohr and Maurice Tabasinique)
Astarta-Kyiv	235	Poltava, Vinnytsia, Ternopil, Khmelnytsky, Kharkiv, Cherkasy, Chernihiv and Zhytomyr regions	Victor Ivanchyk
Continental Farmers Group	195	Ternopil, Khmelnytsky, Ivano-Frankivsk, Chernivtsi, Lviv regions	SALIC Ltd. (Saudi Arabia)
Epicenter K	160	Cherkasy, Khmelnytsky, Kyiv, Ternopil and Vinnytsia regions	Galyna Gerega and Oleksandr Gerega
HarvEast	127	Donetsk, Kyiv and Zhytomyr regions	"System Capital Management" (Rinat Akhmetov) and "Smart Holding" (Vadim Novinsky)
Industrial dairy company	123	Poltava, Chernihiv, Sumy regions	Oleksandr Petrov
Ukrprominvest-Agro	120	Vinnytsia, Zhytomyr, Cherkasy, Poltava, Dnipropetrovsk and Kirovohrad regions	"Ukrprominvest" (Petro Poroshenko)

agro-industrial sector of Ukraine there is a situation in which corporate landowners control 18.4% of arable land. However, these companies exist in the form of vertically integrated holdings that specialize in growing export-oriented crops. In connection with the adoption of the Law on the Land Market No 2178-10, the existing agricultural holdings will have the opportunity to further increase the land bank.

The second largest goods export group after agricultural products are metallurgical industry products. The structure of exports of metallurgical products is characterized by a significant share of semi-finished products, i.e. products with low added value. Thus, semi-finished products accounted for 43% of total exports of hardware in 2018 (Hrynko & Androsova, 2019). In general, the structure of production of the main categories of products of the metallurgical complex for 2019 is shown in the Fig.3. Compared to 2018, the production of cast iron decreased by 2.4%, steel - by 1.2%, and rolled metal - by 0.9% (Ukrmetalurgprom, 2020).

In contrast to the agricultural sector, the specifics of this industry determines the presence of large enterprises in the first place. The modern metallurgical industry of Ukraine is represented by large diversified groups of companies in the form of vertically integrated, horizontally integrated and conglomerate business groups (Kasianchuk, 2016). This can be explained by the fact that the creation of vertically integrated companies based on mining, coke and metal, allows to reduce VAT by almost two times, which is reflected in a 20 percent reduction in unit cost. That is, the vertical integration of metallurgical industry structures reduces tax, management and technical costs (Plavshuda, 2013).

At the same time, privatization processes that accompany the creation of holding structures primarily satisfy the private interests of the owners of these enterprises and deprive the state of the opportunity to influence this area (Plavshuda, 2013). Thus, the constant influence of lobbyists on the Verkhovna Rada and the Cabinet of Ministers of Ukraine facilitated the adoption of laws, regulations and other regulations, which allowed some enterprises of the mining and metallurgical sector to receive installments of some payments to the budget at various levels, reduced tax deductions, etc. Mazur & Skoroxod, 2009). At the same time, the funds saved were not used for the development and construction of production capacity, especially during periods of extremely high prices for raw materials and ferrous metallurgy products and, consequently, surplus profits (for example, in 2010 the annual profit from iron ore exports alone was about 4 billion USD.) (Mazur, 2016). As a result, insufficient modernization and loss of industrial capacity in Donbass (approximately 3.3 million tons of steel per year) (Hrynko & Androsova, 2019) led to a decrease in steel production by 53.04 between 2008

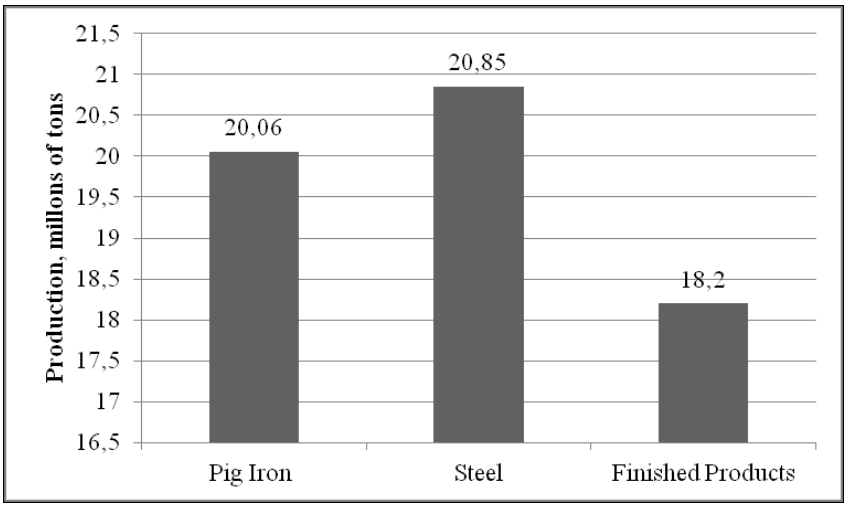

Fig. 3. Production of the main categories of products of the metallurgical complex for 2019 (Ukrmetalurgprom, 2020).

and 2018. %, from 42.8 million tons to 20.1 million tons annually (World Steel Association).

As of 2018, in the market of ferrous metallurgy of Ukraine the dominant position is occupied by several largest holdings (Table 3). The specific location of minerals explains the geographical location of ferrous metallurgy enterprises. The main areas for their concentration are Dnipropetrovsk, Donetsk, Poltava and Zaporizhia regions. However, the geography of the place of registration of these low rents for iron ore mining and are subsidized by Ukrzaliznytsia (Gholovnjov & Vinnichuk, 2019). However, this holding reflected the crisis situation in the metallurgical industry that has developed in the Ukrainian market in recent years - in 2017, Metinvest for the first time in its history showed losses, while only profit was recorded before (Hrynko & Androsova, 2019).

Most The majority of other companies in the industry are integrated into the holding structures

Table 3. The largest enterprises in ferrous metallurgy of Ukraine (Gholovnjov & Vinnichuk, 2019)

Name of Company	Total income, billion UAH, 2018	Regional location	Owner
Metinvest	323	Dnipro, Donetsk, Luhansk, Zaporizhia regions	“System Capital Management” (Cyprus, Rinat Akhmetov) and “Smart Holding” (Netherlands, Vadim Novinsky)
ArcerolMital Kryvyi Rih	68	Dnipro region	ArcerolMittal, Luxembourg
Ferrexpo	35	Poltava region	Kostiantyn Zhevago, registered in Switzerland
Interpipe	29.2	Dnipro region	“EastOne”, (Great Britain, Victor Pinchuk)

holdings or their parent companies, which have their core business in Ukraine, includes Cyprus, the United Kingdom, the Netherlands and Switzerland. Thus, most metallurgical enterprises in Ukraine are owned or controlled by large financial and industrial groups (Hrynko & Androsova, 2019).

The Groups of companies Metinvest holds an informal monopoly position in the market of ore mining and steel production in Ukraine and in 2018 was the largest company in Ukraine; however, some sources claim that the privatization of the holding’s assets took place without competition and at a reduced cost, and the group’s companies pay extremely of individual businessmen (Konstantin Zhevago, Viktor Pinchuk) and the international corporation ArcerolMital. Thus, one of the main items of raw material exports of Ukraine is fully controlled by individual holdings owned by oligarchs and foreign companies.

Some studies argue that to address the situation in the metallurgical industry, first of all, it is necessary to create a state regulatory organization, the purpose of which should be to develop regulations for metallurgical enterprises, cooperation with investors to attract innovation, ensure the introduction of new energy-saving technologies and environmental

protection technologies, purchase of new equipment that will stimulate the production of high quality products and will change the existing paradigm of dependence on exports of raw materials and low competitiveness in international markets (Hrynko & Androsova, 2019).

The experience of the world leader in metallurgy - China can also help Ukraine in this situation. Establishing a full production cycle in the country, deepening research, improving the technical and engineering base, expanding intersectoral cooperation, especially with the chemical industry will improve the properties of steel and cast iron (Hrynko, 2013).

Conclusions

The monopoly of certain sectors of the economy destroys competition as the basis of market self-regulation. In the Ukrainian economy, the main export items - products of agriculture, mining and metallurgical complexes - are controlled or subject to significant influence of a small number of vertically integrated holdings, which may indicate a low level of competition. In these circumstances, one of the most important functions of the state in this area is to maintain a competitive environment and limit monopolies. At the same time, the lack of quality legislation does not allow the state to fully regulate and influence the real situation in the country.

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Mineralogical justification for potentiality of producing marketable hematite products

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Abstract. Hematite quartzites are a product of weathering of magnetite quartzites, which make up the ferruginous horizons of deposits of the Precambrian banded-iron formation. They occur all over the planet. The largest deposits are found in the iron-producing areas and basins of Central Kazakhstan, the Kursk magnetic anomaly, the Karelian-Kola region, Western Australia, Southeastern India, Brazil, the United States, and Canada. The geological and mineralogical issues of hematite quartzites as raw materials for producing concentrate and sinter ore have been studied most deeply and comprehensively for the deposits of the Kryvyi Rih basin and Central Kazakhstan. However, when developing an effective scheme for producing high-quality metallurgical raw materials, the mineralogical features of hematite ores have been taken into account insufficiently. The aim of the authors of the present work was to study the localization, structure of deposits and mineral composition of hematite quartzites as raw materials for sinter ore and concentrate production. Data from geological observations and mineralogical studies were used as source material. Proven geological, mineralogical, petrochemical methods were used. In accordance with the obtained results, the hematite quartzites are composed of ore-forming (quartz, hematite) and secondary (relict and newly formed) minerals. The total content of the hematite and quartz exceeds 90 mass %. The peculiarity of Ushkatyn III deposit ores is the high content of manganese oxides. The depth of distribution of the weathering crust composed of hematite quartzites varies from 200 to 1000 m. The hematite quartzites' bodies are characterized by a zonal structure. Their central parts are represented by martite-micaceous hematite, micaceous hematite-martite quartzites; intermediate ones by martite quartzites; peripheral parts – by dispersed hematite-martite, kaolinite-martite-dispersed hematite quartzites. The horizons differ in the quantitative ratio of these varieties. The quantitative ratio of mineral varieties of hematite quartzites, morphology of individuals and aggregates of ore-forming and secondary minerals, their chemical composition and physical properties must be taken into account when developing the optimal technology for the production of high-quality hematite concentrate.

Key words: Precambrian banded-iron formation, hypergenesis, hematite quartzite deposits, mineralogical zonation

Мінералогічне обгрунтування можливості виробництва гематитових товарних продуктів

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Анотація. Розглянуті питання локалізації, будови та складу гематитових кварцитів Валявкинського родовища (Криворізький басейн) та родовища Ушкатин III (залізорудний район Каражал) як первинної сировини для виробництва високоякісних товарних гематитових продуктів. Охарактеризовані процеси мінералогічних перетворень вихідних метаморфогенних магнетитових кварцитів, поклади яких у поточний час розробляються гірничозбагачувальними комбінатами Центрального Казахстану, Курської магнітної аномалії, Карело-Кольського району, Криворізького басейну та інших регіонів планети. Показано, що найбільш глибоко та всебічно питання мінералогічного обгрунтування збагачуваності гематитових кварцитів розглянуті для родовищ Криворізького басейну. Потужність кори вивітрювання їх залізорудних товщ, складеної гематитовими кварцитами, коливається від 50 до понад 2500 м. Автори виконали детальні геологічні, мінералогічні дослідження покладів гематитової сировини. Встановлено, що поклади гематитових кварцитів зосереджені, головним чином, в корі вивітрювання четвертого, п'ятого, шостого залізистих горизонтів саксаганської світи Валявкинського родовища та залізорудної товщі родовища

Ушкатин ІІІ. Для всіх їх властива мінералогічна зональність, проявлена закономірною зміною в напрямку від центральних до периферійних частин горизонтів верств гематитових кварцитів наступного мінерального складу: мартит-залізнослюдкові – залізнослюдко-мартитові – мартитові – дисперсногематит-мартитові – каолініт-мартит-дисперсногематитові. Гіпергенна зональність наслідує первинну аутигенну метаморфогенну зональність цих залізистих горизонтів. Мінеральний склад зазначених п'яти різновидів гематитових кварцитів аналогічний в розрізах усіх досліджених рудних покладів. Відміна полягає в різному кількісному співвідношенні мінеральних різновидів у розрізах залізистих горизонтів. Рудоутворювальні мінерали гематитових кварцитів – кварц і гематит, представлений трьома морфологічними різновидами (мартит, залізна слюдка, дисперсний гематит). Їх загальний вміст перевищує 90 мас.%. Другорядними є реліктові (магнетит, матаморфогенні силікати, карбонати, сульфіди) та новоутворені (гетит, каолініт) мінерали. Мінералогічні особливості гематитової сировини та хімічні, фізичні показники рудоутворювальних і другорядних мінералів необхідно враховувати при розробці оптимальної схеми виробництва високоякісної металургійної сировини.

Ключові слова: докембрійська залізисто-кремниста формація, гіпергенез, поклади гематитових кварцитів, мінералогічна зональність

Introduction

Hematite (martite) quartzites are the product of weathering of magnetite quartzites, which are currently mined in many regions of the world as a raw material for producing iron ore (magnetite) concentrate. Industrial deposits of hematite quartzites occur in the iron ore strata of most deposits of the Precambrian banded-iron formation. Their distribution is mainly controlled by two factors: 1) the effective action of hypergenic factors on primary magnetite quartzites; 2) the intensity of erosion of iron ore strata weathering crust under formation. The most significant reserves and resources of hematite raw materials were identified at the Karazhal deposit (Central Kazakhstan), Lebedinsky, Mikhailovsky and other deposits of the Kursk magnetic anomaly, Olenegorsk deposit of the Kola iron ore district, Kryvyi Rih basin (Ukraine), Hamersley deposits (Western Australia), the Quadrilátero Ferrífero (Brazil), the Upper Lakes (USA), etc. In the CIS countries, the problem of the use of hematite quartzites has been studied most deeply and comprehensively for the Kryvyi Rih basin deposits (Demchenko, 2018; Evtekhov, 2016; Prilepa, 2019; Tsypin, 2015).

Currently, the problem of the use of hematite raw materials at the mining and beneficiation enterprises of Kryvbas is being studied in connection with the increase in the level of integrated use of the mineral mass extracted from the subsoil. The priority directions involve the operation of deposits of hematite (oxidized) quartzites in order to produce sinter ore and concentrate . In the course of mining operations, hematite quartzites are extracted as overburden and accumulated at specially organized stockpiles (Southern Mining and Beneficiation Plant (YUGZK), ArselorMittal Kryvyi Rih (AMKR) Mining and Beneficiation Complex, or are stocked at waste dumps (Inhulets, Central, Nothern GZKs).

The depth of the weathering crust of different Kryvbas deposits varies from less than 50 m in areas of crust distribution to more than 2,500 m in areas of linear weathering crust along discontinuous faults (Dodatko, 1973; Yurk, 1960). .

The Skeliuvatka (Southern GZK) and Valyavkinske (AMKR GZK) hematite quartzite deposits belonging to the Southern iron ore region of the Kryvbas are recognized to be the priority for the development. The explored reserves of hematite raw materials here exceed 2 billion tons. The deposits were considered to be the raw material base for oxidized ores GZK (GZKOR).

The authors studied the bodies of hematite quartzites of the Valyavkinske deposit in detail, the explored reserves of which make up about 25 mass % of its productive stratum. The depth of distribution of the weathering crust of magnetite quartzites varies from 200-250 m in the southern part to 700-800 m in the northern part of the deposit. A significant part of the hematite raw material (about 400 million tons) was extracted from the subsoil and is stored in two stockpiles. Reserves in the subsoil are about 500 million tons. The average iron content in hematite quartzites is about 37 mass %.

Since the 1960s attempts have been made to use hematite raw materials on a commercial scale. Concentration plants were designed and built on the basis of magnetic technology for beneficiating low grade hematite ores: roasting-magnetic plant for beneficiating hematite quartzites of Central GZK, Kryvyi Rih GZKOR, section №10 of the beneficiation plant #2 of AMKR GZK. The obtained results showed that it is impossible to obtain hematite concentrate with an iron content of more than 60-61 mass % in industrial conditions by the method of wet magnetic separation. The suggested repreparation of the rough concentrate by the method of reverse flotation contributed to the increase of the iron content in the final concentrate to 64-65 mass %. Thus, flotation recovery does not allow a high quality concentrate to be obtained (67-69 mass %).

The technology of wet gravitational beneficiation with the use of conical and spiral separators has proved to be the most effective. In the Kryvbas, it is

implemented in three industrial plants with a capacity of up to 1 million tons of raw materials per year, it allows hematite concentrate to be obtainined with iron content of not less than 65 mass %. Semi-industrial tests were also conducted for the ores of the Karazhal, Ushkatyn III deposits.

The results of laboratory and industrial tests of the authors of the present work showed the fact that it is possible to produce the end-product with various iron content from hematite quartzite deposits of Karazhal iron ore region, Southeast India, Kursk magnetic anomaly, Kryvyi Rih basin and similar deposits from other regions depending on the selected technologies for ore preparation and beneficiation: low-grade sinter ore (total iron content 55-57 mass %), ordinary sinter ore (58-60%), high-quality sinter ore (60-62%), sinter concentrate (62-64%), ordinary concentrate (64-66 %), high-quality concentrate (67-69%).

The **goal** of the authors of this work was to study the localization, structure of deposits and mineral composition of hematite quartzites as raw materials for the production of sinter and concentrate using the example of the Valyavkynske deposit in the Kryvbas and the Ushkatyn III deposit in Central Kazakhstan.

Source material and research methods

The results of geological observations and mineralogical studies of hematite quartzites of these deposits were used as source material. Proven geological and mineralogical methods were used.

Research results

The *Valyavkinske deposit* of ferruginous quartzites is located in the southwestern part of the Kryvyi Rih structure (Fig. 1). The rocks of the Skeliuvatka, Saksagan and Hdantsivka suites of the Kryvyi Rih Paleoproterozoic series occur in its structure. The Novokryvorizka and Hleyuvatka suites within the deposit boundaries have not been opened up (Belevtsev, 1962; Svital'skyi, 1932; Shcherbak, 1988).

Geology of hematite raw material deposits. Geologically, the deposits of hematite raw materials of the Kryvbas and Central Kazakhstan are similar, represented by layers, lenses of hematite quartzites, which alternate with layers of low-ore, ore-free rocks. They differ in age - Paleoproterozoic deposits of the Kryvbas, Paleozoic - Central Kazakhstan and mineral composition: the deposits of Central Kazakhstan are characterized by manganese-iron ore specialization. The genesis of both iron ore basins is volcanic-sedimentary.

As the main object, the authors have chosen the more deeply and comprehensively studied deposits of the Saksagan suite of the Kryvbas.

The Saksagan suite is represented by six schistose and six ferruginous horizons. The thickness of the weathering crust of the first, second and third ferruginous and first, second, third, fourth schistose horizons does not exceed 50-70 m. The main deposits of hematite ores belong to the fourth, fifth, sixth ferruginous horizons.

The fourth ferruginous horizon is characterized by a thickness of 260 to 540 m, 392 m on average. Up to a depth of 200 to 400 m it is composed of hematite quartzites, below it – of magnetite quartzites, which are currently mined as raw materials for producing magnetite concentrate. The horizon is characterized by the heterogeneity of the mineral composition, structural and textural features of the ores, corresponding to the features of the authigenic mineralogical zonation of ferruginous horizons (Evtekhov, 1971; Lazarenko, 1977; Strakhov, 1962). The central zones of the horizon are represented by micaceous hematite-magnetite, the intermediate ones – by magnetite, peripheral zones – by cummingtonite-magnetite and magnetite-cummingtonite quartzites. In this direction, the texture of ores naturally changes, from thin-bedded to medium-bedded and wide-bedded. The average value of the total iron content ($Fe_{tot.}$) is about 37 mass %, the iron content in the magnetite ($Fe_{magn.}$) makes up about 32 mass %.

There was a change in the mineral composition of ores in the weathering crust due to iron oxidation. The section of the horizon here in the same direction is as follows: micaceous hematite-martite → martite → dispersed hematite-martite → kaolinite-martite-dispersed hematite quartzites. In the upper parts of the weathering crust there is an intense goethitization of ferruginous quartzites to a depth of 30 m. The textural features of the ores are preserved. The average value of the total iron content due to its poor mobility in the weathering crust is almost unchanged, it makes up 37.2 mass %, the iron content in the magnetite varies from less than 1 mass % (in the upper part of the weathering crust) to 15 mass % (in the lower part).

The fifth schistose horizon is composed of alternating layers of barren quartzites and graphite-containing schists of muscovite-chlorite-cummingtonite-quartz-biotite composition. The thickness of the horizon varies from 20 to 50 m.

The fifth ferruginous horizon for the entire depth of deposit development (up to 700 m) is composed of weathering products of magnetite-micaceous hematite, micaceous hematite-magnetite, magnetite, cummingtonite-magnetite and magnetite-cummingtonite quartzites. The presence of powerful layers of magnetite-micaceous hematite quartzites in the central parts of the fifth ferruginous horizon is dissimilar

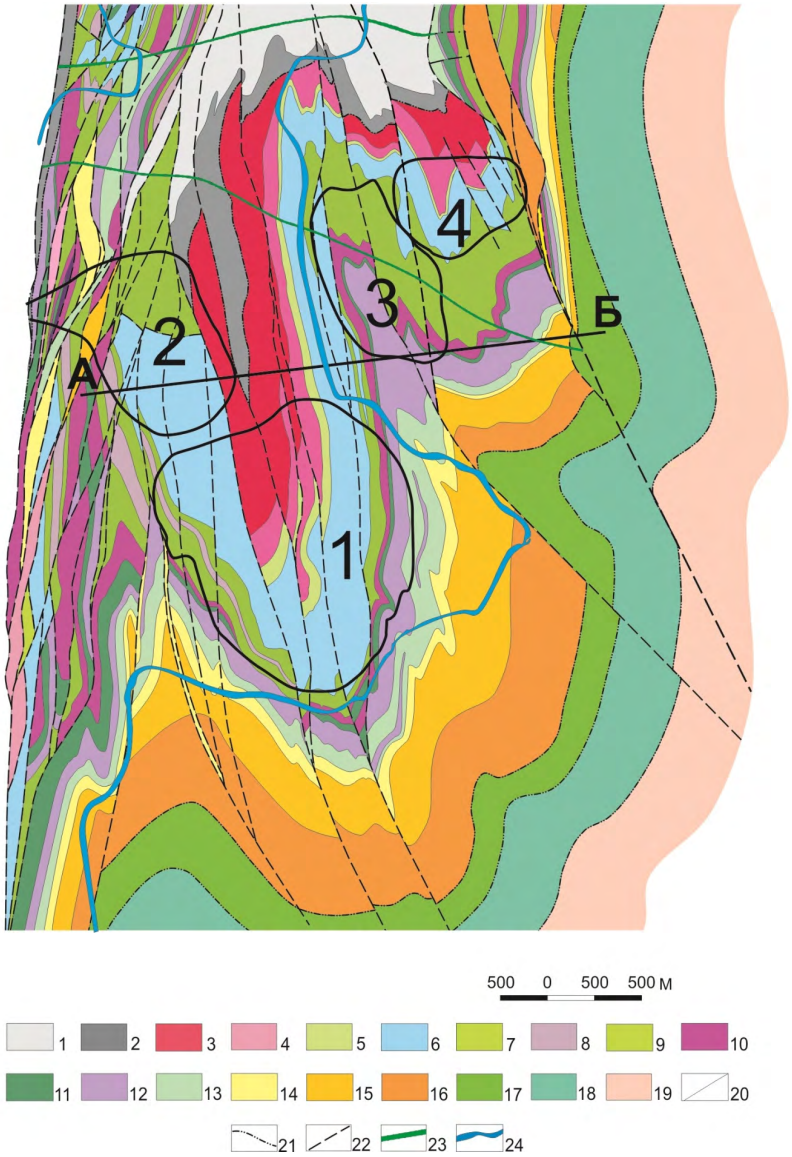

Fig. 1. Geological map of the area of the Skeliuvatka and Valyavkynske deposits.

1-17 – Kryvyi Rih series: 1-2 – Hdantsivka suite: 1 – metaclastolites and dolomite marbles of the upper subsuite; 2 – metaclastolites and high-grade iron ores of the lower subsuite; 3-13 – Saksagan suite: 3, 4 – hematite quartzites of the sixth (3) and fifth (4) ferruginous horizons; 5, 7, 9, 11, 13 – schists with interlayers of barren quartzites of the fifth (5), fourth (7), third (9), second (11) and first (13) schistose horizons; 6 – magnetite quartzites of the fourth ferruginous horizon; 8, 10, 12 – magnetite-silicate and silicate-magnetite quartzites of the third (8), second (10) and first (12) ferruginous horizons; 14-16 – Skelyuvatka suite: 14 – talc-containing schists of the upper subsuite; 15 – quartz-muscovite schists (phyllites) of the middle subsuite; 16 – muscovite quartzites, metaconglomerates (arcoses) of the lower subsuite; 17 – metaclastolites with interlayers of amphibolites of the Novokryvorizka suite; 18 – amphibolites with interlayers of metaclastolites of the Konka series; 19 – granitoids of the Dnipropetrovsk complex; 20 – contact lines of stratigraphically conformably occurring strata; 21 – contact lines stratigraphically inconsistent with the strata; 22 – faulting; 23 – diabase dykes; 24 – the bed of the river Ingulets.

Iron ore quarries: 1 - Skelyuvatsky of the Southern GOK; 2, 3, 4 - (respectively) Valyavkynsky, Novokryvorizhsky-2, Novokryvorizhsky -1 GOK of the AMKR plant.

AB is the line of the reference section of the productive stratum of the Southern iron ore district of Kryvbas.

to the fourth and sixth ferruginous horizons. In the weathering crust, these magnetite-containing ferruginous quartzites are transformed into martite-micaceous hematite, micaceous hematite-martite, martite, dispersed hematite-martite, and kaolinite-martite-dispersed hematite quartzites. The ores of the fifth ferruginous horizon are characterized by a micro- (less than 2 mm) and thin-bedded (2-5 mm) texture. The average iron content in ferruginous quartzites of the weathering crust is slightly higher than the corresponding indicators of the fourth and sixth ferruginous horizons making up about 38 mass %. The average iron content in the magnetite is about 4 mass %. The thickness of the horizon varies from 50 to 150 m.

The sixth schistose horizon is also composed of hypergenically altered ferruginous rocks – low-ore dispersed hematite-martite, martite, and ore-free quartzites, which are often intensely marshalitized. Silicate, quartz-silicate interlayers of initial rocks have been converted into kaolinite-dispersed hematite-quartz ones. The thickness of the horizon varies from 10 to 50 m.

The sixth ferruginous horizon completes the section of the Saksagan suite of the deposit. Its section is similar to the section of the fourth ferruginous horizon. At a depth of up to 700 m, the original magnetite-containing ferruginous quartzites are replaced by hematite varieties. Its constituent rocks are also intensely hypergenically altered. The texture of ores is medium-bedded, more rarely thin-bedded and wide-bedded. The average content of $Fe_{tot.}$ is 36.7 mass %, that of $Fe_{magn.}$ is 0.8% in hematite quartzites of the horizon. The thickness of the horizon within the boundaries of the deposit is from 200 to 500 m.

The mineral composition of hematite quartzites of the fourth, fifth and sixth ferruginous horizons of the Valyavkinske deposit is relatively simple due to the hypergenic replacement of polymineral associations of primary metamorphogenic magnetite quartzites by their hypergenic hematite varieties:

– magnetite has been replaced by hematite (martite);

– iron-free carbonates (calcite, dolomite, etc.) have been completely dissolved;

– iron-containing carbonates (siderite, sideroplesite, pistomessite, etc.) have partially been dissolved (calcium, magnesium components), the iron component has been replaced by dispersed hematite or dispersed goethite;

– iron sulfides (pyrite, pyrrhotine, etc.) have been replaced by dispersed hematite or dispersed goethite; sulfur in the form of sulfur dioxide passed into solution;

– alumina-free silicates (cummingtonite, ferrous talc (minnesotaite), celadonite, etc.) have been replaced by an aggregate of fine-crystalline quartz (chalcedony, opal) and dispersed hematite (dispersed goethite); the calcium and magnesium ions, which are a part of them, passed into solution;

– alumina-containing silicates have been replaced by fine crystalline aggregate of quartz, dispersed hematite (dispersed goethite) and kaolinite (Lazarenko, 1977; Martynenko, 1971; Yurk, 1960).

Thus, polymineral aggregates of initial metamorphogenic magnetite ores have been replaced by bimineral (hematite + quartz) or trimineral (hematite + quartz + kaolinite) associations of hypergenic hematite ores; in the upper parts of the weathering crust – by trimineral (hematite + quartz + goethite) or four-mineral (hematite + quartz + kaolinite + goethite) associations.

Due to incomplete substitution, relic magnetite has been preserved in hematite ores in an amount of from less than 1 to 15 mass %. The average content of $Fe_{magn.}$ as a part of hematite raw materials of all three studied ferruginous horizons is 4.2 mass %.

Hematite is represented by three morphological varieties: martite (a granular variety), iron mica (a lamellar, scaly variety) and dispersed hematite (a fine-crystalline, pulverized variety); goethite – by two of them: proper goethite (dripstone metacolloid aggregates) and dispersed goethite (fine-crystalline, pulverized variety). Occasionally lepidocrocite is present in goethitized hematite quartzites. The magnetite content, as noted above, increases with depth. Its relict sharply xenomorphic buildups are usually present in the central parts of martite aggregates (Martynenko, 1971; 1932; Yurk, 1960).

Quartz is the leading nonmetallic mineral. The amount of relict silicates (cummingtonite, biotite, chlorite, celadonite, etc.) and iron carbonates (sideroplesite, pistomesite, ferrodolomite, dolomite, calcite, aragonite, etc.) gradually increases with depth. Accessory minerals include sulfides (pyrite and less commonly pyrrhotine and cellular pyrite), zircon, apatite, tourmaline, garnet, etc.

Hematite quartzites of all three ore bodies are also divided according to the main textural feature – the thickness of the interlayers into: microbedded (jaspilite-like ones) (the thickness of the interlayers is less than 2 mm); thin-bedded (2-5 mm); medium-bedded (5-10 mm); wide-bedded (10-20 mm); coarsely-bedded (20-50 mm); giant-bedded (more than 50 mm).

The quantitative ratio of mineral varieties of hematite quartzites in the ore bodies of the three ferroginous horizons, which has been determined from detailed geological exploration data, operational exploration data and topomineralogical studies conducted by the authors, of the faces of the Valyavkynskyi open-pit, is given in Table. 1.

Fig. 2 shows schematic sections of the fourth, fifth and sixth ferruginous horizons. As can be seen, they are represented by the same mineral varieties of hematite quartzites, but differ in quantitative ratio. The fifth ferruginous horizon is characterized by the maximum prevalence of micaceous hematite-containing varieties, and the fourth and sixth ones are characterized by prevalence of martite varieties.

The ore mined in the open-pit and accumulated in stockpiles contains mineral varieties of low-grade hematite ores of the three studied ferruginous horizons in the amount determined not only by the natural ratio

Table 1. Quantitative ratio (mass %) of mineral varieties of hematite quartzites in the ore bodies of the fourth, fifth and sixth ferruginous horizons

Mineral varieties of ferruginous quartzites	Stratigraphic horizons		
	the fourth ferruginous	the fifth ferruginous	the sixth ferruginous
martite-micaceous hematite	2.9	12.7	8.5
micaceous hematite-martite	12.8	26.8	20.7
martite	44.1	35.3	37.9
dispersed hematite-martite	29.0	18.1	23.6
martite-dispersed hematite, kaolinite-martite-dispersed hematite	11.2	7.2	9.3

of hematite raw materials in the subsoil, but also by the dynamics of stripping conducted in different directions of open-pit development. Petrographic study of the material of hematite quartzite stockpiles showed that the following quantitative ratio of the main mineral varieties of low-grade hematite ores (volume %) can be expected in the primary hematite quartzite raw material of the beneficiation plant of the Valyavkynske deposit: martite-micaceous hematite quartzites; micaceous hematite-martite quartzites – 19.3; martite quartzites – 36.9; dispersed hematite-martite quartzites – 23.9; martite-dispersed hematite quartzites – 8.1. The average content of diluting non-metallic impurities (schists of different composition, silicate quartzites) in the ore material is 4.8% by volume.

Mineralogy of ores. *Martite-micaceous hematite quartzites* are the product of weathering of the original magnetite-micaceous hematite quartzites (Fig. 3a). They form layered, less often lenticular bodies which are up to 50 m thick, spatially tend to the central zones of the studied ferruginous horizons. The ores are strong, relatively easily cleave along lamination. The structure is microcryptocrystalline and fine-crystalline. The texture is micro-bedded, rarely thin-bedded and medium-bedded. The quantitative ratio of ore-forming and secondary minerals is given in Table 2.

Micaceous hematite-martite quartzites are the product of weathering of the original micaceous hematite -magnetite quartzites. They are represented by embedded bodies, which are up to 50 m thick, spatially tend to the central zones of the studied ferruginous horizons. The ores are strong, in the areas of marshalitization the strength decreases significantly, the ore becomes loose. The structure is microcryptocrystalline and fine-crystalline. The texture is thin-bedded, rarely micro- and medium-bedded.

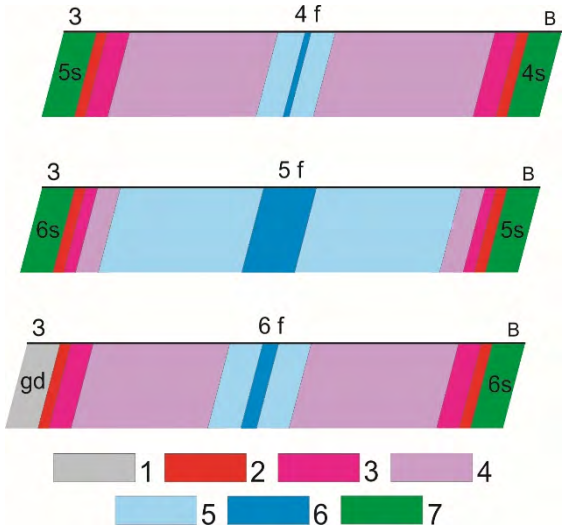

Fig. 2. The scheme of horizontal zonation of hematite quartzite deposits of the fourth, fifth and sixth ferruginous horizons of the Valyavkynske deposit.

Stratigraphic horizons of the Saksagan suite: 4s – the fourth schistose; 4f – the fourth ferruginous; 5s – the fifth schistose; 5f – the fifth ferruginous; 6s – the sixth schistose; 6f – the sixth ferruginous; gd – Hdantsivska suite.

Mineral varieties of ferruginous quartzites and other rocks: 1 – metaclastolites of the Hdantsivska suite; 2 – martite-micaceous hematite quartzites; 3 – micaceous hematite-martite quartzites; 4 – martite quartzites; 5 – dispersed hematite-martite quartzites; 6 – martite-dispersed hematite, kaolinite-martite-dispersed hematite quartzites; 7 – cummingtonite-siderite-chlorite-quartz-biotite schists of the fourth, fifth and sixth schistose horizons.

Table 2. The average mineral composition (vol.%) of hematite quartzites of the fourth, fifth and sixth ferruginous horizons

Minerals	Mineral varieties of hematite quartzites				
	MrMhs	MhsMr	Mr	DhMr	MrDh
quartz	51.4	51.1	50.2	49.7	48.8
martite	19.5	27.1	3,3	29.2	16.2
micaceous hematite	2.8	12.4	2.5	0.3	0.0
dispersed hematite	0.6	0.8	2.1	8.1	17.1
magnetite	2.7	2.9	3.0	2.9	2.5
goethite	2.9	3.1	3.4	3.5	3.9
dispersed goethite	0.5	0.7	1.1	2.0	3.8
carbonates	0.8	0.9	1.1	1.3	0.9
apatite	0.1	0.1	0.1	0.2	0.2
kaolinite, beidellite	0.1	0.2	0.5	1.9	5.4
pyrite, cellular pyrite	0.1	0.1	0.1	0.1	0.2
other minerals	0.5	0.6	0.6	0.8	1.0
Total	100.0	100.0	100.0	10.,0	10.,0

Other minerals: hydromicas, chlorite, cummingtonite, celadonite, stilpnomelane, Fe-talc (minnesotaite), garnet, zircon, tourmaline, chloritoid, gypsum, jarosite, lepidocrocite, chalcedony, opal.

Mineral varieties of hematite quartzites: MrMhs – martite-micaceous hematite; MhsMr – micaceous hematite-martite; Mr – martite; DhMr – dispersed hematite-martite; MrDh – martite-dispersed hematite.

Martite quartzites are the product of weathering of the original magnetite quartzites (Fig. 3b). They form embedded bodies with a thickness of up to 70 m in the sections of the fifth and sixth ferruginous horizons and up to 150-200 m of the fourth ferruginous horizon. In the primary magnetite quartzites micaceous hematite or silicates (cummingtonite, chlorite, biotite) occurred in an amount of up to 5 mass %. In this regard, martite quartzites contains both weathering-resistant micaceous hematite and dispersed hematite, which is the product of hypergenic changes of silicates. The ore is strong, cleaves poorly along lamination. The structure is microcryptocrystalline and fine-crystalline. The texture is bedded, due to the alternation of ore (quartz-martite) and non-ore (quartz, micaceous hematite-quartz, dispersed hematite-quartz) interlayers. The medium-bedded texture predominates, thin- and wide-bedded texture is less common. Manifestations of coarse- and giant-bedded texture are rare.

Dispersed hematite-martite quartzites were formed as a result of hypergenic changes of the initial silicate-magnetite quartzites. They form layered bodies with a thickness of up to 30 m in the section of the fifth ferruginous horizon, up to 50 m in the section of the sixth ferruginous horizon and up to 80 m in the section of the fourth ferruginous horizon. They spatially tend to the peripheral zones of the horizons. The ores have reduced strength, cleave well along lamination due to the layer-by-layer presence of dispersed hematite. The structure is microcryptocrystalline and fine-crystalline. The texture is wide-bedded, less often medium- and coarsely bedded. Manifestations of thin- and giant-bedded texture are rare.

Martite-dispersed hematite quartzites are the product of weathering of the original magnetite silicate quartzites. In the layers that prior to weathering contained up to 30% or more by volume of chlorite, biotite and other alumina-containing silicates, kaolinite is present in an amount of more than 5% by volume. Martite-dispersed hematite quartzites form layered bodies, which are up to 10 m thick in the section of the fifth ferruginous horizon, up to 15 m in the section of the sixth ferruginous horizon and up to 20 m in the section of the fourth ferruginous horizon. They compose the extreme peripheral zones of the horizons. The ores have medium strength, cleave well along lamination. The structure is microcryptocrystalline and fine-crystalline. The texture is wide-bedded, less often coarse- and medium-bedded.

Diluting non-metallic impurities. Due to the suboptimality of drilling-and-blasting and mining technologies, low-ferruginous rocks are present in the material of hematite raw material stockpiles. The most common are chlorite-cummingtonite-quartz-biotite (Fig. 3c) schists and monomineral silicate quartzites of the fourth, fifth, and sixth schistose horizons. Fragments of vein quartz in monomineral form or in intergrowth with hematite quartzites are noticed less often (Fig. 3d).

The Ushkatyn III deposit is part of the Zhairem ore district (Brusnitsyn, 2018). In terms of mineral and petrographic composition of the productive stratum, it

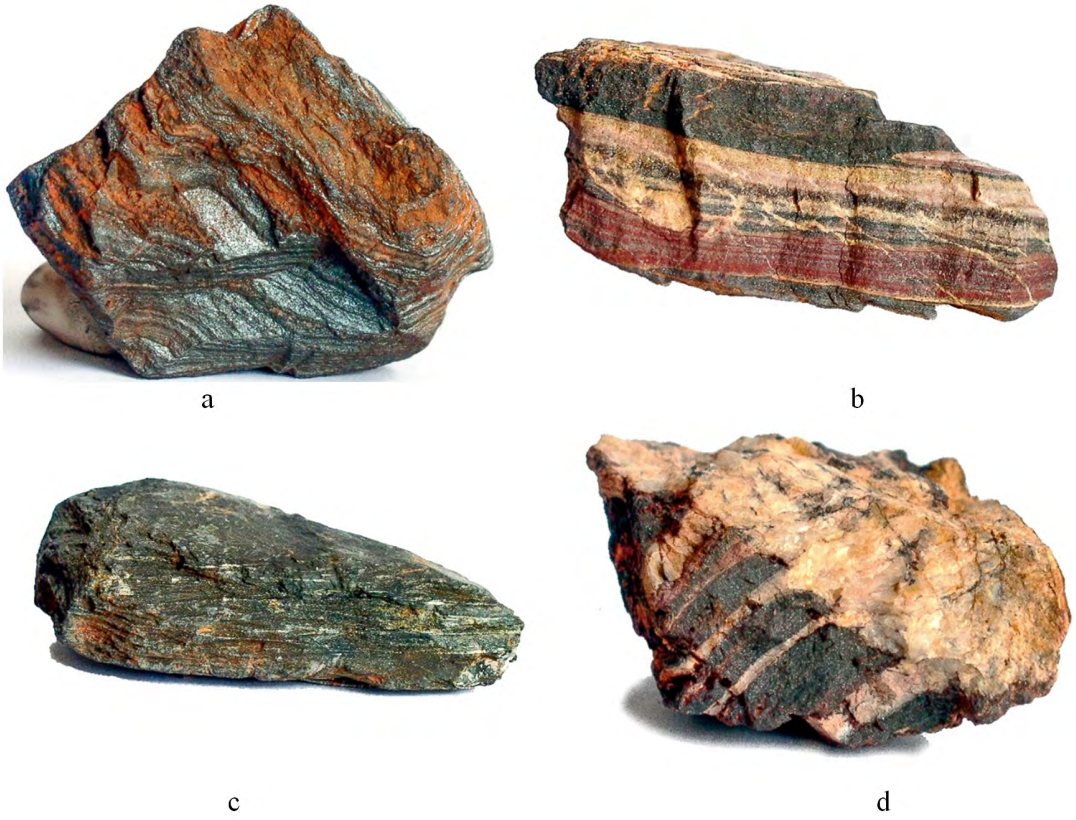

Fig. 3. Low-grade hematite ores and diluting rocks of ore stockpiles.

a – martite-micaceous hematite quartzite (jaspilite) of the fifth ferruginous horizon; b – martite quartzite of the fourth ferruginous horizon; c – chlorite-cummingtonite-quartz-biotite schist of the fourth schistose horizon; d – vein quartz from martite quartzite of the sixth ferruginous horizon.

The maximum size of samples is 10 cm.

is similar to the Valyavkynske deposit of the Krivbas. The increased content of manganese oxides (from 1 to 20 mass %) is the difference between them. Iron-containing minerals are represented by hematite of three morphological varieties: martite, micaceous hematite (specularite, dispersed hematite) (Fig. 4). A characteristic feature of individuals and aggregates of hematite is their much smaller size in comparison with the ores of the Kryvyi Rih deposits. In this regard, the same degree of grinding (0.05-0.06 mm), allows a full release of hematite from the Valyavskinske deposit, the hematite of the Ushkatyn III deposit retains intergrown pieces with non-metallic minerals – quartz, carbonates, silicates.

Thus, the ore-forming minerals of hematite raw materials of the studied deposits are represented by hematite (martite, micaceous hematite, dispersed hematite), quartz. Their total content in all mineral varieties of hematite quartzites exceeds 90 mass %. Secondary minerals include relict (magnetite, metamorphogenic silicates, carbonates, sulfides, etc.) and newly formed (iron hydroxides, clay minerals, etc.) minerals. Their quantitative ratio, morphology of individuals and aggregates, chemical composition and physical properties must be taken into account when developing an optimal technology for the production of high-quality hematite concentrate.

The production of hematite sinter ores and concentrates is not associated with fundamental technological difficulties for deposits of different scales. The first results of the search for an effective technology for the enrichment of hematite raw materials were obtained during the 1960s. Technological schemes based on the use of magnetic, gravitational, flotation units were considered. To date, the optimal technology has not been determined. Reducing the explored volumes of magnetite quartzites helps to intensify its search. According to the authors of this publication, the least energy-consuming, the most technologically efficient is gravity technology.

This also applies to the ores of Central Kazakhstan, the feature of which is the presence of a wide range of minerals ; manganese and other metals. Effective involvement of the latter in the operation can be achieved by updating the ore preparation (Demchenko, 2018; Evtekhov, 2016; Prilepa, 2019; Tsypin, 2015), including utilization of the lump sorting module of mineral raw materials produced by scientific production enterprise “Gamayun”. The module provides a significant reduction in energy

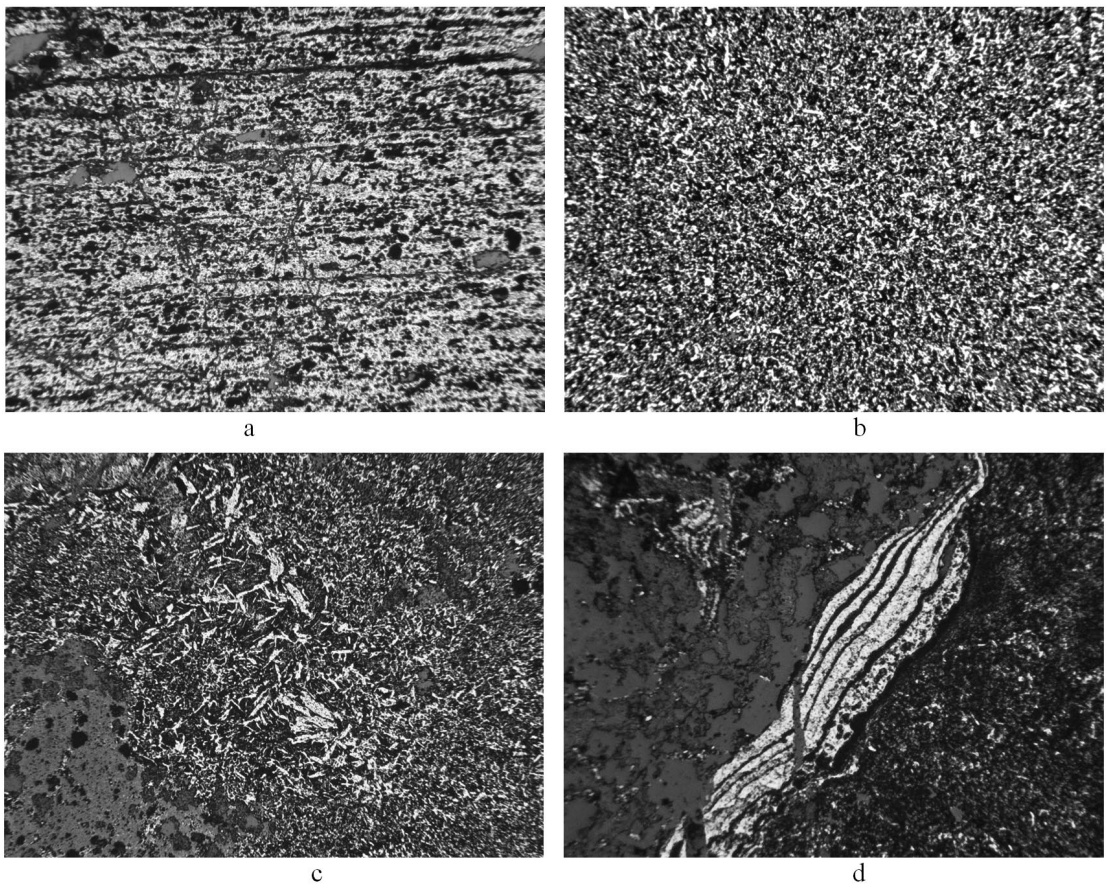

Fig. 4. Mineral composition, structure and texture of hematite ores of the Ushkatyn III deposit.

a – layer-by-layer oriented aggregates of fine-crystalline martite; b – finely-impregnated aggregate of micaceous hematite; c – an alpine streak of macrolaminar micaceous hematite (specularite); d – alpine hematite vein of rhythmic structure.

Reflected light; without analyzer; magnification 30^x.

consumption, mobility, efficiency of integration with existing structures. It was tested at the Atasui ore deposits of Central Kazakhstan (Karazhal, Ushkatyn III, Zhairem).

Conclusions

1. Hematite quartzites belong to the types of iron ore which commonly occur all over the planet. Depending on the technologies of ore preparation and beneficiation, it is possible to produce metallurgical raw materials with different iron content (from 55 to 69 mass %).

2. The optimal technology for hematite quartzite beneficiation for ores of most deposits has not been developed due to insufficient mineralogical justification.

3. Bi- (hematite + quartz) or trimineral (hematite + quartz + kaolinite) composition is typical for hematite ores.

4. The results of geological and mineralogical research must be taken into account when drawing up effective technological schemes for ore preparation and beneficiation of hematite quartzites in order to produce metallurgical raw materials with different iron content.

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Regional measurement of the hotel sector development of a tourist destination (on the example of Odessa region, Ukraine)

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Abstract. In the conditions of transformation of the national economy and intensification of competition in the regional tourist markets, Ukrainian hotel business enterprises have an important problem related to increasing the efficiency of filling hotel places and attracting tourist flows. One of the ways to solve this problem is to form a management measures based on forecasting the length of stay of tourists in accommodation facilities, load levels of hotel enterprises in tourist destinations of Ukraine, planning the production of competitive hotel services that can meet the needs of foreign and domestic consumers, market demand. This problem is especially important in the context of overcoming the effects of the global COVID-19 pandemic. The purpose of the article is to identify trends in the hotel business in the tourist regions of Ukraine and outline the prospects that can be realized in post-crisis conditions. The study used a statistical method of trend analysis of the dynamics of the duration of tourists in hotels, which aims at the establishing patterns of changes in the levels of the studied indicators over time, to identify the main trend of this phenomenon. The example of Odessa region proved that the evaluation of the hotel business areas are the basis for predicting spatial and temporal relationships in the regional economy for the development of hotel business in other tourist destinations, increase their competitiveness and improve the marketing of tourist flows. According to the calculations, the annual decrease in the length of stay of tourists for the period 2021-2022 in hotel establishments of the Odessa region is forecasted. The experience of experimental verification of the proposed approach to forecasting the length of stay of tourists in hotel establishments shows that the proposed research methods can form modern tools for diagnosing the current state of regional markets for hotel services and making management decisions.

Keywords: hotel industry, tourist flow, forecasting, tourism, trend analysis.

Регіональний вимір розвитку готельного сектору туристичної дестинації (на прикладі Одеського регіону, Україна)

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Анотація. В умовах трансформації національної економіки та загострення конкуренції на регіональних туристичних ринках, українські підприємства сфери гостинності мають важливу проблему, пов'язану з підвищенням ефективності завантаження готельних місць та приваблення туристичних потоків. Одним із шляхів вирішення цієї проблеми, автори вважають формування заходів управління на основі прогнозування тривалості перебування туристів в засобах розміщення, рівнів завантаження підприємств готельної сфери в туристичних дестинаціях України, планування виробництва конкурентоспроможних готельних послуг, які зможуть задовольнити потреби іноземних та вітчизняних споживачів, оперативно реагуючи на ринковий попит. Ця проблема набуває особливого значення в умовах подолання наслідків світової пандемії COVID-19. У статті проаналізовано тенденції розвитку сектору гостинності в туристичних дестинаціях України та запропоновано заходи, які можливо реалізувати у посткризових умовах діяльності підприємств галузі. Для дослідження був використаний статистичний метод трендового аналізу рядів динаміки тривалості перебування туристів в готелях, який спрямовано на встановлення закономірностей змін рівнів досліджуваних показників у часі, виявленні основної тенденції (тренда) розвитку цього явища. На прикладі Одеського регіону доведено, що оцінка діяльності підприємств готельного сектору є основою для прогнозування просторово-часових зв›язків в регіональній економіки щодо розвитку готельного бізнесу в інших туристичних дестинаціях, підвищення їх конкурентоспроможності та вдосконалення маркетингу туристичних потоків. За даними розрахунків прогнозується щорічне зменшення тривалості перебування туристів на період 2021-2022 років в готельних закладах Одеського регіону. Досвід експериментальної перевірки запропонованого підходу щодо прогнозування тривалості перебування туристів в готельних закладах показує, що запропоновані методи прогнозування можуть сформувати сучасні інструменти для діагностики стану регіональних ринків послуг гостинності та прийняття управлінських рішень.

Ключові слова: готельна індустрія, туристичний потік, прогнозування, туризм, трендовий аналіз

Introduction

Research and forecasting of regional economic processes in the hotel sector of tourist destinations is necessary for unambiguous formulation and solution of the problem, which requires an extremely important solution for the formation of tourist flow and development of regional tourist markets. In Ukraine, there are 3165 hotel-type accommodations, the largest share of which needs modernization. The global hotel industry has about 350 thousand hotels and similar accommodation facilities, providing more than 14 million rooms, with their number growing by 3-4% annually (Bulgaru, Petrariu, & Colan, 2019). The share of the hotel sector of Ukraine in the global hotel industry is less than one percent, which indicates the need to develop the hospitality services in tourist regions.

In our country, there is a problem of concentration of tourist resources in certain regions, most of these areas are experiencing a shortage of categorical hotels and specialized accommodation. Therefore, it is necessary to form a modern infrastructure for recreation and tourism in attractive regions, such as cultural and historical resources of event tourism or sacred resources of religious tourism, to introduce models of hotel sector development, which will primarily focus on diversifying activities and providing domestic investment resources.

Methods of analysis and forecasting of demand for hotel business services in the regions of Ukraine are the most important tools to attract investment and innovative approaches to modernization of the hotel industry, solving problems and shaping prospects for further growth of the regional economy through tourism and recreation services. Assessing the real state and dynamics of the hotel and tourism sector allows to put forward approaches to forecast the demand for hospitality services in tourism destinations of Ukraine on the basis of reliable and trusty sources of information, substantiate the prospects of their development and reproduce the possible future situation, local authorities will outline its strategic planning and prospects. The urgency of solving these issues in the context of overcoming the effects of the global pandemic led to the choice of research topic, defined its purpose and objectives.

The purpose of the article is to analyze the current state of the hospitality sector in the Odessa region of Ukraine and identify prospects for further development based on methods of forecasting the load of hotel enterprises in post-crisis conditions, forming proposals for management decisions of hotel business in tourist destinations.

Analysis of recent research and publications

Our study is based on the work of foreign and domestic scientists, which are aimed at developing methods for analyzing and forecasting the development of the hotel sector of certain territorial entities. The issues of definition and typifying of the category “destination” were considered in the works of O. Lyubitseva, O. Tretyakov (2012); L. Yurchishina (2017), who believes that in the field of tourism, this term, defines tourist destinations from a particular hotel, resort, city to a country or territory of a particular region that has administrative boundaries. Experts at UNWTO emphasize that the term “tourist destination” defines the physical space in which a tourist spends at least one night (A Practical Guide to Tourism Destination Management, 2007).

Modern research on the assessment of sustainable development of tourism destinations in the EU uses the methodology of The European Tourism Indicator System (ETIS), which defines the process of data collection and analysis for the general purpose of assessing the impact of tourism on the destination. One of the basic indicators of ETIS is the level of tourist accommodation in the regions (The European Tourism Indicator System, 2016). Methods for measuring the levels of development of tourist accommodation in the regions are considered by Derkach and Mylashko (2020). Chaitip and Chaiboonsri (2014) proposed methods for forecasting tourist flows to Thailand using a nonlinear model. The use of a logistic growth regression model to predict the demand for travel services in Macau hotels has been proposed by Chu, F.L. (2011). Forecasting the demand for international urban tourism services using one-dimensional and multidimensional models using monthly data is presented in the study of Gunter & Önder (2015), methods for forecasting the weekly occupancy of destination hotels using big data are proposed in the Pan & Yang study (2017). Modelling and forecasting of tourist and hotel demand was considered in the work of Wu, Song & Shen (2017). A thorough review of modern methodological approaches in scientific works and the application of econometric methods and hybrid models for forecasting in tourism were made by Jiao & Chen (2019). In their study, researchers focus on the methodology of analysis of socio-economic components of small and medium-sized enterprises of the hotel business at the regional level (Yadegaridehkordi et al., 2020), model the management of hotel enterprises and travel agencies to shape tourist demand for hotel services (Huang Yin, Goh, & Law, 2019), substantiate the regional «smart - specialization» in terms of sustainable development (Andryeyeva et al.,

2020), propose a method of component analysis for interregional modelling of tourism seasonality (Tsiotas, Krabokoukis, & Polyzos, 2020). The growing interest in assessing the efficiency of the hotel industry from a regional point of view is indicated by studies analysing the impact of the length of stay of tourists in hotels on the economy of hospitality in the regions of Spain (Sellers-Rubio, & Casado-Díaz, 2018).

Issues of improving the methodology for assessing the tourist potential of regional recreational areas are considered in a monograph edited by V. Gerasimenko (2016). The work of O.A. Melnichenko and V.O. Shveduna «Features of the tourism industry in Ukraine» (2017) highlights the current problems of tourism in the country, analyses the implementation of regional reforms in tourism and hospitality, proposed ways to develop the domestic tourism industry, the principles of reforming the mechanism of state regulation of tourism in the regions. Researchers conducted an empirical study of international tourism flows in Southeast Asia and proposed a comprehensive and accurate systematic approach to the analysis of regional tourism demand, based on the Bayesian model of global vector autoregression (Assaf, Li, Song & Tsionas, 2019). Researchers propose to use the «semiparametric GWR model» to study the spatiotemporal relationships in the regional economy to predict the development of tourist areas (Jin, Xu & Huang, 2019), scientists focus on measures to overcome the effects of the COVID-19 pandemic (Gaffney, & Eeckels, 2020), offer tools for marketing and management of hotel services in a crisis (Jiang & Wen, 2020).

According to the World Travel and Tourism Council (WTTC), in 2020 the global decline in tourism could reach 25% and lead to job reduction by 12-14%. The World Tourism Organization (UNWTO) has called on governments to support small and medium-sized enterprises in tourism, as they make up to 80% of the industry. «The travel and tourism sector has a unique impact, and we believe that 50 million jobs worldwide are at risk,» experts say (Open Letter to Governments from the WTTC and the Travel and Tourism Sector, 2020). Strict quarantine measures and a policy of social distancing have forced the hotel sector to actively seek ways to restore the flow of tourists in the regions. For example, to ensure the safety of hotels in the international group Accor, introduced enhanced hygiene and prevention measures for tourists. The ALLSAFE certificate, developed in collaboration with Bureau VERITAS, introduces new protocols and standards of high cleanliness and ensures that all anti-epidemic measures are followed in Accor hotels. Including the possibility of contactless check-in at the hotel and subsequent departure, subject to contactless payments (Accor launches the Cleanliness & Prevention ALLSAFE label, 2020).

Despite the wide range of researchers in this direction and significant developments in this area, the issues of forecasting the development of hospitality in post-crisis conditions in tourist destinations in Ukraine remain insufficiently studied.

Material and methods of research

For the analysis of the current condition of Ukraine hotel business sphere, the forecast of prospects of realization of its potential, methods of the regional analysis of statistics of indicators of material and technical base of the enterprises of regional hotel business, distribution of establishments of accommodation of tourists in regions were used. The State Statistics Service of Ukraine, starting with the report for 2011, introduced a new form of state statistical observation No1 - KZR (annual) "Report on the activities of collective accommodation", the analysis of which is the basis of this study. Data provided by collective accommodation facilities is one of the sources of data on tourist flows (Collective accommodation facilities, 2015-2018; Collective accommodation in Ukraine, 2020). The main indicators of tourist flows according to collective accommodation are the number of accommodated, including foreigners, the number of nights spent by visitors in hospitality establishments and the average length of stay, which allows for comprehensive research in tourism and hospitality (Brida, Garrido, Deidda, & Pulina, 2012; Lado-Sestayo, Vivel-Búa, and Otero-González, 2017; Srovnalíková, Semionovaitė, Baranskaitė, Labanauskaitė, 2020; Kanina, 2020).

To determine the level of hotel development of tourism regions of Ukraine, based on quantitative indicators of tourist flows, the dynamics of tourist arrivals, revenues from services, the state of material and technical base, i.e. tourist infrastructure were used methods of statistical trend analysis (Chattopadhyay, & Mitra, 2019; Lozynskyy, & Kushniruk, 2020). The analysis of time series is to establish patterns of changes in the levels of the studied indicator over time, to identify the main trend of the phenomenon – a certain direction of change: the tendency to increase, stability or decrease the levels of the phenomenon. Thus, the above indicators were compared in dynamics with similar indicators of activity of regional subjects of hotel business in various time intervals, the "horizontal" analysis was carried out. Researchers believe that the method of trend analysis of the above indicators (comparing data from different years) also allows you to analyse how the processes

of intensification went on, in hotel activities of tourist regions (Bondarenko, Kulyniak, and Prokopyshyn-Rashkevych, 2019). This method of analysis allows you to transfer the experience of leading regions to other less successful regions (Maximov et al., 2016, p. 46). The processing of regional indicators of hotel activity was carried out with the help of the application package "Statistics" MS EXCEL. Here are the basic formulas for our calculations:

Absolute growth:

chain gain : $\Delta y_c = y_i - y_{i-1}$ (1)

basic gain : $\Delta y_b = y_i - y_1$ (2)

Growth rates characterize the absolute increase in relative terms. The percentage growth rate shows how many percent the comparable level has changed from the level taken as the basis of comparison.

Growth rate:

chain growth rate : $T_{cgr} = \Delta y_i / y_{i-1}$ (3)

basic growth rate : $T_{bgr} = \Delta y_b / y_1$ (4)

A common statistical indicator of the dynamics is the rise rate. It characterizes the ratio of the two levels of the series and can be expressed as a coefficient or as a percentage.

Rise rate:

chain rise rate: $T_{crr} = y_i / y_{i-1}$ (5)

basic rise rate : $T_{brr} = y_b / y_1$ (6)

The absolute value of 1% increase:

chain: $1\%c = y_{i-1} / 100\%$ (7)

basic: $1\%b = y_b / 100\%$ (8)

An important statistical indicator of the dynamics of socio-economic processes in the hotel business is the build rate, which in the context of economic intensification measures the increase in time of economic potential in tourist-active regions.

Build rate:

$$T_{br} = \Delta y_c / y_1 \quad (9)$$

Application of this technique will allow to make the forecast in development of potential hotel business in Odessa region as in one of active tourist regions basing on an indicator – duration of stay of tourists in means of accommodation.

Results and analysis

Market instability and current problems of economic growth in tourist regions require a critical analysis of the hotel industry, forecasting the length of stay of tourists in accommodation facilities, calculating the load levels of hotel enterprises in the regions of Ukraine. The study of structural and functional relationships in the economy is the basis for forecasting and modelling the future development of the hotel sector and destinations, which is possible through the integrated use of own resources in competition (Zhang, Tu, Zhou & Yu, 2020; Bekjanov & Matyusupov, 2020). Analysis of market trends in the hotel sector of tourist regions corresponds to the state priorities for socio-economic growth of recreation and tourism through efficient management (Strategy for the development of tourism and resorts for the period of up to 2026: the Order of the Cabinet of Ministers of Ukraine, 2017).

The analysis of the state of the hotel sector of the economy according to statistical information in Ukraine, shows that the number of hotel-type enterprises increased by 690 units in the period from 2015 to 2019. The largest growth was observed from 2018 to 2019, totally by 14%. However, there was a negative trend to reduce the number of hotel enterprises by 6% in 2015 compared to 2014 and by 2% in 2017 compared to 2016. The number of places also gradually increased, except for a slight decrease of 2% in 2017 compared to 2016, in 2019 the number of places increased by 27% or 36 400 units compared to 2018. Due to the introduction of new hotels, the total number of places increased by 39.192 units (Collective accommodation facilities, 2015-2018; The main indicators of collective accommodation in Ukraine in 2019, 2020) from 2015 to 2019. We also observe a slight fluctuation in the number of placed persons, the highest growth rate observed from 2015 to 2017 is 17%, then the figure falls sharply. During the analysed period, the number of accommodated persons increased by 1.197.020 people (Table 1).

The distribution of hotel enterprises of Ukraine in 2019 by region indicates that the largest number of them is in the Lviv region – 106 units, Kyiv region and the city of Kyiv, which together consist of – 145 units, Odessa region – 72, Transcarpathian region – 49, Ivano-Frankivsk region – 44, Kharkiv region – 38 (Fig. 1). These regions with the largest localization of hotels and similar accommodation are developed tourist destinations of various types of tourism: business tourism, cultural and cognitive, ski resorts, health tourism, as well as transit (for example, the city of Borispol, where there is the country's main airport). All of them have attractive recreational resources and tourism infrastructure services, a significant number of full-time employees, relatively high capacity, as well as a high percentage of foreign tourists.

Our further research focuses on the example of the Odessa region, which is one of the leading tourist regions of Ukraine, as it has significant recreational and cultural – historical resources, transport infrastructure and hotel services. The city of Odessa forms the core of cultural, cognitive and business tourism in the region (Gerasimenko, Bedradina,

Table 1. The dynamics of the development of enterprises of Ukrainian hotel sector for 2015–2019

Year	Number of hotel-type enterprises, units		Number of rooms, units		Number of accommodated persons	
	The absolute value of the indicator, units	Growth rate,%	The absolute value of the indicator, units	Growth rate,%	The absolute value of the indicator, units	Growth rate,%
2015	2 478	-6	132 535	6	4 297 190	7
2016	2 534	2	135 916	3	5 037 075	17
2017	2 474	-2	133 396	-2	5 135 164	2
2018	2 777	12	135 327	1	5 410 242	5
2019	3 165	14	171 721	27	5 494 210	2

Source: developed and compiled by the authors according to the State Statistics Service.

Galasyuk et al, 2016). The region has powerful resources for the formation of a modern sphere of hotel and resort services. According to statistics, the number of hotels and similar accommodation in the region in 2019 amounted to 72 companies, which are by 12 companies less than in 2017. For the last 3 years, the Odessa region takes the third place in the ranking, which is inferior only to the Lviv region and the city of Kyiv.

Authors would like to note, that the reduction in the number of hotel enterprises has led to a reduction in accommodation capacity due to the liquidation of unprofitable enterprises. During the analysed period, the base of tourist accommodation amounted to 6961 places in 2019, which is by 1002 places less than in 2017, which affected the overall rating of the region (Collective accommodation facilities, 2015-2018; the main indicators of collective accommodation in Ukraine in 2019, 2020). The total number of serviced tourists in 2019 increased by 32.089 people compared to 2017 (Table 2). According to the study, the number of foreign tourists served during the analysed period increased slightly, by only 108 people, while in 2018 their number decreased significantly, by 7839 people compared to 2017 (Table 2).

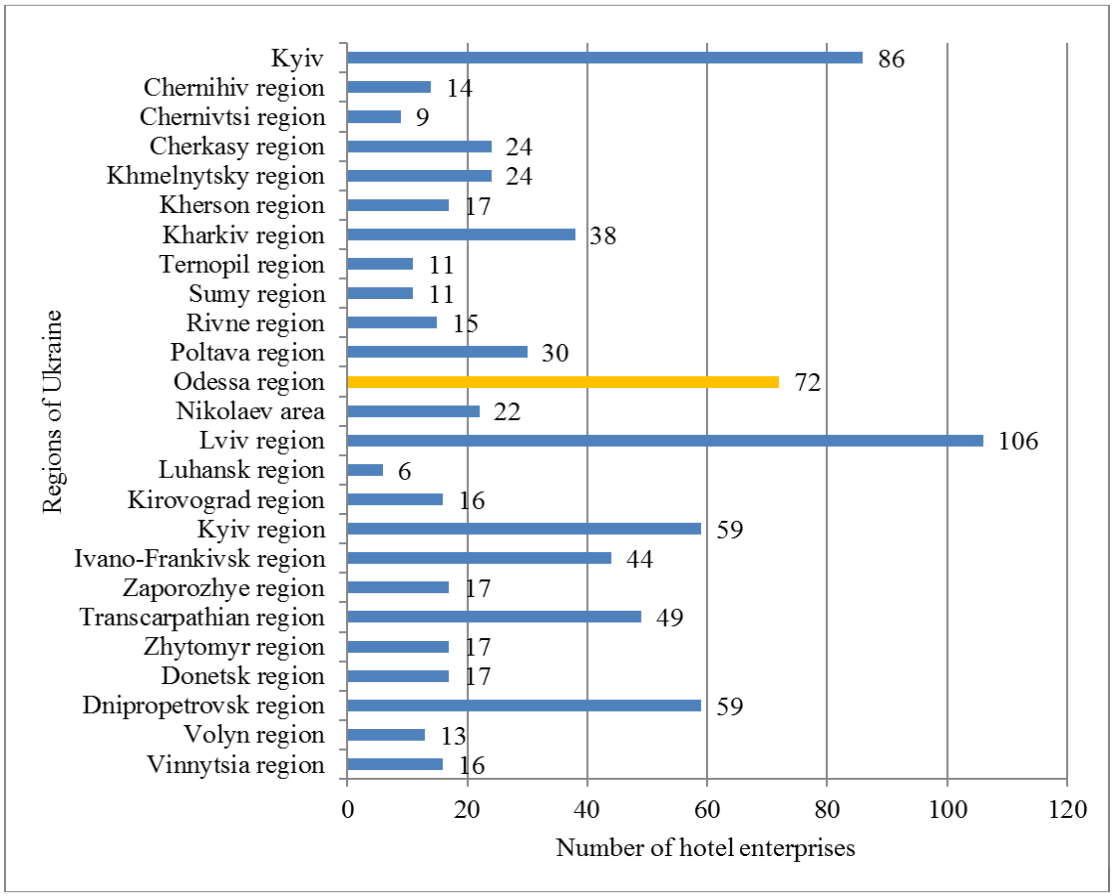

Fig. 1. Regional distribution of hotel business enterprises of Ukraine in 2019, units

Source: compiled and developed by the authors according to the State Statistics Service. The information is given without taking into account the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and part of the temporarily occupied territories in Donetsk and Luhansk regions.

Table 2. The place of the Odessa region among other administrative-territorial units of Ukraine by the main indicators of the hotel sector in 2017-2019

Indicators		Years		
		2017	2018	2019
Number of hotel enterprises, units	Place	3rd, after Lviv region, Kyiv	3rd, after the city of Kyiv, Lviv region	3rd, after Lviv region, Kyiv
	Indicator value	80	67	72
One-time capacity of hotel enterprises, places	Place	3rd, after the city of Kyiv, Lviv region.	3rd, after the city of Kyiv, Lviv region	3rd after the city of Kyiv, Lviv region
	Indicator value	7963	6713	6961
The total number of served visitors, persons	Place	5th, after the city of Kyiv, Lviv region, Kyiv region, Kharkiv region	4th, after the city of Kyiv, Lviv region, Kyiv region.	4th, after Kyiv, Lviv region, Kyiv region
	Indicator value	187275	201306	219364
Number of served foreigners, persons	Place	3rd, after the city of Kyiv, Lviv region	4th, after the city of Kyiv, Lviv region, Kyiv region.	3rd, after Kyiv, Lviv region
	Indicator value	49480	41641	49588
Duration of stay of visitors, man-days	Place	3rd, after the city of Kyiv, Lviv region	3rd, after the city of Kyiv, Lviv region	3rd, after Kyiv, Lviv region
	Indicator value	484064	414030	433111
Number of rooms, units	Place	3rd, after the city of Kyiv, Lviv region	3rd, after the city of Kyiv, Lviv region	3rd, after Kyiv, Lviv region
	Indicator value	4043	3490	3453

Source: developed and compiled by the authors according to the State Statistics Service.

The length of stay in the Odessa region also tends to decrease, during the analysed period it decreased by 50.953 man-days compared to 2017, the number of rooms also decreased by 590 units (Table 3).

is less than the average for the regions of Ukraine, a slight increase of – 1.02%, for the analysed period is observed in 2019. The share of hotel enterprises in the Odessa region in the total capacity of Ukraine averages

Table 3. The load level of the hotel sector of Ukraine and in Odessa region

Row No	Indicators		Indicator values by years			Change in the values of indicators from 2019 to 2017,%
			2017	2018	2019	
1	The total number of seats places in the enterprise hotel entities (EHE), seats places	Total in Ukraine	87882	74198	75667	-13.90%
2		Odessa region	7963	6713	6961	-12.58%
3	The share of EHE of Odessa region in the total capacity of EHE of Ukraine, % (row 2: row 1 x 100%)		9.06%	9.05%	9.20%	x
4	Duration of stay of visitors in EHE, man-days	Total in Ukraine	7708079	7103662	7040927	-8.70%
5		Odessa region	484064	414030	433111	-10.53%
6	Share of EHE in Odessa region in the total amount of man-days of service provided,% (row 5: row 4 x 100%)		6.28%	5.83%	6.15%	x
7	EHE load level,%	Total in Ukraine	24.00%	26.20%	25.50%	6.30%
8		Odessa region	16.65	16.85	17.04	1.02

Source: developed and compiled by the authors according to the State Statistics Service.

The analysis of the level of occupancy of hotel enterprises in the dynamics by regions of Ukraine and separately in the Odessa region proves that the total number of locations of hotel enterprises in the regions of Ukraine decreased by 13.9%, respectively in the Odessa region decreased by 12.58%. The level of occupancy of hotel enterprises in the Odessa region

9.1%. Competition in the hotel services market has led to a reduction in the number of hotel enterprises – legal entities in Ukraine as a whole by 15.7%, and in the Odessa region decreased by 10%. The total share of regional hotels and similar accommodation facilities averaged 8.5%, in Ukraine as a whole, and in 2019, the maximal share was 9.09%. In August, the

capacity of hotel enterprises in Ukraine increased by 3.20% and in the Odessa region – by 1.40% during the analysed period (Table 4).

Table 4. The average capacity of enterprises in the hotel sector of Ukraine and in Odessa region

№ Row No	Indicators		Indicators value by years			Change in the values of indicators from 2019 to 2017, %
			2017	2018	2019	
1	The total number of seats places in the enterprise hotel entities (EHE), seats places	Total in Ukraine	87882	74198	75667	-13.90%
2		Odessa region	7963	6713	6961	-12.6%
3	The share of EHE in Odessa region in the total capacity of EHE of Ukraine, % (row 2: row 1 x 100%)		9.10%	9.00%	9.20%	x
4	Number of enterprise hotel entities, units	Total in Ukraine	940	789	792	-15.70%
5		Odessa region	80	67	72	-10%
6	Share of EHE in Odessa region in the total number of UGS of Ukraine, % (row 5: row 4 x 100%)		8.51%	8.49%	9.09%	x
7	The average capacity of the hotel industry, places	Total in Ukraine	93	94	96	3.20%
8		Odessa region	96	100	97	1.40%

Source: developed and compiled by the authors according to the State Statistics Service.

The indicator of the length of stay of tourists in Ukraine also decreased during the analysed period by 8.7%, and in the region decreased by 10.53%. The share of the Odessa region in the total volume of services provided (man-days) averages 6% for the whole period (Table 5).

Table 5. Average time of stay of tourists in the enterprises of the hotel sector of Ukraine and in Odessa region

№ row	Indicators		Indicator value by years			Change in the indicator value from 2019 to 2017, %
			2017	2018	2019	
1	Visitors duration of stay, man-days	Total in Ukraine	7708079	7103662	7040927	-8.70%
2		Odessa region	484064	414030	433111	-10.53%
3	The total number of served visitors	Total in Ukraine	3792576	3747656	3693556	-2.61%
4		Odessa region	187275	201306	219364	17.13%
5	The share of EHE in Odessa region in the total volume of served visitors, % (row 4: row 3 x 100%)		4.94%	5.37%	5.94%	X
6	The average visitors length of stay, days	Total in Ukraine	2	1,9	1,9	-5.00%
7		Odessa region	2,6	2,1	2	-23.08%

Source: developed and compiled by the authors according to the State Statistics Service.

The indicator of the total number of served tourists in Ukraine decreased by 2.61% during the analysed period, but in the Odessa region this figure increased by 17.13%, the share of hotel services in the Odessa region in the total number of served visitors ranged from 4.94% in 2017 to 5.94% in 2019. The average length of stay of visitors in Ukraine decreased by 5% and amounted to 1.9 days in 2019. In the Odessa region there is also a negative trend of decreasing the number of visitors by 23.08% during the analysed period, so in 2017 the average length of stay was 2.6 days and in 2019 – 2 days. This trend is due to the rapid development of regional alternative rented accommodation and private apartments. For example, Airbnb is the largest platform for tourists in search of accommodation in 2019, which presents more than seven million properties around the world. Researchers note that partnership services for tourists in search engines in the field of private accommodation have significantly undermined the hotel sector of the tourism industry (Keogh, Kriz, Barnes & Rosenberger III, 2020), and at the same time should attract the attention of local authorities and owners. Alternative accommodation facilities for limited recreational activities in relation to the natural resources of the destination (Sinlapasate, Buathong, Prayongrat, Sangkhanan, Chutchakul & Soonsawad, 2020).

In modern conditions, under the influence of intensified competition, in the regions of Ukraine

there are hotels by category, which provide a range of basic and additional services. The largest number of such hotels is located in the Kyiv region – 57, then in Odessa – 46, in Lviv – 31. Also, the largest five-star hotels in the Odessa region – 12, in Kiev – 8, Lviv – 4 (Register of certificates of establishment of hotel categories, 2020). The sector of hotels of three stars and below in Ukraine remains unfilled and is represented mainly by enterprises with a medium level of service and a small set of additional services, so it is necessary to develop demand in recreational regions for health services with SPA-hotels. Let's pay attention to the development of international hotel chains in Ukraine. Thus, the international hotel business operator Radisson Hotel Group plans to open a new hotel under the Radisson brand in Odessa in 2021. With the launch of the new hotel Radisson Hotel Group will be represented by eight hotels and 1445 guest rooms in Ukraine. But in the regions under international management is less than 1% of the hotel fund of the country, which indicates a low degree of investment attractiveness of the Ukrainian market of hotel services for international hotel operators.

An important factor influencing the occupancy of hotels is the level of cooperation of hotels with tour operators and travel agents in the implementation of tourist vouchers. Based on the fact that there is no official statistical information on the income of hotels and similar accommodation in Ukraine for 2018-2019, we analyse the income structure of hotel enterprises in 2017 in Ukraine and in the Odessa region (Collective accommodation facilities, 2015-2018; the main indicators of collective accommodation in Ukraine in 2019, 2020). The share of hotel business enterprises in the Odessa region by income, by regional distribution of Ukraine is 4.77% or 346582.9 thousand UAH, in the structure of income – 274180.5 thousand UAH is the income from the sale of rooms, 5964.1 thousand UAH from the sale of vouchers, 66438.3 thousand UAH from additional services. The largest percentage of the total income by region of Ukraine is the income from the sale of rooms, the smallest from the sale of tourist vouchers. But in the Odessa region the share of the realized permits made 31.96% of the general income across Ukraine. Thus, we can conclude that the region has sold the largest number of tourist vouchers to accommodation facilities of different profiles compared to other regions of Ukraine (Table 6).

The most dynamic hotel industry is developing in Kyiv and Kyiv region (where 150 facilities with a total number of rooms over 9200 are concentrated), as well as in the recreational areas of Odessa, Lviv and Transcarpathia as a whole). But, even in Kiev, where the rate of hotel rooms is about 6-7 places per 1 thousand inhabitants, it is still very far from the rate of European capitals. For example, in the city of Vienna, this figure is 26 places per 1 thousand inhabitants, and in Paris – 35 (Kapranova & Nikitin, 2018, p.110). Increasing the number of rooms in category hotels is a necessary condition for the development of business tourism in the regions of Ukraine.

To predict the development of hospitality in the Odessa region, we will calculate the dynamics of the increase rate in the length of stay of tourists in hotels, which in the context of economic intensification measures the increase in time of economic potential of the hotel sector. Calculations of chain indicators of a number of dynamics of duration of stay of tourists in hotels for 2017-2019 are given in (Table 7).

As we can see from the calculations, in 2019, compared to 2018, the length of stay of tourists increased by 19081 days or by 4.6%. The maximal increase is observed in 2019 (19081 days). The minimal increase was recorded in 2018 (-70.034 days). The growth rate shows that the trend is increasing, which indicates an acceleration of the length of stay. Calculations of basic indicators of a number of dynamics are given in the Table. 8.

In 2019, compared to 2017, the length of stay decreased by 50.953 days or by 10.5%. The above indicators according to formulas 1-9 are grouped in summary table 9.

Table 6. The structure of revenues of enterprises in the hotel sector of Ukraine and in the Odessa region in 2017

Indicators	Total in Ukraine	Odessa region	Part of the Odessa region
Revenues from hotel services and similar accommodation, total thousand UAH	7261479.6	346582.9	4.77%
Rooms sale	5406776.4	274180.5	5.07%
proportion, %	74.46	79.11	x
from the sale of vouchers, thousand UAH	18658.5	5964.1	31.96%
proportion, %	0.26	1.72	x
from additional services that are not included in the price of the room / vouchers, thousand UAH	1836044.7	66438.3	3.62%
proportion, %	25.28	19.17	x

Source: own collaboration

Table 7. Chain indicators of a number of dynamics of duration of stay of tourists in hotels of the Odessa region for 2017 – 2019

Year	Duration of stay, days	Absolute growth	Growth rate, %	Rise rate, %	Absolute value of 1% increase	Rise rate, %
2017	484064	-	-	100	-	0
2018	414030	-70034	-14.47	85.53	4840.64	-14.47
2019	433111	19081	4.61	104.61	4140.3	3.94

Source: own collaboration

Table 8. Basic indicators of the dynamics of duration of stay of tourists in hotels of the Odessa region for 2017 – 2019

Year	Duration of stay, days	Absolute growth	Growth rate, %	Rise rate, %
2017	484064	-	-	100
2018	414030	-70034	-14.47	85.53
2019	433111	-50953	-10.53	89.47

Source: own collaboration

Table 9. Chain and baseline indicators of dynamics of the duration of stay of tourists in hotels of the Odessa region for 2017 – 2019

Year	Duration of stay, days	Absolute growth		Rise rate		Growth rate		Absolute value of 1% increase
		Chain	Basic	Chain	Basic	Chain	Basic	
1	484064	-	-	100	100	-	-	-
2	414030	-70034	-70034	85.53	85.53	-14.47	-14.47	4840.64
3	433111	19081	-50953	104.61	89.47	4.61	-10.53	4140.3

Source: own collaboration

Let's calculate the average characteristics of the series. The average level of the series y of the dynamics characterizes the typical value of absolute levels. To find the average level of the moment series use the chronological average:

$$\overline{y} = \frac{\sum y_i}{n} \quad (10)$$

$$\overline{y} = \frac{1331205}{3} = 443735.$$

.

The average length of stay for the analysed period was 443 735 days.

Average rise rate:

$$\overline{T_p} = \sqrt[n-1]{\frac{y_n}{y_1}} \quad (11)$$

$$\overline{T_p} = \sqrt[2]{\frac{433111}{484064}} = 0.9459.$$

The average for the entire period of growth of the analysed indicator was 0.9459.

Average growth rate:

$$\overline{T_{np}} = \overline{T_p} - 1 \quad (12)$$

$$\overline{T_{np}} = 0.9459 - 1 = -0.0541.$$

.

On average, the length of stay decreased by 5.4% annually. The average absolute increase is a generalized characteristic of individual absolute increments of a number of dynamics.

Let's calculate the average absolute increase:

$$\overline{dy} = \frac{y_n - y_1}{n - 1} \quad (13)$$

$$\overline{dy} = \frac{433111 - 484064}{2} = -25476.5.$$

.

Thus, every year the length of stay of tourists in hotels in the region decreased by an average of 25 476.5 days. Let's make a forecast for the length of stay of tourists in hotels in the region for the next 3 years, using the rate of absolute growth:

y (2020) = 433 111-25 476.5 = 407 634.5 days.

y (2021) = 407 634.5-25 476.5 = 382 158 days.

y (2022) = 382 158-25 476.5 = 356 681.5 days.

According to the calculations, the annual decrease in the length of stay of tourists for the period 2020-2022 in hotel establishments of the Odessa region is forecasted. Therefore, it is possible to offer the management of regional hotel business enterprises to intensify marketing activities in foreign and domestic tourism markets to attract tourist flows to their accommodation facilities, establish mutually beneficial cooperation with international hotel operators, develop franchised hotel chains in the region, and implement flexible pricing. The obtained results support and complement modern methods of regional research on forecasting tourist flows and tourist stays (Karadzic, Pejovic, 2020).

Conclusions

A study of the hotel sector according to statistical information in Ukraine shows that over the past 3 years, the Odessa region ranks third in the main

indicators of economic activity of the hotel industry, second only to the Lviv region and the city of Kyiv. It is established that the largest percentage of sold tourist vouchers to accommodation establishments in the regions of Ukraine, falls on the hotel sector of the Odessa region. At the same time, the commercial activity of the hotel sector of the destination is influenced by the development of alternative accommodation: hostels, private mini-hotels, as well as short-term rented apartments, which affected the demand for hotel services, hotel revenue from room sales, travel vouchers and additional services.

It is established that the effective operation of enterprises in the hotel sector affects the attractiveness of the tourist destination. The movement of tourist flows depends primarily on the level of development of hospitality, quality and specialization of services. The calculated data obtained during the study show that for the period 2021 - 2022 the annual decrease in the indicator of the length of stay of tourists in the enterprises of the hotel sector of the Odessa region is forecasted. In the context of overcoming the effects of the global COVID-19 pandemic, managers of regional hotel enterprises need to focus on marketing activities to attract consumers of domestic tourism services, in particular, establish cooperation with regional and municipal networks of tourist information centres and tour operators, and promote hotel services through communication channels, Internet networks. To ensure the support of their own segment of the tourism market, owners and managers of regional hospitality enterprises must guarantee safe conditions for consumers of hotel services, providing them with prompt medical, technical and legal assistance.

According to the results of the study, it is advisable to recommend the hotel sector to form post-crisis bonus programs to increase the length of stay of tourists in their institutions, develop loyalty programs to attract foreign and domestic tourists to destinations, establish mutually beneficial cooperation in franchising hotel chains, additional services to pursue a flexible pricing policy for room tariffs and services based on methods of forecasting the load of hotel enterprises in post-crisis conditions.

Further research of the authors will be aimed at forming a mechanism for promoting tourist destinations in Ukraine in foreign markets.

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Spatial mapping for Groundwater Vulnerability to Pollution Risk Assessment Using DRASTIC Model in Ponnaiyar River Basin, South India

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Abstract. Groundwater is the principle source of drinking water and protection of groundwater quality is an important issue meets out the increasing population and agricultural practices. The present research an attempt made to develop DRASTIC model to understand the groundwater contamination risk in Ponnaiyar River Basin (PRB), Tamil Nadu, India using geographical information system (GIS). GIS have been shown to be useful tools for assessing groundwater pollution hazard. According to Central Ground Water Board reports the PRB categorized by semi-critical groundwater development. In view of the extensive reliance on this basin, contamination of PRB groundwater became an alarming issue. To assess groundwater contamination risk in the PRB the parameters such as Groundwater depth, Net recharge, Aquifer media, Soil media, Topography, Impact of vadose zone and Hydraulic conductivity were selected. Based on the importance of groundwater contamination all the parameters were assigned to rank and weights. Then all the themes were integrated and classified into five categories such as very low (9.33%), low (26.54%), moderate (34.77%), high (22.38%) and very high (6.98) risk. To validate the DRASTIC model, nitrate concentration was selected and found that it is 81.53% accurate which reflects that, DRASTIC model is appropriate to understand groundwater pollution risk assessment. In the GSB groundwater is contaminated mainly due to extensive use of groundwater extraction for agriculture purpose. Groundwater risk index assessment is an effective tool for groundwater management in the PRB.

Keywords: Remote sensing, GIS, DRASTIC indeed, Groundwater vulnerability, South India

Просторове картографування вразливості підземних вод до оцінки ризику забруднення з використанням моделі DRASTIC у басейні річки Поннаяр, Південна Індія

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Анотація. Підземні води є основним джерелом питної води, а захист якості підземних вод є важливим питанням, що відповідає зростаючій чисельності населення та сільськогосподарській практиці. У цьому дослідженні зроблена спроба розробити модель DRASTIC для розуміння ризику забруднення підземних вод у Поннаярському річковому басейні (ПРБ) (штат Тамілнад, Індія), використовуючи географічну інформаційну систему (ГІС). Показано, що ГІС є корисними інструментами для оцінки небезпеки забруднення підземних вод. Згідно з повідомленнями Центральної ради з питань ґрунтових вод, ПРБ класифікується за напівкритичним розвитком підземних вод. З огляду на значну залежність від цього басейну, забруднення підземних вод ПРБ стало загрозливою проблемою. Для оцінки ризику забруднення підземних вод у ПРБ були обрані такі параметри, як глибина ґрунтових вод, поповнення запасів, водоносний шар, ґрунтове середовище, топографія, вплив вадозної зони та гідравлічна провідність. Виходячи з важливості забруднення підземних вод, всім параметрам були присвоєні ранг та вага. Тоді всі показники були інтегровані та класифіковані за п'ятьма категоріями, такими як дуже низький (9,33%), низький (26,54%), помірний (34,77%), високий (22,38%) та дуже високий (6,98) ризик. Для перевірки моделі DRASTIC була обрана концентрація нітратів, і було встановлено, що вона є точною на 81,53%, що підтверджує можливість застосування моделі DRASTIC для розуміння оцінки ризику забруднення підземних вод. У GSB підземні води забруднені головним чином завдяки широкому використанню видобутку підземних вод для сільського господарства. Оцінка індексу ризику забруднення підземних вод є ефективним інструментом управління підземними водами в ПРБ.

Ключові слова: дистанційне зондування, ГІС, DRASTIC, вразливість підземних вод, Південна Індія

Introduction

Groundwater is one of the most valuable resources for living peoples. Due to extensive pumping, agricultural, and industrial activities, aquifers are at risk of being contaminated. Intensive application of pesticides and fertilisers, discharge of wastewater, and industrial effluent and excessive groundwater abstraction are just a few examples of activities that lead to groundwater contamination. These activities have resulted in the deterioration of water resources in various regions around the world (Pandey et al. 1999).The drastic model developed by the U.S. Environmental Protection Agency in 1985 with aiming to evaluate groundwater pollution potential for the entire USA. The word DRASTIC is an acronym formed the initial letters of the seven factors which are used for determining relative rankings. (D) refers to depth to water, (R) refers to net recharge, (A) refers to Aquifer media, (S) refers to soil media, (T) refers to topography, (I) refers to impact of the vadose zone media, and (C) refers to hydraulic conductivity of the aquifer (Aller et al.,1987) It is very common to use intrinsic vulnerability either alone or coupled with other factors to assess groundwater contamination risk. The most widely used method for intrinsic vulnerability assessment is the DRASTIC approach (Aller et al. 1985). A calibrated drastic model was used to predict the intrinsic vulnerability as well as the groundwater pollution risk (Shahid, 2000;Smail, 2014; Kazakis and Voudouris, 2015; Mfumu Kihumba et al.,2017).Ahirwar and Shukla (2018) assessed the groundwater vulnerability in Upper Betwa River watershed using GIS based DRASTIC model. The revealed that high vulnerable zone located in unsuitable of nitrate concentration in groundwater. It is proved that DRASTIC model is one the suitable model for groundwater contamination.

DRASTIC is a standardized system, for assessing ground water pollution potential using hydrogeologic setting (Sahu and Nandi,2015).In groundwater context, risk can be defined as the probability that groundwater at a drinking well becomes contaminated to an unacceptable level by activities on the land surface(Morris and Foster 1998). Baalousha (2011) conducted a case study on mapping groundwater contamination risk using GIS and groundwater modeling in Gaza Strip at Palestine. The results show that area o highest contamination risk occurs in the southern cities of Khan Yunis and Rafah. Remote sensing and Geographical Information System (GIS) has been widely used in risk mapping (Al-Adamat et al. 2003; Mimi and Assi 2009).Groundwater vulnerability map for the Kherran plain designed to demonstrate areas of maximum potential for groundwater pollution based on hydro-geological state and human impacts. (Chitsazan and Akhtari, 2009). A vulnerability map for the Ordos Plateau has been designed to demonstrate the areas of the maximum potential for groundwater pollution based on hydrogeological conditions (Yin, 2013). Venkatesan et al. (2019) explained the groundwater vulnerability using GIS a DRASTIC model for Upper Palar River basin, Tamil Nadu. The result of the study shows that, 50% of the study area falls under very high pollution potential zones. The very high vulnerability class, which is covered by the alluvium along the river course, is most likely to pollution due to the very lower slope terrains in the direction of central part which allows better percolation of contaminants into the groundwater. In this study, a new approach is proposed for contamination risk mapping. This approach depends on the idea that groundwater contamination risk is a product of probability of contamination occurring and contamination impact.

Study Area

The study area Ponnaiyar River basin extends over approximately of 11,595 sq. km, and lies between 11º350 and 12º35’0’’ N latitudes and 77º45’0’’ and 79º55’0’’ E longitudes (Fig. 1). Ponnaiyar River originates on the southeastern slopes of Chennakesava Hills, northwest of Nandidurg of Kolar district in Karnataka State at an altitude of 1000 m above mean sea level (amsl). The total length of Ponnaiyar River is 432 km of which 85 km lies in Karnataka state, 187 km in Dharmapuri, Krishnagiri and Salem districts, 54 km in Thiruvannamalai and Vellore districts and 106 km in Cuddalore and Villupuram districts of Tamil Nadu. The Ponnaiyar basin is predominantly built up with granite and gneisses rocks of Archean period. The granite is of very good quality and extensive outcrops and masses of it are commonly found. The chief components of rocks are hornblende and feldspar. Foliation is seldom seen. In the plains of reserve forest, quartz is found commonly. The diamond granite is also found in scattered pockets in the area of Chitteri hills in Dharmapuri and Krishnagiri sub-divisions. Charnockite rocks of Archean period are also seen in some areas. Alluvium and sand dunes of quaternary period are also seen at a few places. The 15 years (2000–2014) average annual rainfall in the basin is 969 mm. The catchment falls under the tropical belt. The climate in general is hot; April and May being the hottest months of the year when the temperature rises to 34ºC.

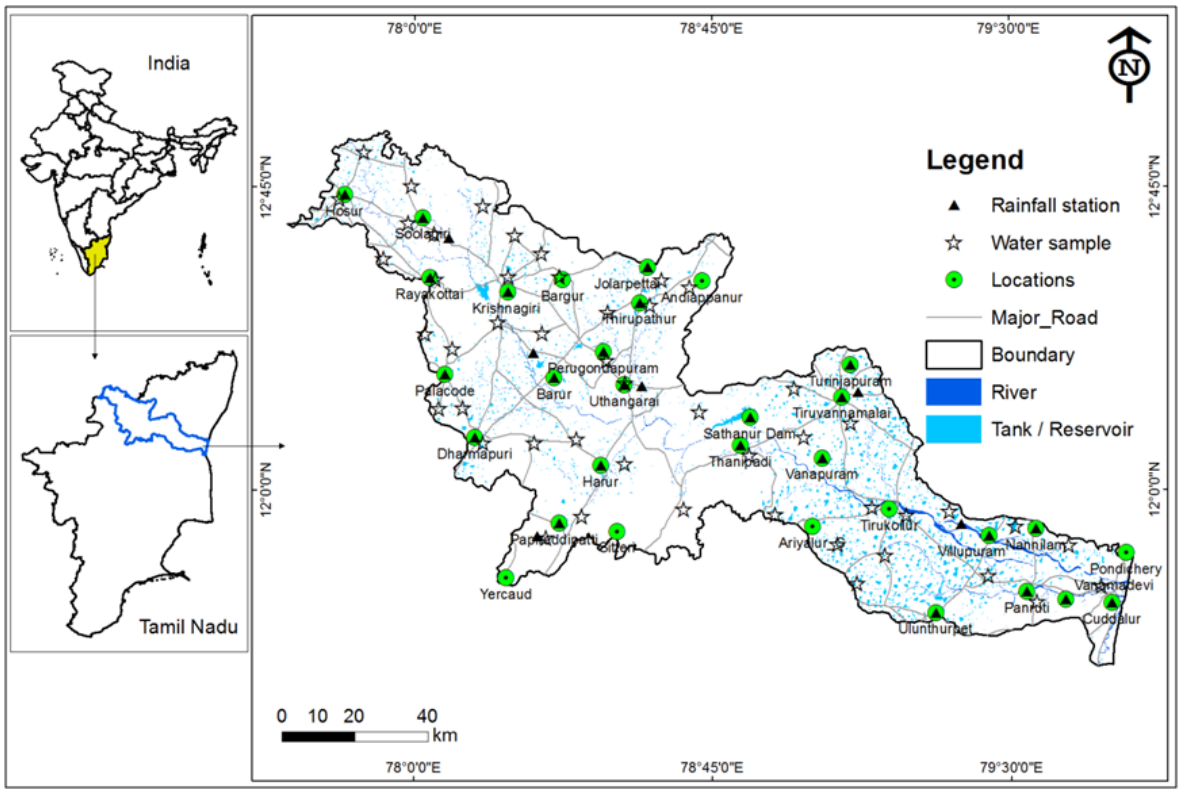

Fig. 1 Location of the study area Ponnaiyar River Basin shows the Rainfall station, water sample location for water level and groundwater quality.

Methodology

The DRASTIC model consist of seven parameter based on the previous literature such as D-depth to water, R-recharge, A-aquifer media, S-soil media, T-topography, I- impact of the vadose zone, and C-hydraulic conductivity. The system contains three parts such as ratings, ranges, and weights. Every drastic parameter has been assigned a relative weight between 1 to 5, with 5 being considered most significant and 1 being considered least significant regarding contamination potential. Moreover, each parameter has been assigned a rating according to range between 1 and 10, which depends upon the influence of pollution concentration.

DRASTIC parameters

Depth to water level (D)

There are 48 water level sample has been collected during the pre-monsoon season, June 2018 for estimation of groundwater depth. The maximum and minimum water level depths measured in the watershed are 26 m and 3.5 m below ground level (bgl) respectively. This point data were contoured by interpolating and divided into five classes. Areas with shallow water table depth are more vulnerable because pollutants have to pass the shortest distance to join the water table. The deeper water table levels imply lesser chance for contamination to occur. The depth to water table map was then classified into ranges defined by the DRASTIC model and assigned rates ranging from 1 (minimum impact on vulnerability) to 10(maximum impact on the vulnerability) and index was calculated by multiplication of weight (5) to ratings for each range which is shown (Fig.2).

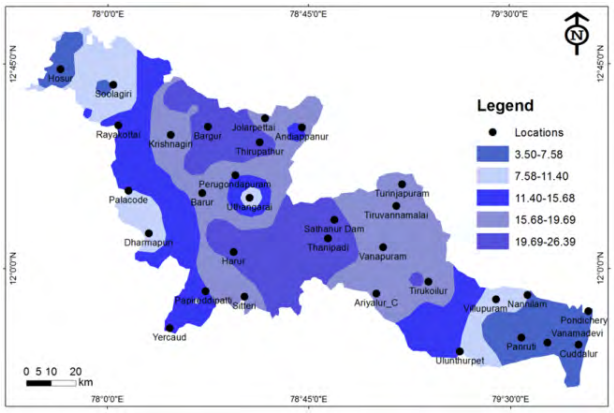

Fig. 2. Groundwater depth spatial distributions in the study area

Net Recharge (R)

Net-Recharge is the amount of water which penetrates the ground surface and reaches the water table, recharge water represents the medium for transporting pollutants. Recharge water thus available to transport a contaminant vertically to the water table and horizontally within the aquifer. The present study, Sehgal (1973) formula, utilized for net recharge from rainfall. The formula is

$$W = 12.6(P - 406.4)^{0.5} \quad (1)$$

The spatial distributions of the net recharge are shown in Figure 3. The rank and weights are assigned based on the importance.

Aquifer Media (A)

Aquifer media refers to consolidated or unconsolidated rocks serve that as an aquifer. It is the saturated zone material, which controls the

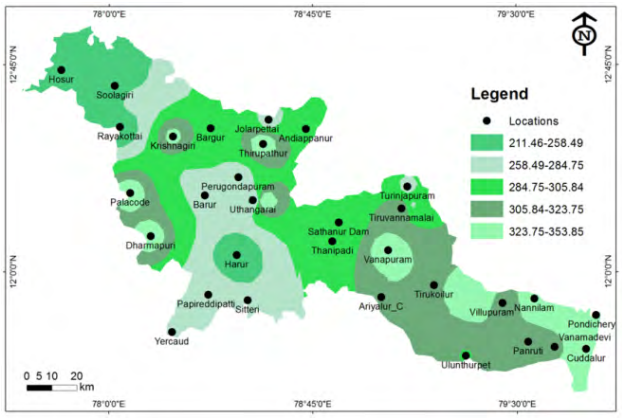

Fig. 3 Net recharge calculated from average annual rainfall for the study area

pollution attenuation processes which determine the flow rates and types of contamination. There are thirteen lithological features covered in the study area. The assigned rating for aquifer media is found to be in the range, rating and index were calculated by multiplication of weight (3) to rating for each range which is shown in (Fig.4).

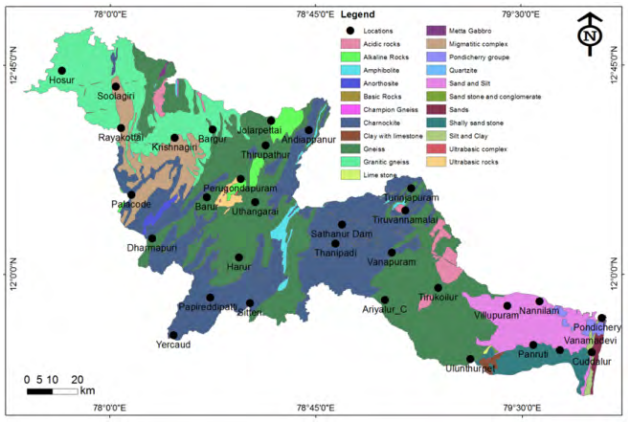

Fig. 4 Aquifer media in the study area

Soil Media (S)

Soil media refers to the weathered portion of the earth surface characterized by considerable biological activity. The soil types mostly affect soil act as transport media for contaminants to travel vertically into the groundwater because, of its ability to infiltrate impurities through rainfall recharge. Soil pollution potential. Soil types were analyzed and identified from different sampling stations using soil texture analysis. Based on soil order, the soil categories is alfisols, entisols, inceptisol, vertisols, hill soil, Pondicherry group and reserved forest. The rating value of 6 was the greatest in the study area. This result was then compiled into a soil media map as an index. The range, rating and index of soil media of the study area are given in Figure 5.

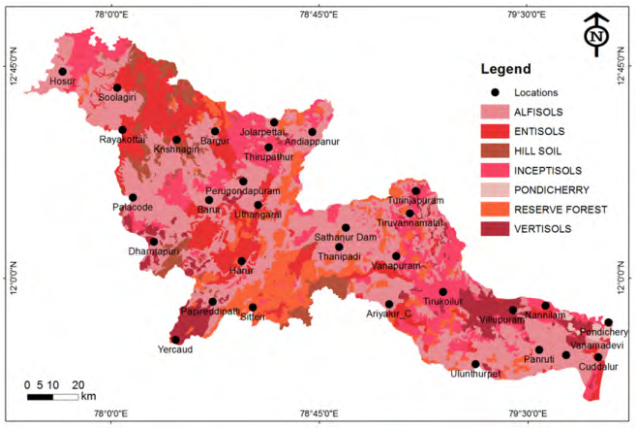

Fig. 5 Soil order in the study area

Topography (T)

Topography refers to the slope and slope variability of the land surface. Topography helps control the likelihood that a pollutant will run off or remain on the surface for long to infiltrate. Therefore, the greater the change of infiltration, the higher the pollution potential associated with the slope. Topography influences soil development and therefore has an effect on attenuation. Topography is also significant from the standpoint that the gradient and direction of flow are controlled by topography. Generally, steeper slopes signify high surface runoff. The details of slope classes are given in Figure 6.

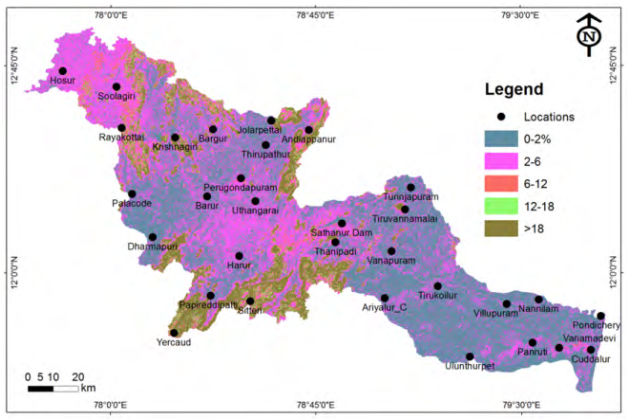

Fig. 6 Topography in the study area

Impact of Vadose Zone (I)

The vadose zone is defined as the zone above the water table which is unsaturated. When evaluating a confined aquifer, the «impact" of the vadose zone is expanded to include in the case of a confined aquifer, the significantly restrictive zone above the aquifer which forms the confining layer is used as the type of media which has the most significant impact. The

type of vadose zone media determines the attenuation characteristics of the material below the typical, soil horizon and above the water table. The materials at the top of the vadose zone also exert an influence on soil development. The details of vadose zone classes are shown in Figure 7.

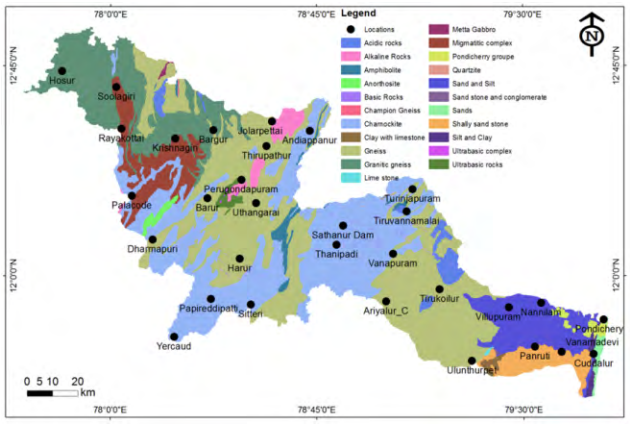

Fig. 7 Impact of vadose zone in the study area

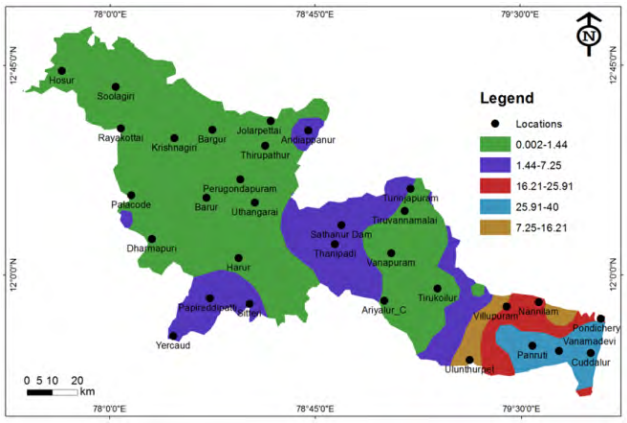

Fig.8 Hydraulic conductivity in the study area

Hydraulic Conductivity (C)

Hydraulic conductivity refers to the ability of the aquifer materials to transmit water, which in turn, controls the rate at which groundwater will flow under a given hydraulic gradient. The rate at which the ground water flows also controls the rate at which a contaminant will be moved away from the point at which it enters the aquifer. Hydraulic conductivity is controlled by the amount and interconnection of void space within the aquifer which may occur as a consequence of factors such as inter-granular porosity, fracturing and bedding planes. Hydraulic conductivity values for different soil medium determined by Ritzema (2006) have been used in the study (Table 1). The details of Hydraulic conductivity classes are shown in Figure 8.

Table 1. Hydraulic conductivity: K-value range by soil texture (Ritzema, 2006)

S.No	Texture	Hydraulic conductivity, K (m.day-1)
1	Gravelly coarse sand	10 – 50
2	Medium sand	1-5
3	Sandy loam, fine sand	1-3
4	Loam, clay loam, clay (well structured)	0.5-2
5	Very fine sandy loam	0.2-0.5
6	Clay loam, clay (poorly Structured)	0.002-0.2
7	Dense clay (no cracks, pores)	<0.002

DRASTIC Index

In the present study, the DRASTIC method, for evaluating groundwater pollution potential was used. The DRASTIC model is used in many countries because the input information required for its application is readily available. The model was developed for the purpose of GW protection in the United States of America (USA) and its methodology is referred as "DRASTIC" (Rahman, 2008). A numerical ranking system to assess ground water pollution potential in hydrologic settings has been devised using the DRASTIC factors. The system contains three significant parts i.e. weights, ranges and ratings. DRASTIC model evaluates the intrinsic vulnerability (Di) of groundwater in term of DRASTIC index using formula

DRASTIC Index (Di) = DrDw + RrRw + ArAw + SrSw +TrTw + IrIw + CrCw (2)

Where, D- depth to water, R- net-recharge, A- aquifer media, S-soil media, T- topography, I- impact of Vadose zone, and C- hydraulic conductivity are the parameters, "r" is the rating value, and "w" the weight assigned to each parameter.

Each DRASTIC factor has been evaluated with respect to the other to determine the relative importance of each factor. Each DRASTIC has been assigned a relative weight ranging from 1 to 5 (Table 2). The most significant factors have weights of 5; the least significant, a weight of 1. This exercise was accomplished by using a Delphi (consensus) approach. These weights are a constant and may not be changed. Each DRASTIC factors have been divided into ranges/classes which have an impact on pollution potential. Each range for each DRASTIC factor has been evaluated with respect to the others to determine the relative significance of each range with respect to pollution potential. The range for each DRASTIC factor has been assigned a rating which varies between1 to 10 (Table 3).The DRASTIC model is based on seven parameters, corresponding to seven layers to be used as input parameters for modeling.

Table 2. Assigned weight for DRASTIC parameters (Aller, 1985)

Factors/ Hydrological settings	Description	Relative weights
Depth to water level	It is depth from ground to water table, deeper the water table lesser will be the chances of pollutions to interact with ground water.	5
Net Recharge	It is the amount of water/unit area of land that penetrates the ground surface and reaches the water table, it is the reporting agents for pollutants to the ground water.	4
Aquifer media	It is the potential area for water storage, the contaminant attenuation of aquifer depends on the amount and sorting of fine grains, lower the grain size higher the attenuation capacity of aquifer media.	3
Soil media	Soil media is the uppermost and weathered part of the ground, soil cover characteristics influence the surface and downward movement of contaminants	2
Topography	It refers to slope or steepness, areas with low slope tend to retain water for longer, this allows a greater infiltration of recharge of water and a greater potential for contaminant migration and vulnerable to ground water contamination and vice versa.	1
Impact of Vadose zone	It is the ground portion found between the aquifer and the soil cover in which pores or joints are unsaturated, its influence on aquifer pollution potential similar to that of soil cover, depending on its permeability, and on the attenuation characteristics of the media.	5
Hydraulic conductivity	It refers to the ability of the aquifer formation to transmit water; an aquifer with high conductivity is vulnerable to substantial contamination as a plume of contamination can move easily through the aquifer.	3

Results and Discussion

The DRASTIC index was calculated by combining all seven layers in the ArcGIS environment to delineate the groundwater vulnerability zones shown as the groundwater vulnerability map have been divided into five vulnerable zones. The very low vulnerable zones ranging from 55 to 80 DRASTIC index with a geographical area of about 1082 sq.km, low vulnerable zones ranging from 80 to 105 DRASTIC index with a geographical area of about 3077 sq.km,moderate vulnerable zones ranging from 105 to 131 with 4032sq. km geographical area, high vulnerable zones ranging from 131 to 156 DRASTIC index with a geographical area of about 2595 sq.km and very high vulnerable zones with DRASTICindex ranging from 156 to 182 with 809 sq. km area (Fig. 9).

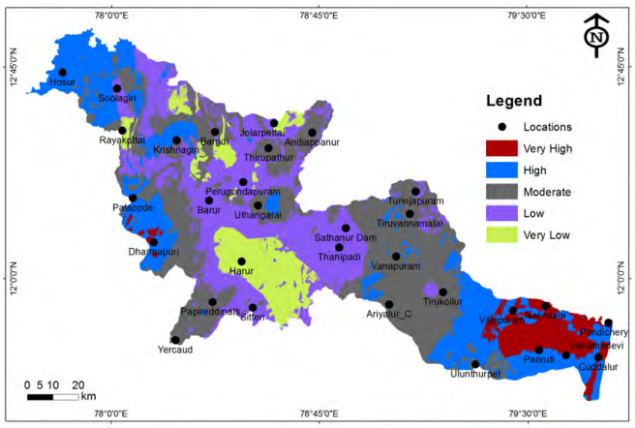

Fig. 9 DRASTIC index in the study area

According to the vulnerability map, about 3.98% of the study area falls under very high vulnerability class which is close to the coastal area; this is most likely due to the very lower slope terrains in the direction of the eastern part, which is predominantly covered with alluvium, and which allows better percolation of contaminants into the groundwater (Table 4). About22.38 % of the area falls under high vulnerblearea, this is owing to lower slope terrain sand mainly covered with sandy loam and loam which allows percolation of contaminants to the groundwater. about34.77 % of the area falls under moderate vulnerable area, this is probably because of somewhat high elevation terrains, which is covered with silty loam, where pollution is in moderate range in this area and 26.54% of the area falls under low and very low vulnerable area, this is probably due to very high slope terrains, which is covered with clay, so pollution is in very low range in this area.

Validation

The Groundwater vulnerability map was validated with nitrate concentration in groundwater as shown in (Fig.10). Results of validation have shown that in the low vulnerable zone, no nitrate contamination has been recorded. While in the moderate zone nitrate has been found in the range of up to 46 mg/l. However, in high vulnerable zone, up to 110 mg/l of nitrate

Table 3. DRASTIC model used for rank and weight assignment

Factors	Classes	Rank	Weight	Index
Groundwater depth (m, bgl) (D)	03.50-07.58	10	5	50
	07.58-11.40	8		40
	11.40-15.68	6		30
	15.68-19.69	4		20
	19.69-26.39	1		5
Net Recharge (mm/year) (R)	211.46-258.49	1	4	4
	258.49-284.75	3		12
	284.75-305.84	5		20
	305.84-323.75	8		32
	323.75-353.85	10		40
Aquifer media (A)	Gneiss	5	3	15
	Charnockite	6		18
	Granitic gneiss	9		27
	Metta Gabbro	10		30
	Basic Rocks	5		15
	Amphibolite	6		18
	Migmatitic complex	4		12
	Acidic rocks	6		18
	Champion Gneiss	7		21
	Alkaline Rocks	3		9
	Ultrabasic rocks	6		18
	Ultrabasic complex	7		21
	Quartzite	10		30
	Anorthosite	5		15
	Sand and Silt	4		12
	Pondicherry group	2		6
	Sands	3		9
	Silt and Clay	1		3
	Shally sand stone	2		6
	Lime stone	1		3
	Sand stone and conglomerate	1		3
	Clay with limestone	1		3
Soil Media (S)	Entisols	1	2	2
	Alfisols	5		10
	Inceptisols	7		14
	Vertisols	10		20
	Reserved forest	1		2
	Hill soil	6		12
	Pondicherry group	2		4
Topography (T)	0-2%	10	1	10
	2-6%	9		9
	6-12%	6		6
	12-18%	3		3
	>18%	1		1
Impact of Vadose Zone (I)	Gneiss	5	5	25
	Charnockite	6		30
	Granitic gneiss	9		45
	Metta Gabbro	10		50
	Basic Rocks	5		25
	Amphibolite	6		30
	Migmatitic complex	4		20
	Acidic rocks	6		30
	Champion Gneiss	7		35
	Alkaline Rocks	3		15
	Ultrabasic rocks	6		30
	Ultrabasic complex	7		35
	Quartzite	10		50
	Anorthosite	5		25
	Sand and Silt	4		20
	Pondicherry group	2		10
	Sands	3		15
	Silt and Clay	1		5
	Shally sand stone	2		10
	Lime stone	1		5
	Sand stone and conglomerate	1		5
	Clay with limestone	1		5
Hydraulic Conductivity cm/day C	0-5 m/day	1	3	3
	5 – 10	4		12
	16-Oct	5		15
	16-24	8		24
	24-42	10		30

Table 4. DRASTIC model index area and their percentage

ID	drastic	Index	Area	%
1	Very High	156-182	809	6.98
2	High	131-156	2595	22.38
3	Moderate	105-131	4032	34.77
4	Low	80-105	3077	26.54
5	Very Low	55-80	1082	9.33

concentration was recorded. As per the standards of WHO Guidelines for Drinking Water Quality (1984), the permissible limit of nitrate in groundwater is 45 mg/l and beyond this range it is harmful.

Conclusion

In the study, an assessment the groundwater vulnerability of the upper part of PRB using DRASTIC model was carried out. During the study, seven parameters such as depth to water table, net-recharge, aquifer media, soil media, topography, impact of

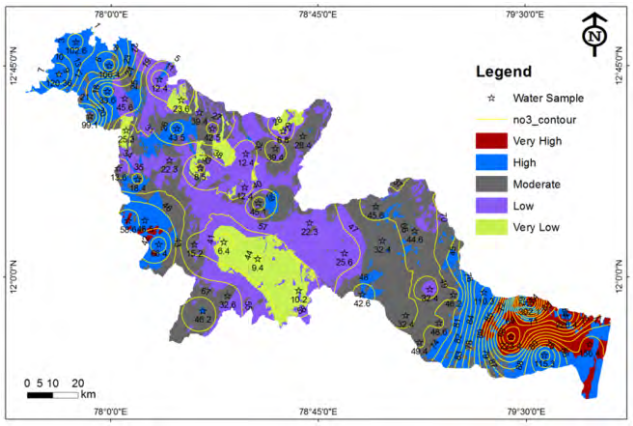

Fig. 10 DRASTIC Model with validation of nitrate concentration in the study area

the vadose zone, and hydraulic conductivity which represent the natural hydro-geological conditions of the watershed were combined in ArcGISand a groundwater vulnerable map has been prepared. The PRB the themes were integrated and classified into five categories such as very low (9.33%), low (26.54%), moderate (34.77%), high (22.38%) and very high (6.98) risk. Furthermore, Groundwater vulnerability map has been validated with nitrate concentration. This study also indicated that the GIS technique could provide an efficient way to deal with a large quantity of spatial data used in the DRASTIC model. This study gives a very comprehensive picture of vulnerability to groundwater to contamination in the area.

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International youth migration: features, tendencies, regulation prospects

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Abstract. The article examines the global and regional issues of international youth migration. The obtained results are most interesting for those regions where the population is shrinking and aging with a rising need to involve youth for educational services and local labor markets, or vice versa, for those losing youth due to their emigration. It is emphasized that youth create an economically active social group, which volume and quality significantly affect the country's development. During the global migration trends identification, the authors identified the international youth migration flows' differences and features. The paper notes that the global trends in the international youth migration development include: increase in volume and percentage of youth in the overall number of migrants and the local population; growth of youth migrants in more developed regions and high-income countries; the dominance of migratory centers for youth in Oceania, North America, and Europe; formation of powerful centers of migration of intellectual young labor resources in the UAE, Canada, the USA, Australia, and New Zealand. The available formational policy in youth migration regulation, on the example of India, China, Taiwan, Japan, USA, and Western Europe, is studied. The impact of the COVID-19 pandemic on international migration flows is considered, including changes in international migration in 2020. Based on the UN data analysis on age groups of migrants within geographical regions, it was determined that the prerequisite for such a structure of migration centers is a high level of migratory attractiveness. Such migration-center structure is also explained by the significant level of cross-regional migration, as in the localized regions, their factors of «attraction-repulsion» are formed. It is stressed out that increasing military and political instability has led to the uphill of forced youth migrants. The paper proposes the flow optimization directions of international youth migration by formulating the link between migration policy and elements of other integration policies on migrant youth (employment policy, social, educational, information and security policies).

Keywords: migration, international migration, youth migration, youth, global issues, centers of gravity, students, COVID-19

Міжнародна молодіжна міграція: особливості, тенденції, перспективи регулювання

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Анотація. У статті досліджено глобальну та регіональну проблематику розвитку міжнародної молодіжної міграції. Отримані результати найбільш цікаві для тих регіонів, у яких відбувається скорочення та старіння населення, виникає необхідність залучення молоді у сферу надання освітніх послуг та на місцеві ринки праці, або навпаки, які втрачають молодь за рахунок їхньої еміграції. Наголошено, що молодь є тією економічно-активною соціальною групою, обсяг та якість якої суттєво впливає на розвиток країни. На фоні ідентифікації глобальних міграційних трендів, авторами визначено відмінності та особливості потоків саме міжнародної молодіжної міграції. Зазначено, що глобальними тенденціями розвитку міжнародної молодіжної міграції є: зростання обсягу та ваги молоді у загальній чисельності мігрантів та місцевому населенні; зростання обсягу молодіжних мігрантів у більш розвинених регіонах і країнах з високим рівнем доходу; домінування міграційних центрів тяжіння молоді у Океанії, Північній Америці та Європі; формування потужних центрів міграційного тяжіння інтелектуальних молодих трудових ресурсів у ОАЕ, Канаді, США, Австралії та Новій Зеландії. Досліджено наявні форми національної політики країн у сфері регулювання молодіжної міграції, на прикладі Індії, КНР, Тайваню, Японії, США і країн Західної Європи. Проведено локальне дослідження мотивів, умов та намірів молоді в Україні, на прикладі університетської студентської спільноти. Враховано вплив пандемії COVID-19 на міжнародні міграційні потоки та розглянуто зміни які відбулися у сфері міжнародної міграції в 2020 році. На основі аналізу даних ООН щодо вікових груп мігрантів в межах

географічних регіонів визначено, що передумовами такої структури міграційних осередків є високий рівень міграційної привабливості. Така структура міграційного осередку пояснюється також значним рівнем внутрішньорегіональної міграції, оскільки у локалізованих регіонах формуються власні фактори «притягування-виштовхування». Зазначено, що посилення військово-політичної нестабільності спричинило зростання кількості вимушених молодіжних мігрантів. Запропоновано напрями оптимізації потоків міжнародної молодіжної міграції шляхом формулювання зв'язку між міграційною політикою та елементами інших інтеграційної політик щодо мігруючої молоді (політики зайнятості, соціально, освітньої, інформаційної та безпекової політик).

Ключові слова: міграція, міжнародна міграція, молодіжна міграція, молодь, глобальні проблеми, центри тяжіння, студенти, COVID-19

Introduction

In the second half of the XX century, the irreversible globalization force covered all spheres of public life and, accordingly, granted independace to countries and people interdependence. Humankind faced rapid changes in global political and economic systems, causing a significant intensification of global migration flows and forming a fundamentally new migration at the international level. The migration issues importance is underlined by the interest of many on international and non-governmental level. Those included the European website on Integration, International Labour Organization, International Association for Intercultural Education, European Council on Refugees and Exiles, Platform for International Cooperation on Undocumented Migrants (PICUM), Platform for Intercultural Europe, Refugee International, Human right watch, Separated Children in Europe Programme, Society for Intercultural Education, Training and Research, ect. and others. In their activities, they pamper issues, including migration and integration of youth and respect for their rights.

Increased focus on migration started with the human capital theory when G. Becker (Becker, 1962) emphasized the significant role of migrants in creating social wealth and differences in motivation for migration of different ages. Human resources and noted that «individuals who have not yet invested in themselves will have an incentive to migrate, and that partly explained the reason of youth migration over older generations.» That determines one of the appropriate areas of the study systematization and specification of the advantages and disadvantages of the country's involvement in international migration to form trends in relevant processes regulation.

Several features determine modern international migration. According to the UN, in 2020, 71% of all migrants originated from developing countries, and over the past 30 years, the number has more than doubled (United Nations Departments of Economic and Social Affairs, Population Division, 2020). Current migrations are not followed by colonization or conquest and (Manning, 2017), current migrations across ethnic, cultural, and even religious boundaries (Kerwin, 2020). On the other hand, the immigrant workers might ensure a stable economic development of the country (Osaulenko et al., 2020).

In recent years, migration has become a global challenge to the prospects for further human development. According to World Migration Report 2020 (IOM), "The current global estimate is that there were around 272 million international migrants in the world in 2019, which equates to 3.5 percent of the global population" (International Organization for Migration, 2020).

Historically, many migrants are youth, so youth migration has attracted the particular attention of the world scientific community for a long time (Döringetall, 2021).

Literature review

International organizations, government agencies, and scientists study migration processes quite thoroughly. Statistics from the United Nations and the International Organization for Migration depict the global demographic process of increasing population migration since the end of the twentieth century (Fig. 1).

Helliwell (2004) studied the impact of political and economic factors on demographic change and increasing migration flows until 2050; he found that changes in trends and volume of migration flows depend on domestic policies and harm the global demographic situation. Heinsohn (2019) notes that population migration, especially its youth segment, is a global phenomenon and a catalyst for social development. Kobzar et al. (2015) studied the migration evolution wherein there is an increase in the global middle class and changes in the population demographic profile due to increasing migration. Tyers and Bain (2015) developed a demographic submodel as a part of the global economy standard model that illustrates the dependence of migration flows on the level of real wages and the motivation of migrants. Bil (2017), based on the dynamics of migration flows analysis, created the concept of migration institutionalization in modern society and identified societies where the population majority is migrants. Shymanska, Kurylo, Karmaza, and Timchenko (2017) investigated

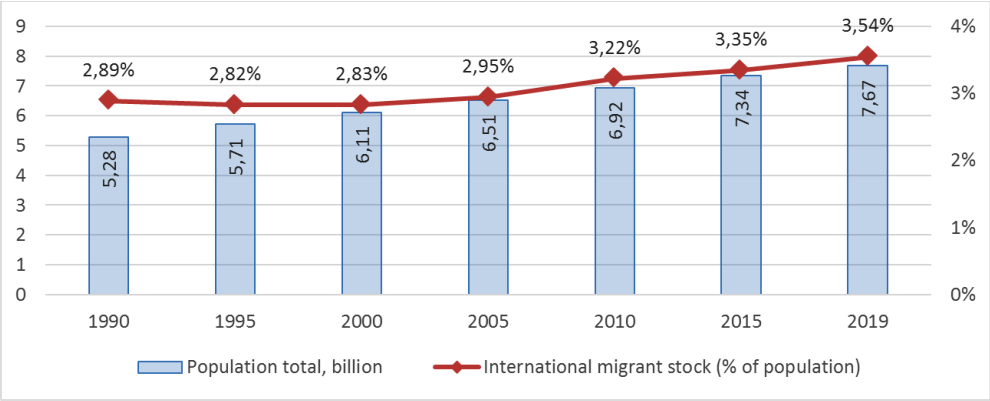

Fig. 1. The dynamics of the world's population and the international migrants share (according to the WorldBank (2019a, 2019b), International Organization for Migration (2020)).

Note: the international migrants' share in the world's population in 2019 is calculated independently according to International Organization for Migration (2020).

the migration motives determinants as a prerequisite for the migration flows formation and identified the transformation of modern migration flows under the influence of economic, social, and demographic, political security, linguistic, cultural, environmental and natural factors. Sardak et al. (2018) took a comprehensive approach to study the migration movement of human resources and noted global migration trends. Malynovs'ka (2018) explored global and national aspects of migration policy. R. Stakanov (2020) considered the impact of the COVID-19 pandemic on international labor migration. Menozzi and Mishra (2020) comprehensively identified changes in international migration flows and determined ten significant trends in 2020. However, migration flows studies by age groups are limited, and statistics differ. That causes difficulties in determining trends in international youth migration and the consequences for the economy and society.

Among the studies of youth migration, the latest studies on the environmental aspects of family migration can be distinguished, which's part is the youth migration (Lu, 2020). Attention should also be focused on the study of Despagne & Manzano-Munguía (2019) that raised the youth reverse migration issue, considering Mexico's case. In particular, their work considers the mechanisms of linguistic, cultural, social adaptation of youth in the destination country. Impressive research by Döring et al. (2021) studied 569 528 18-year-old Swedes who already work. Researchers have found that education quality affects all-cause mortality in such age group. That is the essential conclusion, as for a large number of conscious migration begins at this age.

Pitiulych et al. (2020) ran sociological monitoring of youth migration in the Transcarpathian region of Ukraine. Their research gives an idea of the migration motives of Ukrainian student youth. A similar study on Moldova and Georgia›s example was conducted by Bastianon (2018), who found that the individual capabilities, youth aspirations, and the households' capabilities significantly involve youth decision-making on migration. On the example of Bulgarian youth Kovacheva and Hristozova (2019) studied a narrower phenomenon – the female youth migration. After studying the migration impact on identity formation, they concluded that youth maintains their national identity at the highest level. Although, highly qualified individuals had a more excellent social and political orientation.

Accordingly, we note the study relevance of the youth migration features that establish the decomposition direction of national migration policies for this migrants' category.

Material and research methods

Nowadays, the migration processes require an in-depth study based primarily on statistical research to establish the causes and negative consequences in the future. That is especially relevant for the study of youth migration. Since youth is the population age cohort with an internal structure and mechanisms to support cultural patterns. Youth are more inclined and have a high potential for innovation in all spheres of society. Being the most economically active part of society, youth have high employment potential and workability. It has high demographic productivity from a demographic point of view (70-80% of births occur at a young age). However, youth also have a high adaptability degree, ability to learn and develop new knowledge.

The study used systematic, and logical, and historical methods, deduction, and induction to study international migration's nature and trends,

particularly youth migration. The theoretical generalization and abstraction allowed establishing the social and economic consequences of youth migration. Methods of theoretical generalization, abstraction, formalization, and modeling are used to model the youth migration regulation by decomposing its components. The empirical basis for assessing the migratory mood of youth was the results of a poll.

The data from international organizations (UN, World Bank, Eurostat, IOM), non-governmental organizations, and analytical agencies, including materials from the Gallup Center for Migration Studies (world survey), papers of national and international scientists, the results of their surveys became the source for information materials.

Results and analysis

In recent years, international migration is one of the world's major problems (Kerwin, 2020). Thus, according to the World Economic Forum, migration (in particular, forced migration) is mapped at Global Risks 2020 (WorldEconomicForum. (2020, 15 January)) in inseparable unity with the problems of social instability, unemployment, and the global governance crisis. Worldwide, the number of people crossing international borders accros the globe has been increasing: from 176 million at the turn of the twentieth and eleventh centuries to 272 million in 2019 (International Organization for Migration, 2020).

The modern migration main features significantly differ from those in past centuries. First of all, there was a change in the direction of the main flows. People move from less developed economies to more developed ones. Initially, the migration was mainly directed towards less developed territories. Another feature is that the current migration is inherent in colonization or conquest. What distinguishes them from the large population flows of previous epochs? The next difference is that currently, there is no synchronicity of technological development and demographic processes that stimulate migration. Previously, technologically advanced countries had the fastest population growth. Today, technologically slow regions experience rapid population growth. Finally, current international immigration is a massive intercultural movement. Early immigration tended to redistribute the population within a single cultural region (Puryhina, 2007).

The worldwide databases concerning origins and destinations originally developed at Sussex University and now widely expanded and maintained by the United Nations Population Division and the World Bank provided the basis for more accurate global international population flow measurement.

From accumulated multi-year data, it is known that international migration is not equable in the world but is formed under the influence of economic, geographical, demographic, and other factors that lead to different migration patterns, including migration "corridors" created for many years. As a rule, the most significant corridors run from developing countries to countries with more developed economies, such as the United States, France, the Russian Federation, the United Arab Emirates, and Saudi Arabia. This model will remain unchanged for many years ahead, especially when coming decades in some developing countries foresee population growth that will create migratory pressure on future generations (International Organization for Migration, 2020).

The main reasons for international migration growth include asymmetry of the regions' social and economic development; population awareness; intensification of international economic relations; political, economic, and social crises; military conflicts; and natural disasters. Local migration is caused by the same reasons as international migration, adding some driving factors, and sometimes prevailing the family, educational, and management factors by state, corporate, and family influence. The number of people involved in local migration is several times higher than in international migration, so we can assume that the current annual total number of migrants is about 1 billion people (Puryhina, & Sardak, 2009).

The main factor that changes the place of residence is an economic motive. According to estimates, almost two-thirds of international migrants are migrant workers, mainly youth. Labor migration has contributed to significant population changes, especially in the Gulf Cooperation Councils, except for Oman and Saudi Arabia (International Organization for Migration, 2020). Thus, the IOM Report on Migration in 2020 states points that the estimated number of migrants is 272 million people; estimated share of migrants from the total population is 3.5%; a region with the highest share of international migrants is Oceania; the country with the highest share of international migrants is the United Arab Emirates; the number of stateless people is 3.9 million individuals (International Organization for Migration, 2020).

The international labor migrants are more frequently attracted by a higher (sometimes continuously) wage level in the employment country compared to their home country. Also substantial is the increased demand for certain specialties, which, in turn, provides adequate earnings for the migrant. Other

parts of migration flows include people looking for a better life do not want to pursue a beggar's existence or are dissatisfied with inequality in society (such are the majority), people who feel a specific danger of natural disasters, deterioration of the ecological environment and climate change, and those who avoid various military and political conflicts, amongst several internally displaced people is over 24 million (United Nations, 2015).

Among the world regions, Europe among all regions in the world holds the leading place as a destination for migrants (82 million people), followed by North America (59 million) and Western Asia (49 million). In 2019, almost a half of all immigrants on the planet arrived in ten recipient countries: 51 million - in the United States (19% of their total) 13 million – in Germany and Saudi Arabia, 12 million – in Russia, 10 million – in Great Britain, 9 million – in the UAE, 8 million – in France, Canada, and Australia, 6 million – in Italy (WorldBank, 2019a). One-third of all international emigrants also come from only ten countries. In 2019, emigrants left such donor countries as India – 18 million, Mexico – 12 million, China – 11 million, the Russian Federation – 10 million, Syria – 8 million (WorldBank, 2019a).

The migration flows indicators show that the United States has been the top destination country for international migrants since 1970. Since that time, the number of aliens living in the country has grown more than by four times – from less than 12 million people in 1970 to almost 51 million people in 2019. Over the same years in Germany, the second country in terms of arrivals of migrants, there was also an increase: from 8.9 million people in 2000 to 13.1 million people in 2019 (WorldBank, 2011; WorldBank, 2019a).

However, if people could migrate to the most desirable places, according to the Center for Migration Studies "Gallup," the most popular destination countries would be North America, Europe, and Australia, Singapore, New Zealand (Gallup, n.d.). Obstacles are Prohibitive borders has become obsticles. A typical illustration is the "pre-ban" measures taken by Canada to deal with the geopolitical "threat" posed by asylum seekers from Mexico. The Mexican visa and safe countries and origin formed a virtual border, which allows to filter and prevent immigrants from Mexico effectively. Similarly, the EU border control regime during the European refugee crisis in 2015 became a mechanism for rejection and vulnerability of migrants.

Regarding migration areas, it should be noted that in contrast to the late nineteenth – early twentieth century had the main migration flows directed from Europe to North America and Eastern Siberia, and secondary flows from North to South, in the XXI century, the significant flows begin to reorient changd orientation from South to North, from East to West, as well as to new centers of gravity – Canada, Australia and New Zealand (Puryhina, & Sardak, 2009, Heinsohn, 2019). Besides an essential migration manifestation of the world's population is the relocation of rural population to cities and urbanization that of the current 50% of urban residents will reach 60% in 2030, and the number of megacities (with over 10 million inhabitants) will grow from 20 to 37 in 2025, (Future State 2030, 2014). Given that people aged 15-24 now account for up to 40% of the unemployed population and 90% of the world's young population living in developing countries, it can be predicted that these trends will remain (Future State 2030, 2014).

Therefore, in recent years, there have been significant changes in the global migration regulation, manifested mainly in the United Nations Network setting on migration and the development of two global agreements on refugees and migration. Although, not legally binding, both global treaties embody an almost universal consensus on issues that require sustained international cooperation and commitment (International Organization for Migration, 2020).

Menozzi and Mishra (2020) identified ten major migration trends in 2020. Among them, an increase in the number of international migrants to 281 million people and the coronavirus pandemic COVID-19 has reduced the number of international migrants and remittance flows. However, according to their observations, forced resettlement across international borders continues to grow, and most refugees in the world are accommodated in low- and middle-income countries. Almost two-thirds of all international migrants live in high-income countries (mostly in small numbers), and international migration often remains within the central regions. Regarding gender and age migration trends, they also note that women make up 48% of all international migrants, with international migrants usually working age. In general, most countries' policies aim at promoting orderly, safe, legal and responsible migration. As one we can see, in 2020, some migration trends persisted, but there are significant changes compared to previous years.

The COVID-19 pandemic caused significant changes in migration flows (ILO, 2020). Thus, in OECD countries, 2020 became a historical minimum in international migrants, and cash flows of migrants to low- and middle-income countries fell by 19.7% to $ 445 billion (Stakanov, 2020). According to World Bank forecasts, there will be a decrease in

remittance flows of migrants in Europe and Central Asia by 27.5%, sub-Saharan Africa by 23.1%, South Asia by 22.1%, the Middle East and North Africa by 19.6%, Latin America and the Caribbean by 19.3%, East Asia and the Pacific by 13% (World Bank, 2020). Unprecedented reversal migration, e.g., in India, repatriated over 1.3 million, in Egypt 1 million, in the Philippines over 230 thousand, and in Cambodia about 120 thousand migrant workers repatriated (Stakanov, 2020).

We state that the trends identification issue in the migration development in general, and especially the study of youth migration flows in particular, is still a permanent problem. The problem of studying youth migration flows is due primarily to their scale and that they carry a political burden on social and political institutions. Therefore, that is not only a theoretical and methodological, but also a political issue in all its components.

In particular, there is youth problem identification. So Thus, the UN provides the following people classification by age: 0-14 years (children), 15-24 years (early working age), 25-54 years (primary working age), 55-64 years (mature working age), 65 years and older (elderly) (Youth, n.d.) However, it should be noted that Article 1 of the United Nations Convention on the Rights of the Child refers to the term "children" to persons under 18. At the same time, in the EU, youth is considered people aged from 15 to 29 years. In Ukraine, according to current legislation, youth include people aged 14 to 35 years, but in 2020 in Ukraine adopted a bill the law draft "On the basic principles of youth policy," which proposes to reduce the age of youth under 29 years as in the EU. Thus, national legislation will be harmonized with the EU countries' legislation.

In 2019, there was 1.2 billion youth aged from 15 to 24, which is 16% of the world's population, and by 2030, it is projected that their number increases by 7% and reach almost 1.3 billion (Youth, n.d.). Meanwhile, a significant part of youth is migrants. Thus, the Table 1 shows the number of international migrants aged 15 to 24 years to the total population (both genders) in 1990-2019.

The table depicts the following global trends in international youth migration development: the weight and volume of international youth migration are growing and remain significant in more developed regions and high-income countries; the largest centers of international youth migration are Oceania, North America, and Europe.

The critical issue of changing the population age structure becomes relevant. According to the US CIA website, the population age structure affects the country's critical social and economic problems. The age structure is also applicable for potential political problems prediction. For instance, the rapid growth of young adults who cannot find work may lead to unrest (Central Intelligence Agency, 2020).

Youth strive to become a positive force for development if they are provided with the knowledge and opportunities necessary for their prosperity. In particular, youth should receive the education and skills needed to contribute to developing a productive economy; and they need access to the labor market, which could take them into the labor force.

Table 1. Number of international migrants aged from 15 to 24 years to the total population (both genders) in 1990-2019, %

Region	1990	2000	2010	2019
WORLD	4.5	4.3	4.6	5.1
Development groups according to the UN classification				
More developed regions	13.4	16.1	18.7	21.3
Less developed regions	2.6	2.2	2.5	3.0
Income groups according to the World Bank classification				
High-income countries	12.7	16.5	21.5	24.1
Middle-income countries	2.7	2.0	1.9	2.4
Low-income countries	5.8	3.8	3.2	3.0
Countries with uncertain income levels	26.9	40.0	37.1	36.6
Geographical regions				
Africa	5.5	3.8	3.1	3.4
Asia	2.2	1.9	2.4	2.8
Europe	12.8	13.7	16.4	20.4
Latin America and the Caribbean	2.2	1.7	2.1	3.0
North America	18.9	25.7	24.9	24.1
Oceania	21.5	22.3	29.0	39.2

Source: elaborated by the authors according to International Organization for Migration (2020)

Therefore, youth are increasingly demanding more just, equal, and progressive opportunities in their societies. Döring, Lundberg, Dalman, Hemmingsson, Rasmussen, Wallin & Lager (2021) conclude that «expanding the education system may be a natural response to falling demand for low-skilled labor, but not the one that addresses major societal challenges. As long as education systems do not adequately respond to such a challenge that only expectedly leads to an increase in inequality." The need to resolve youth's multifaceted problems (such as access to education, health, employment, and gender equality) is becoming more acute than ever.

The mature problem solution in the migration policy (especially for youth) requires scientific understanding. It should be noted that it is advisable to distinguish this social group from the standpoint of age and the standpoint that it is an exceptional social and demographic group. It is class differentiated, has specific social and psychological properties that depend on social and political, cultural conditions, and socialization peculiarities.

Demographic factors of population division into groups outline the international migration effects: changes in age, gender, and quantitative structure. The most mobile group of the population is youth, which, in turn, is the most significant potential group in terms of creating new families. Therefore, such population stratification groups' migration directly affects the birth rate in the origin country and population age structure.

Fig. 2 illustrates the age structure of migration centers in the countries of individual particular regions according to the developed UN database results on age groups of migrants within each destination region.

The age distribution of migration flows to individual regions allowed drawing the following conclusions. A significant number of people aged 0-24 are immigrants in Africa and Latin America, and the Caribbean, and Asia. We can make assumptions that the prerequisites for such immigration centers structure, first, are high birth rates in these countries as a whole. Secondly, this situation leads to the second assumption – a significant intraregional migration level explains this migration-center structure. In this regard, it is advisable to study such migration trends, including the existing "attraction" and "ejection" factors in the region. Third, military and political instability, along with the number of military conflicts, have increased amid ongoing ethnic conflicts in Africa and crime problems in Latin America, and the state of post-conflict migration of unaccompanied children.

The demographic prerequisites for youth migration are pretty interesting in this regard. Bloom

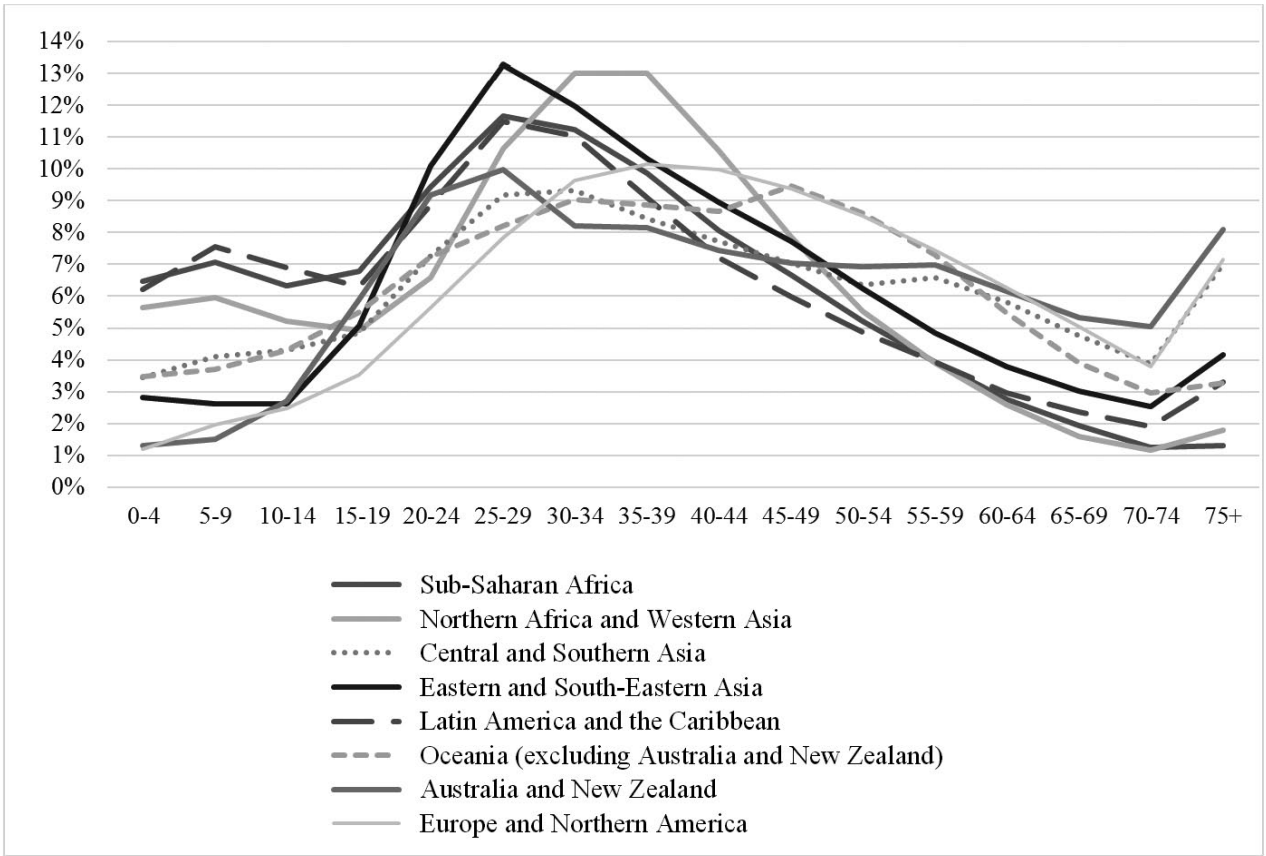

Fig. 2. Age distribution of migrants in destination countries in 2020, % of the number of migrants in the region (systematized and elaborated according to the UN) (UNDP, 2015; International Organization for Migration, 2020)

& Canning (2004, p. 20) sets such an example in the study: "Ireland has historically had a high level of young adults' migration (about 1% of the population per a year) due to the inability of its economy to absorb the large influx of young workers created by high birth rates."

It should be noted that the most active in the migratory sense is such a clearly defined group as student youth, which has significance for all spheres of life society specific social and psychological features.

However, for the origin country, the student migration problem, in our opinion, lies in youth non-return after the training course, which is now observed in Ukraine. However, the negative impact is covered by the positive effect of international youth migration, which covers gaining new knowledge and experience (improving knowledge of a foreign language, increasing the chances of success in the professional environment after returning to the origin country, obtaining financial resources to a certain extent). It is worth considering those cases where migrants remain in permanent residence in the destination country. Then, human capital as migrants of the origin country affects the country's social development, but this improves the welfare of the world's population.

Migration processes are heterogeneous with their specifics and change over time, which necessitates differentiation of different youth migration types. Thus, for reasons we can distinguish educational (educational migration), intellectual outflow (migration of young highly skilled professionals and graduates), and labor migration (due to the disproportion of development regions: labor market, living standards, etc.). Simultaneously, if educational migration is sufficiently managed, then other types are subject to management quite poorly. Furthermore, the uncontrolled growth of migration flows, in turn, leads to an increase in local hostility of migrants, to local conflicts, an increase in migrant phobia, which initiates ethnic nationalism in the most popular regions.

The burden on migrants will be felt significantly in the labor market, which also occurs due to the educational and professional structure of migrants and the sectoral economic structure of the destination country. Herein, several comments should be added:

1) structural unemployment in the country of origin under conditions of low wages provokes the human resources migration of different educational and professional groups; however, the same situation in the destination country determines potential niches in the labor market for migrants employment;

2) educational and professional structure mismatching the jobs obtained by migrants to their jobs leads to "brainwashing" – human resources are used inefficiently in the destination country and lose the quality features formed during training, and therefore can not be used re-emigration effectively while re-imigration of a person.

Therefore, we believe that in the long run, one needs to harmonize migration and education policy. That should give positive results, as the educational programs adapt to the national economic conditions, its sectoral and territorial structure help balance the labor's supply and demand, reduce structural unemployment. Therefore, it is advisable to strengthen academic and scientific mobility to increase the population education level (primarily young professionals), gaining international experience. The regulation also requires education in the country by aliens due to the expediency of activating and immigrating youth and their integration into the educational space and the labor market, which potentially means the country's labor and demographic resources.

In this respect, we believe that the regulation of the benefits and threats of youth migration should be based on the differentiation of such resources because they have a different impact on the country's demographic and labor potential in different migrants' categories. Therefore, the regulation also requires provisions to ensure equal access to economic benefits, promotion of youth employment, and social programs adaptation for different people categories.

It means that the primary purpose of migration policy for youth is to balance the interests of citizens of the destination country and migrants. The global migration centers in countries resort to various coordination strategies: preventing the low-skilled migration and restricting immigration in general, setting quotas for the most qualified categories, mandatory job invitations, etc.

Typically, global migration flows of skilled workers are regulated at the employer initiative: before a skilled migrant is allowed to enter the country, he/she must receive an invitation.

The youth immigration policy that arose due to the disproportionate regions' development was most effective in countries like Japan, China, and Germany. Those countries' regulation mechanisms can be divided into at least two types: socio-economic, and administrative and legal. Socio-economic mechanisms could include investment in transport, agglomeration development, territorial wage coefficients applicable at the regional level.

Thus, at the end of the XX century, Japan faced mass migration to large cities, which affected, above all, the population aged 18-30. The Japanese government, concerned about this problem, has long taken many measures to address it – significant investment

has been made in the transport infrastructure development, which has undoubtedly become an effective social and economic mechanism of regional migration policy, as it increases mobility and living standards of living. Considering the Japanese experience in solving the problem of reversal migration flows, it should be noted the other effective mechanisms of soft ("smart") population consolidation – the construction development as a way to solve the population housing problem. In this case, we can talk about the policy of regional "growth points" as a mechanism for creating new jobs and attracting youth.

Germany, after unification, faced severe differences in the economic development of the regions and as a result of the outflow from East Germany to the West. One of the mechanisms for reducing one-way youth migration flows was unique coefficients that increase wages in East Germany, the construction of new enterprises, and infrastructure development. These measures reduced the young migrants' flow and later allowed it to be redirected.

Administrative and legal mechanisms for regulating migration flows can be divided into the registration system and legal restrictions on the population flow; migration sanctioning. Those mechanisms can be applied only at the state level. Thus, in the early 1950s, the Chinese government faced large-scale migration of rural population, mostly youth, in cities apropos the agrarian reform and industrialization in cities. The government has taken drastic measures to address this problem. As a result, by the end of the 1950s, the country developed the "hukou" rigid registration system that hindered the mass influx of youth to cities.

Thus, the primary mechanism for managing migration flows, resulting from the proportions of social and economic development of the country, in the case of Japan, is an investment; in China, it is accounting and control and administrative law enforcement; in the case of Germany, it is territorial income regulation.

All these mechanisms' application positively affected the migration flows redirection in a strategically necessary direction for the country, yet the strict prohibitive measures application to restrict the youth movement freedom in modern democratic society is impossible. Thus, we note the formation of powerful migration attraction centers of intellectual labor resources in the UAE, Canada, USA, Australia, and New Zealand, where youth are provided with priority and tools to motivate immigration.

There is also the intellectual outflow regulation policy, which in most cases affects youth. The nature of such policies varies. In this sense, a successful example of a partnership on regulated, skilled migration (agreed policies between countries of origin and destination) in Australia and Germany with the Philippines, Bosnia and Herzegovina, Tunisia (Hooper, 2018). Assessing the most successful experience in developing policies to combat the "brain drain" of East Asian countries, we can identify common mechanisms feature of these countries: social and economical, and institutional. Social and economic mechanisms include: increasing funding for science and innovative technologies and education reform; creating a critical mass of repatriates through the construction of technology parks and free economic zones. In turn, the institutional mechanisms may include the "circulation of brains" policy, i.e., the international diaspora reserve. These mechanisms are applicable at different levels (Puryhina, 2007).

Taiwan became the first country to implement a mechanism to increase funding for science and innovative technologies and reform education in youth immigration policy. Unlike other states, which usually invest in higher education, the Taiwanese government since 1961, 80% of all funds has allocated for education, directed to the support and development of primary and secondary schools and vocational programs. They further initiated the country's industrial boom, increasing the prestige of the working profession, wage growth, which minimized the incentive to migrate this population category. Besides, as part of the higher education reform, the Chinese government has allocated significant funds to the country's leading universities to improve the education quality, which primary purpose was to enter the ranking of the world's best universities, 20% of these funds have been spent on attracting "new talent," mostly from abroad.

The institutional mechanism for migration return policy can be cited on Taiwan's example with the setting up the Hinschu science and technology park whose purpose was to repeat Silicon Valley's experience in America, i.e., to concentrate the talent and experience of scientists and professionals in a single place. Since 1980 the allocation of funds for the park's construction has begun, creating the necessary working and leisure conditions; by 2000, the park employed 102 thousand people, with a turnover of 28 billion US dollars.

Another effective institutional mechanism for curbing "brain drain" is the "brain circulation" policy. Taiwan, China, and India have made significant progress in such mechanism application. The National Youth Commission (NYC) was established in Taiwan in the early 1970s to conduct a series of programs to recruit young Taiwanese scholars abroad. As a result, by 1987, 20% of all senior executives in Taiwan's giant companies were repatriated.

The modern approach to migration regulation on the European continent is the Blue Card Scheme ("blue card"), adopted by a directive of the European Union Council in May 2009. That is an exceptional opportunity to simplify the entry and residence of qualified professionals from third countries in the European Union and the unimpeded movement of professionals across the EU. The Blue Card enables the employees and their families to enjoy social rights and benefits on an equal footing with local citizens, primarily working conditions and standards. That is the first attempt to regulate skilled migration at the interstate, regional levels (Cerna, 2013).

Besides, in almost all EU countries, the widespread introduction of legislation governing employment and wages of migrant students, when international students can work while studying 20 hours a week. In France, since 2006, students have had the right to engage in employment, and their hours can reach 60% of the country's annual working time.

Analyzing the leading countries' successful experience in attracting migrant students, we identify administrative and legal mechanisms: improving the visa regime, facilitating naturalization procedures in the country after graduation, the legislative act's introduction governing students' employment and curriculum internationalization.

To social and economic mechanisms can include financial and non-financial ones. Their implementation at the regional level can be most effective. Financial mechanisms: reducing the cost of education for international students; introduction of subsidy programs for talented students. Non-financial mechanisms – the policy of aggressive marketing; teaching courses in English. It is also necessary to note the program-targeted mechanisms, targeted loan programs for training.

Instead, the administrative and legal mechanism – the visa regime improvement for international students and facilitation of naturalization procedures in the country after graduation can be implemented only at the national level, when in this regard, almost all world leaders engaged in attracting educational migrants have modified the visa legislation for international students.

It should be noted that the curriculum internationalization mechanism becomes an integral element of education. Knowledge acquired by students in higher education institutions of one country may be applicable in others. Therefore, all leading world powers are interested in curriculum internationalization.

Today, the EU implements anti-discrimination programs and the EQUAL campaign, which aligns integration policy in various areas with anti-discrimination policy and involves the ethnic minorities in developing and implementing these measures, the "Prohibition of discrimination and equal opportunities for all" strategy. The most progressive in the UK and the United States' planned legislation, where representatives of racial groups provide preferences for employment, university admission, and obtaining federal contracts.

It should also be borne in mind that modern problems of youth migration require measures and another direction. It is about protecting donor countries from destructive processes in the economy and social sphere, reducing human development, from the banal extinction of nations in the global sense. That is why, as never before, the governments that suffer from the outflow of young labor resources need the latest scientific research and mechanisms and tools of regulation of a new type.

Thus, in December 2020, Alla Girman conducted a sample express study of youth mobility among students of the University of Customs and Finance in Dnipro (Ukraine). The students' available set was 5119, and the sample – 135 people with a confidence probability of 95% with a sampling error of 5%. As a tool for the survey was developed a questionnaire consisting of six blocks: migration history, the benefits of choosing a place to study, academic mobility, e-mobility, migration intentions after training, and data about a student.

The data showed that the share of non-local students was 58.4%, locals – 41.6%. 72.3% of students live inside the region, and 27.7% came from other regions. The main reason for migration is obtaining higher education. It should be mentioned that several respondents noted other reasons for moving – the lower standard of living in the places they used to live. Thus, 27.5% of respondents noted the poor development of entertainment infrastructure and 38.6% – the lack of social facilities. Such responses were mainly received from respondents who moved from rural areas and small towns.

Among the respondents, only 67.1% partially agree that Dnipro city has a high living standard, which influenced the choice of place for study. At the same time, respondents do not agree with the statement that in Dnipro city, it is easy to get a job after studying (89.1%).

The answers to whether you want to get an education in more than one university, i.e., some time to study in another educational institution, are divided into equal parts: want to study – 49.4%, do not want to study – 50.6%.

Student test data show that the level of education

is high, the share of students settled in the specialty after graduation also corresponds to the average in the region. However, youth migration intentions during training (under the academic mobility program) and after training were relatively high. The vast majority of respondents are set to change the residence place – 71.3%. Amongst, more than a half of them intend to work abroad. However, the youth pointed to three main reasons that prevent them from going abroad to study. The first one is the high financial costs for education and lack of funds (46.8%), the second is poor knowledge of a foreign language (37.3%), the third is the emotional and psychological complexity of separation from family (10.1%), and only 5.8% – other reasons.

Ukrainian students who speak English and want to go abroad for education first chose the United States and Great Britain (23.5%), followed by Germany (17.8%), then roughly the same indicated Poland (12.4%) and the Czechia (11,0%).

The reasons for choosing these countries vary greatly. The students who want to study in the United States choose this country mainly because of the prestige of higher education, employment opportunities, and greater competitiveness in the labor market after studying in the United States.

The students choosing European countries explain their choice for higher quality education, higher living standards, similar conditions in the EU, and a short distance from home. Students are focused on a short-term stay of no more than a month of student exchange or internship, master's and graduate studies, for a period of 2 to 5 years to further employment and citizenship of that country.

The main reasons that prompted respondents to indicate that after graduation, they leave the country: low income in Dnipro city and Ukraine as a whole, lack of opportunity to purchase housing, the uncertainty of political and economic status situation. There is a significant connection with the following features: «I have experience of going abroad for educational and professional purposes (internships, student exchange programs, summer schools, conferences)» R = 0.768, «I speak a foreign language well» R = 0.699, «I am a prize-winner or participant of conferences, olympiads, competitions, grants" R = 0.634. The obtained results confirm the significance of the social and economic factors for international migration.

The survey results touch on a serious problem, which should become the basis for revising the approach to building youth migration policy. As youth's awareness of new prospects and education increases, the youth segment's emigration activity may increase even more, which will have negative consequences for donor countries from the strategic perspective.

Accordingly, the increase of human capital in the region in the strategic perspective should consider the youth segment's migration component. That is made possible by creating conditions for local youth to leave and enter the regional labor market. However, this is facilitated by the formation of conditions to attract local and international flows of youth immigrants to local educational institutions and their further assimilation.

According to the authors, the main direction of optimizing the international youth migration flow should be a global coordination dialogue with civil society participation. Along with international organizations, governments should involve trade unions, human rights groups, diasporas, and migrant associations in addressing youth migration, as such partnerships have every opportunity to address migration issues.

The international youth migration regulation is run by appropriate policies (they constitute a mechanism for regulating international migration) (Fig. 3).

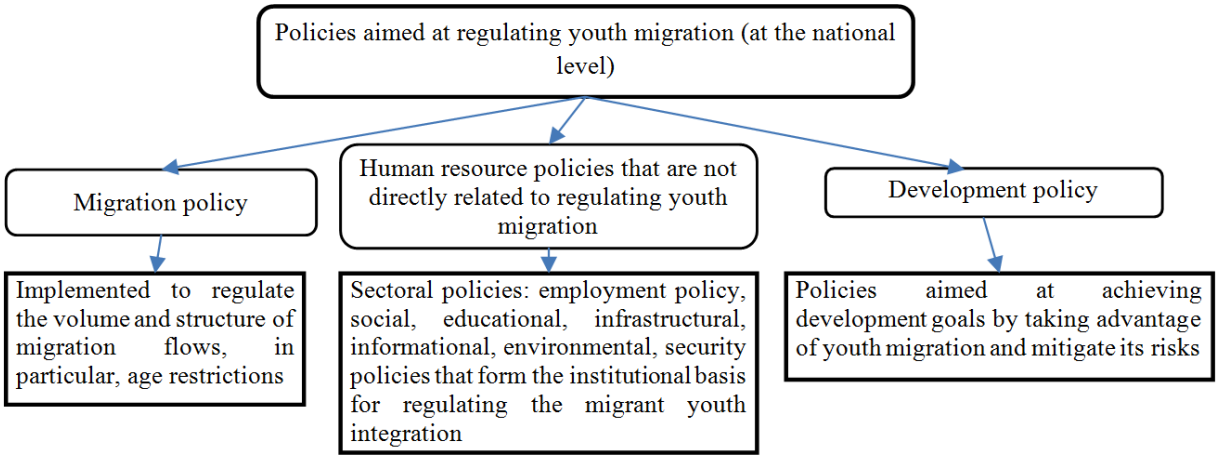

Fig. 3. Regulation policies of youth migration flow

While migration policy is primarily aimed at regulating and controlling border crossings, other policies address specific issues of migrant youth integration. Such policies should include: 1) employment policy; 2) social policy; 3) educational policy; 5) information policy; 5) security policy. Table 2 presents more details of the influence of the above policies on the migration flows regulation.

Table 2. Sectoral policies impact identification on the youth migration regulation

Policy	The policy impact features on the youth migration regulation
Employment policy	Employment policy should consider the potential migratory pressure of youth on the labor market and the impact of labor market conditions for youth employment in the structure of «attraction-push» factors in the migration motives formation.
Social policy	The country's social protection system and youth access are essential factors in the country's migration attractiveness. The social policy determines the opportunities of migrant youth and the availability of social benefits in various forms of social protection.
Educational policy	The quality of the higher education system and the level of its accessibility for young migrants determine 1) the quality of human resources entering the country's labor market; 2) the competitiveness of migrants in the labor market, and the opportunity of obtaining sufficient remuneration for work; 3) the ability to integrate into the social, cultural, and intellectual life.
Informational policy	Information policy is to create, maintain, and improve the migration flows formation and regulation to eliminate institutional, security, social, economic, environmental, and ethnic risks of intensification of migration processes.
Security policy	It consists of preventing humanitarian problems in areas of armed conflict and post-conflict areas, monitoring youth at risk and needing protection, promoting the migrant youth integration in the host society and ensuring their protection as citizens of their origin country, creating an institutional environment and social and economic conditions return of juvenile refugees and asylum seekers.

We believe that in this context, it is worthy to one should pay attention to the employment policy, educational and social policies implementation for migrant youth in this context. For instance, less developed countries should improve youth education and training, which can potentially become migrants and enter regional and international labor markets. Youth need to develop a system of professional skills and competencies that meet the modern labor market requirements. More developed countries, which are predominantly destination countries, should identify ways to improve their integration, mainly through education and retraining, as educating youth in an authentic host environment facilitates their integration into such a society and coordinates professional competencies and qualifications migrant labor force.

Conclusions

The study of trends in international youth migration allows concluding about the relevance of this process and the growth of its impact on social development. For the world as a whole, the positive consequence of the youth migration development is the possible expansion of realizing human potential, enriching public life, increasing the volume of scientific achievements, and improving communications. The negative consequences of youth migration are the destruction and pollution of the natural environment, exacerbation of available and new transport, environmental and social problems, the spread of disease, and rising crime. Nevertheless, despite different aspects of the migration impact on the social development of the world in general and countries in particular, the global demographic process demonstrates an increase in international and local youth migration by the middle of the XXI century that unfolds and at the current pace increasingly affect social development. The further research prospect is to develop coordination and regulatory measures to balance youth migration processes for countries, regional associations, and international organizations in continuing quarantine restrictions related to the COVID-19 pandemic.

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Methodological basis of zoning of tourism-recreation reserves and tourism potential of Gusar region of the Republic of Azerbaijan

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Abstract. In modern times, the potential opportunities of the regions are studied using different methodological approaches to achieve sustainable socio-economic development, and zoning is carried out in different directions to stimulate their future activities. The zoning is based on the demand for available resources and takes into account the level of socio-economic development of the region. At present, the study of tourism in the Republic of Azerbaijan by regions is encouraging attention due to its relevance. However, research work on the identification of tourism zones in the country and the zoning of these areas is weak. From this point of view, the article studies the tourism potential of Gusar region and provides a scheme for its tourism-recreation zoning which meets present-day requirements and attracts attention due to its relevance. The article analyses the development strategy of tourism, which is a new and promising field in the Republic of Azerbaijan, identifies the main directions of this strategy, and explores ways to solve existing problems. For this purpose, first, the criteria for zoning of tourism and recreation resources were determined; then natural and anthropogenic tourism resources were assessed through the example of Gusar region; information on natural and historical-architectural monuments of interest to tourists was provided; the number of hotels operating in the region over the past five years, the number of rooms, full hotel capacity and overnight stays, as well as the income, expenses, and the difference between them were made on the basis of statistical and comparative analysis. Based on the information obtained, for the first time, a "Zoning Map of Tourism and Recreation Resources of Gusar Region" was compiled; the strengths and weaknesses of the tourism sector were identified, and future threats and opportunities for the development of this sector were analysed by means of the SWOT analysis. According to the analysis, the strengths of the region included the favourable economic and geographical position, the availability of unique natural and historical-architectural monuments, the availability of natural and ecological conditions to provide recreation for tourists, and opportunities for ecological, rural, religious, trekking, and other tourism types, etc. Weaknesses included the concentration of hotels mainly in the region's centre, insufficient promotion of tourist attractions, poor level of service and vocational training, lack of guides, etc. The opportunities were high tourism potential, organisation and development of local tourist routes, an abundance of labour resources, etc., while the threats included the aggravation of the geopolitical situation in the border areas, the intensification of natural disasters, etc.

Keywords: *tourism-recreation resources, natural monuments, historical-architectural monuments, zoning, hotel*

Методологічні основи районування туристично-рекреаційних заповідників та туристичного потенціалу Гусарського регіону Республіки Азербайджан

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Анотація. У наш час потенційні можливості регіонів вивчаються з використанням різних методологічних підходів для досягнення стійкого соціально-економічного розвитку, а зонування здійснюється в різних напрямках для стимулювання їхньої подальшої діяльності. Зонування базується на попиті на наявні ресурси та враховує рівень соціально-економічного розвитку регіону. В даний час вивчення туризму в Азербайджанській Республіці за регіонами є дуже актуальним. Однак дослідницька робота з визначення туристичних зон у країні та районування цих районів є недостатньою. З цієї точки зору у статті висвітлено результати вивчення туристичного потенціалу регіону Гусар та забезпечено його туристично-рекреаційне районування, яке

відповідає сучасним вимогам та привертає увагу своєю актуальністю. У статті проаналізовано стратегію розвитку туризму, яка є новою та перспективною сферою в Азербайджанській Республіці, визначено основні напрямки цієї стратегії та досліджено шляхи вирішення існуючих проблем. Для цього спочатку були визначені критерії зонування туристично-рекреаційних ресурсів; тоді природні та антропогенні туристичні ресурси оцінювались на прикладі регіону Гусар; була надана інформація про природні та історико-архітектурні пам'ятки, що цікавлять туристів; кількість готелів, що працювали в регіоні за останні п'ять років, кількість номерів, повну місткість готелів та ночівлі, а також доходи, витрати та різниця між ними були зроблені на основі статистичного та порівняльного аналізу. На основі отриманої інформації вперше було складено Карту зонування туристичних та рекреаційних ресурсів Гусарського краю; було визначено сильні та слабкі сторони туристичного сектору, а також за допомогою SWOT-аналізу проаналізовано майбутні загрози та можливості для розвитку цього сектору. Згідно з аналізом, сильні сторони регіону включали сприятливе економічне та географічне положення, наявність унікальних природних та історико-архітектурних пам'яток, наявність природних та екологічних умов для забезпечення відпочинку туристів та можливості для екологічних, сільських, релігійних, трекінг та інших видів туризму тощо. До слабких сторін належать концентрація готелів переважно в центрі регіону, недостатня підтримка туристичних визначних пам'яток, низький рівень сервісного та професійного навчання, відсутність гідів тощо, розвиток місцевих туристичних маршрутів, велика кількість трудових ресурсів тощо, тоді як загрози включали загострення геополітичної ситуації в прикордонних районах, посилення стихійних лих тощо.

Ключові слова: туристично-рекреаційні ресурси, природні пам'ятки, історико-архітектурні пам'ятки, зонування, готель

Introduction

Tourism has been one of the fastest-growing spheres of the non-oil sector in Azerbaijan in recent years. Thus, benefitting from great opportunities, tourism provides regional development based on the efficient use of local resources, provides a basis for the improvement of infrastructure, as well as serves as an additional source of income for the population. In a broader sense, tourism is a means that affects the formation of the state budget, the improvement of villages and cities, the preservation of historical and architectural monuments, and the development of small and medium enterprises (Imrani, 2018). From this point of view, the identification of ways to develop tourism in the Republic of Azerbaijan, the study of problems in this area, as well as the zoning of tourism and recreation resources on a scientific basis are of great scientific, theoretical, and practical importance.

In order to develop tourism, which is a new and promising field in the Republic of Azerbaijan, the "Law on Tourism" in 1999, the "State Program for the Development of Tourism in the Republic of Azerbaijan" in 2002-2005 and 2010-2014, the "State Program on the Development of Resorts in the Republic of Azerbaijan" in 2009-2018, the announcement of 2011 as the "Year of Tourism", the "Strategic Roadmap for the Development of the Specialised Tourism Industry in the Republic of Azerbaijan" in 2016, and other decisions were of great importance. However, despite the work done, it was not possible to fully and comprehensively solve the existing problems in the tourism sector.

In accordance with the changing dynamics of the tourism sector, five main directions in the development of tourism strategy in Azerbaijan have been identified as global trends: 1. development and promotion of the tourism brand; 2. application of a simplified visa regime; 3. attracting large-scale investment projects; 4. creating an attractive environment for investors; and 5. strengthening international cooperation (Strategic Roadmap…, 2016).

In recent years, the share of tourism in the economy of the Republic of Azerbaijan has increased significantly. If we analyse 2010-2018, it could be seen that the share of tourism in GDP increased from 1.0% to 2.2%. The reason for the increase was the announcement of 2011 as the "Year of Tourism" and the allocation of USD 828 million to the tourism industry that year (National Accounts…, 2019). As a result, the tourism sector began to develop rapidly, new hotels were built in a short time, and the number of tourists visiting the country increased 2.5 times.

Generalisation of existing problems and goals

One of the most important tasks facing each country is to increase employment and reduce unemployment by identifying ways to effectively use labour resources in solving existing socio-economic problems. From this point of view, with the development of the tourism sector in Gusar region, it is possible to create new jobs, thereby eliminating the employment problem, at least in part. For this, first, it is necessary to study the attractive tourism-recreation potential of the region and to determine zoning criteria by conducting its economic-geographical assessment.

Tourism and recreation resources are natural, historical, cultural, and socio-economic resources that are or can be used to meet the recreational needs of society (Alexandrova, 2002). Natural-recreational resources include resources used in the process of restoration and development of human physical and mental strength, ability to work, and health. Almost all natural resources have recreational and tourism potential but the degree of their use is different. It

depends on the demand for recreational resources and the level of specialisation in the region.

Tourist and recreation zoning - industry-specific zoning (Fedotov, 2013). Given its specialisation in specific socio-economic activities, tourist-recreation zoning refers to industry-specific zoning. It should be considered as a tool for studying the territorial organisation of tourism and as a reflection of a certain stage in the territorial development of tourism (Recreational systems, 1986). From the point of view of the scale of the space, the goal and the definition of criteria, the process of touristic division of the territory largely depends on the number, volume, configuration, name, specialisation, and boundaries of the allocated tourist areas (Kristev, 2019).

Natural-recreational resources are divided into 3 categories: physical, biological, and complex. Here, physical natural-recreational resources include geological, geomorphological, climatic, and hydrological resources; biological natural-recreational resources include soil, vegetation, and wildlife; and complex natural-recreational resources include landscapes. These components form the basis of the formation of tourism and recreation systems and manifest themselves in a reciprocal form. For example, therapeutic mud belongs to both the geological and geomorphological groups, while mineral water belongs to both the geological and hydrological groups (Kruzhalin et al., 2014). Physical and biological natural-recreational resources are organically combined and inseparably integrated resources related to the flow of substances and energy.

In general, each type of natural-recreational resource is distinguished only based on their specific characteristics. They can be grouped according to their health characteristics, usability, evolutionary forms, and environmental criteria.

Summarising the above-mentioned components, it could be stated that tourism and recreation resources are a set of conditions that help to meet the needs of the population for tourism. Thus, in order to develop the tourism sector, first of all, the economic and geographical situation of the region is determined. The analysis takes into account the geographical location of the area, tourism and recreation services, the level of socio-economic development, the availability of infrastructure, hospitality, and other factors. The following are related to the comprehensive definition of tourism and recreation potential:

Natural potential includes natural monuments, their attractiveness, rate of use, protection, natural and artificial restoration, etc.

Historical-cultural potential includes a number of cultural-heritage tourism objects, their importance (international or local), degree of use, semantic value, etc.

The socio-economic potential is measured by the number of tourists visiting the area or facility but certain criteria are applied to the number of visitors. Thus, when the number of visitors to the region is too high, it can lead to the creation of ecologically tense zones. Socio-economic potential includes the current state of infrastructure, investments, tourism information centres, staff assistance, etc.

Taking into account the potential of tourism and recreation resources in zoning is one of the most important issues.

As it is known, physical-geographical zoning is based on the laws of nature, while economic-geographical zoning is carried out based on the laws of society, taking into account the rational use of nature (Hasanov, 2012). In the case of tourism and recreation zoning, the main focus is on identifying more attractive areas for tourists. This is determined by similar features of the area or by a combination of these features. Many scientists prefer natural and economic factors when zoning tourism. These indicators allow accurate reflection of the image of each region and revelation of its features. In addition, when conducting tourism-recreation zoning, it is necessary to take into account the potential tourism-recreation zones of the region, natural conditions, historical and cultural features, residential areas and density of the population, and features of hotels and recreation centres.

After determining the criteria for zoning, a digital map of the area is prepared, roads and road facilities are included in the GIS system, statistical materials on the number of settlements and population, demographic indicators are collected, systematised, and analysed.

The principle of classification and distribution of natural resources, the nature of climate comfort as a tourist resource, exoticism of landscapes, hydrology, natural monuments, the material and technical base of tourism, criteria for assessing financial, labour, and socio-economic resources should be analysed while conducting the tourism-recreation zoning in Gusar region.

Critical review of work

The territory of Gusar region, located in the northeast of the Republic of Azerbaijan, is 1.50 thousand km^2, the population is 97.2 thousand people, and the population density is 65 people per km^2. 21.1% of the population is settled in urban and 78.9%

- in rural settlements. The distance between Gusar region and the capital Baku is 180 km (Regions of…, 2019). There are 88 rural settlements , 1 city (Gusar) and 1 settlement (Samur), in Gusar region. The length of the borders of Gusar region is 255 km and it borders Dagestan (95 km) of the Russian Federation in the north-west, Khachmaz region (65 km) in the north-east, Guba region (70 km) in the south-east, and Gabala region (25 km) in the south-west.

The ***climatic*** conditions of Gusar region provide wide opportunities for the development of the tourism sector here. Thus, before the trip, a tourist is primarily interested in the climate of the area, which, depending on the type of recreation he/she chooses, affects the efficient organisation of leisure time. (Imrani and Jafarova, 2020).

Due to the fact that the territory of Gusar region consists mainly of mountains, the vertical zonation of the climate is typical here. There are three climate types in the region. These include a moderately hot climate with evenly distributed precipitations, a moderately hot climate with dry summers, and a cold climate with dry winters. Due to the existence of a vertical zone in this area, the average temperature is -5+2°C in January, and -17-22°C in summer. The average temperature in January is 1°C in the plains, -14°C in the high mountains, and 24°C and 2°C in July, respectively. Annual precipitation is 350-1500 mm. Precipitation falls mainly in the cold period of the year (Hajiyev and Rahimov, 1977). Exposure to the rains in the summer months, mainly in the second half of the day and in the evenings, does not cause any discomfort.

Low humidity in the summer months in Gusar region, the advantage of dry weather conditions, and abundance of oxygen are favourable for the organisation of climate resorts. Analysis of long-term meteorological forecasts shows that the recurrence of comfort levels in the summer months is 64% in the village of Urva, 60% in Khuray and Anig, 55% in Hazra and Ukur, and 62% in the foothills of Shahdag.

One of the important factors influencing the territorial organisation of tourism infrastructure in Gusar region is the ***relief***. The south-western part of Gusar region is a mountainous area (north-eastern slope of the Main Caucasus Range, Yan Range), the central part is a sloping plain (Gusar sloping plain), and the north-eastern edge is the Samur-Davachi lowland. The south-western border of the region passes through the watershed of the Main Caucasus Range. The height of the area is 100 m in the lowland part and 4,466 m on Bazarduzu Mountain. The Salavat Pass (2,895 m) is also situated here. The Yan Range is partitioned by the valley of the Gusar River and divided into the Shahdag and Gizilgaya mountain massifs. There are several branches from the Shahdag in different directions, the longest of which is the Suval Range. Traces of ancient glaciers are clearly visible on the bare rocks in the highlands, parallel to the village of Laza in the Suval Range. Ancient glaciers stretch from the slope of the mountain to the bed of the Shahnabad River and are divided along the slope (Aliyev and Budagov 1973). These areas have favourable natural conditions for the development of mountain tourism. Along with this, Shahdag National Park was established 32 km away from Gusar region on December 8, 2006, where eco-tourism is also developed. The most interesting places for tourists in the national park are the constantly snowy peaks of the Main Caucasus Range - Bazarduzu (4,466 m), Shahdag (4,243 m), and Gizilgaya (3,739 m) (Abadov, 2,014). There are ecological tourism routes such as Laza-Waterfalls or icy waterfalls, Laza-mountain waterfalls, Laza-Sudur, Geleykhudat Heydar Aliyev peak, and Bazarduzu in the territory of the national park.

The ***soils*** in Gusar region are mainly grassy mountain-meadow, brown mountain-forest, typical and carbonate mountain-forest, and brown soils. The main ***vegetation*** of the mountainous area consists of broad-leaved forests on the sloping plains of alpine and subalpine meadows. Meadows and bushes also cover large areas in the region (Mammadov et al., 2012). Forests cover a large part of the territory - 20% of Gusar region. The complex physical and geographical conditions of the area have led to uneven distribution, structure, kind, and age composition of forests (Mammadov and Asadov, 2010). The forests are dominated by hornbeam, oak, beech, poplar, and elm trees. Wild fruits are also widespread in the forests. The vegetation of the tea fields has wild fruits such as cornflower, cornel, cherry-plum, sumac, hawthorn, as well as natural medicinal plants such as dog-rose and blackberries.

In an area of 7 hectares, a beech forest called “Alistan Baba” near the village of Urva in the Gusar region is specially protected. The forest is rich in tall and old beech trees. In addition, a 200-year-old maple tree (*Acer platanoides*) in front of the Hazra village mosque and a 460-year-old eastern plane tree (*Platanus orientalis*) in the old cemetery near the tomb of Sheikh Junayd attract tourists as a natural monument.

Gusar region is also distinguished by its rich ***fauna***. There are wolves, bears, foxes, wild boars, mountain goats, rabbits, and other animals, as well as Caucasian grouse , Caucasian snowcock, chukar partridges, quails, wild pigeons, mallard ducks, and many other different types of birds in the region.

Rivers are considered one of the most attractive areas for tourism development. The rivers of the northern region take their rise from the mountains of the Main Caucasus and flow into the Caspian Sea. (Gashqay and Mehdiyev 1950). Samur, Gusarchay, and Guruchay are the largest rivers in the region. Rivers and their waterfalls are of great interest to tourists.

The length of the Samur River is 216 km. It originates in the highlands (3699 m) between the Main Caucasus Range and the Samur Range watershed, which runs parallel to it in the north, and flows into the Caspian Sea. The Samur River crosses the border of Azerbaijan and Russia. The Samur-Davachi canal was built from the Samur River in 1940, and in the late 1950s, the canal reached the Jeyranbatan reservoir.

The length of the Gusarchay is 108 km, which takes its rise from Bazarduzu Mountain (3780 m) and flows into the Caspian Sea. The main tributaries are the Shahnabat (12 km long) and Sikhur (14 km long) rivers. The water of Gusarchay is widely used for irrigation of agricultural lands; part of the water is discharged into the Samur-Absheron water canal. Gusar, Khuray, Anik, and Guzun Hydroelectric Power Stations have been built on the river (Museyibov, 1998). The length of the Guruchay is 77 km; it takes its rise from the Yan ridge (2550 m) of the Main Caucasus and flows into the Caspian Sea. River water is widely used to irrigate agricultural fields.

Along with the economic importance of the above-mentioned rivers, they also have great tourism potential. There are recreation centres and picnic sites around the rivers. At the same time, there are many ***waterfalls*** on the rivers flowing through the territory of Gusar region. For this reason, Gusar region is called the land of waterfalls. Laza (54 m) and Shahnabal (32 m) waterfalls, as well as Suvar and Kuzun (28 m) waterfalls, which are among the most beautiful natural landscapes in the territory of Azerbaijan, are located here. These waterfalls attract tourists with their grandeur, abundance of water, and mysterious scenery.

Laza and Shahnabat waterfalls are located on the Gurgur River, the right tributary of the Gusar River, near the village of Laza, at an altitude of 2,200 m above sea level. As Laza and Shahnabat waterfalls freeze in winter, ice-climbing competitions are held here. Suvar waterfall is also located near the village of Laza, at an altitude of 2,000 m above sea level. Kuzun waterfall is situated at an altitude of 1,800 m near Kuzun village.

The territory of Gusar region is rich in sources of mineral and thermal waters. There are about 20 springs here, the total flow rate of which is 0.2 m^3. Sources of table mineral water, usually cold, are most common in the Shahdag and Sudur directions. A high flow rate of water is characteristic of such mineral springs as Cherkebulag, Shahbulag, and Kuzunbulag. Currently, these waters are not used for economic and tourist purposes.

There are many ***archaeological monuments*** in Gusar region. They include the mound of the 1st millennium B.C. in Khazra village; Galakhur settlement of the 4th-16th centuries; Mahmudtepe settlement of the 1st millennium B.C., 2 km north-west of Gadazeykhur village; the medieval settlement of Gadazeykhur village; the Bronze Age Gaflatepe settlement, 1 km south of Gadazeykhur village; the Bronze Age Govdishan hill mounds , 2 km east of Imamgulu village; Gunutepe settlement of the 3rd-7th centuries in Gunduzgala village; Maysertepa town of 1th-3rd centuries, 500 m north-west of Badirgala village; the medieval Kalaysuvar settlement in Samur settlement; a necropolis of the 4th-7th centuries on the left bank of the Gusar River, near Anig village; Kukhur hills settlement of 4th-7th centuries, 1.5 km north of Kukhuroba village; Iron Age mound, 50-60 m, on the left side of the Baku-Derbent highway near the Kukhuroba village; Iron Age necropolis in Hil village, etc. (Approved by…, 2001).

The territory of Gusar region is rich in ***historical and architectural monuments***. These include the ruins of 13th-century castle walls in the village of Anig and a 19th-century mosque; the tomb and mosque of Sheikh Junayd in Hazra village built in 1544; a medieval caravanserai in Kirig village; a medieval mosque in Balagusar village; a mosque in Hil village (19th century); Khudat fortress of the 17th century near the Kohna Khudat village; a mosque of the 18th century; mosques in the villages of Khuray, Boyuk Murug, and Tagaroba; mosques of the 19th century in the villages of Zindanmurug, Jagar, Gunduzgala, Chetkun, Mujug, etc..

Along with the historical and architectural monuments found in Gusar region, folk art such as carpet weaving, woodcarving, weaving socks and gloves from colourful coarse wool, processing of sheepskins, etc. has maintained its importance to this day.

One of the important conditions for the development of tourism in Gusar region is the availability of ***hotel*** complexes in accordance with international standards. Although the natural and historical-cultural tourism potential of the region is attractive for tourists, it will not be possible to develop the tourism sector at any level without modern hotel complexes. Unlike other areas of the tourism sector, hotels have a wide range of organisational structures,

which has a significant impact on economic performance.

There were 17 hotels for tourists to spend the night in Gusar region in 2018, most of which were concentrated in Gusar city. The number of rooms in hotels is 981 and the one-time capacity is 2,253 people. The number of hotels, the number of rooms and full hotel capacity have increased over the past five years. If we compare these indicators for 2017-2018, it could be observed that there has been a decrease. However, the increasing trend in the number of overnight stays in hotels was observed every year, and in 2018, the number of overnight stays was 107,496 people (Table 1).

skiing. However, at the beginning of winter, the lack of natural snow cover in the complex and the relative humidity of 80% require the provision of mountain ski slopes with artificial snow-making (generation) systems which requires additional funds. There are currently five hotels in the Shahdag tourist complex: Shahdag Hotel and Spa (for 346 people), Zirve Hotel (for 86 people), Gaya Residences (for 62 people), Peak Palace (for 334 people), and Park Chalet (for 328 people). The complex can accommodate 5,000 tourists at a time.

Along with large hotels, there are more than 50 small motels, hostels, and recreation centres in Gusar region. They include Chateau Hotel Gusar, Alpine

Table 1. Main indicators of hotels in Gusar region

	2014	2015	2016	2017	2018
Number of hotels, unit	14	17	16	19	17
Number of rooms in hotels, units	434	770	910	984	981
Full capacity of hotels, people	961	1625	1721	2352	2253
Number of overnight stays in hotels, person-night	28,452	37,625	70,495	101,581	107,496
- number of citizens of the country	25,341	32,067	50,223	65,040	41,163
- number of foreign citizens	3,111	5,558	20,272	36,541	66,333

Source: Tourism in Azerbaijan. Baku, 2019

During the years studied, the income of hotels in Gusar region increased by 10.3 times and expenses by 7.2 times. However, in 2015 and 2017, hotel revenues and expenditures were lower than in other years. The most sorrowful thing is that the difference between income and expenses was negative in all years except 2017. The largest difference (USD -55,510,824) was recorded in 2018 (Figure 2).

There is "Shahdag" winter-summer tourism complex in the territory of Gusar region, at an altitude of 1,440-1,640 m above sea level. The complex is equipped with a ropeway and ski trails, bench-type lifting facilities, and infrastructure for mountain

Inn Gusar, Gayi Bulakh Resort Center, Star Gusar Resort Center, North Motel, Shah Bulag, and others (Figure 2). However, they do not fully meet the needs of tourists visiting the region.

As a result of the research, it was determined that the average occupancy rate of hotels varies between 60-80% in summer and 30-40% in winter. The average stay of tourists in hotels is 1-3 days, and the average price of a room is USD 35-70.

The zoning of tourism and recreation resources of Gusar region was based on both natural and socio-economic resources. The territory of the region is divided into three zones in terms of tourism and

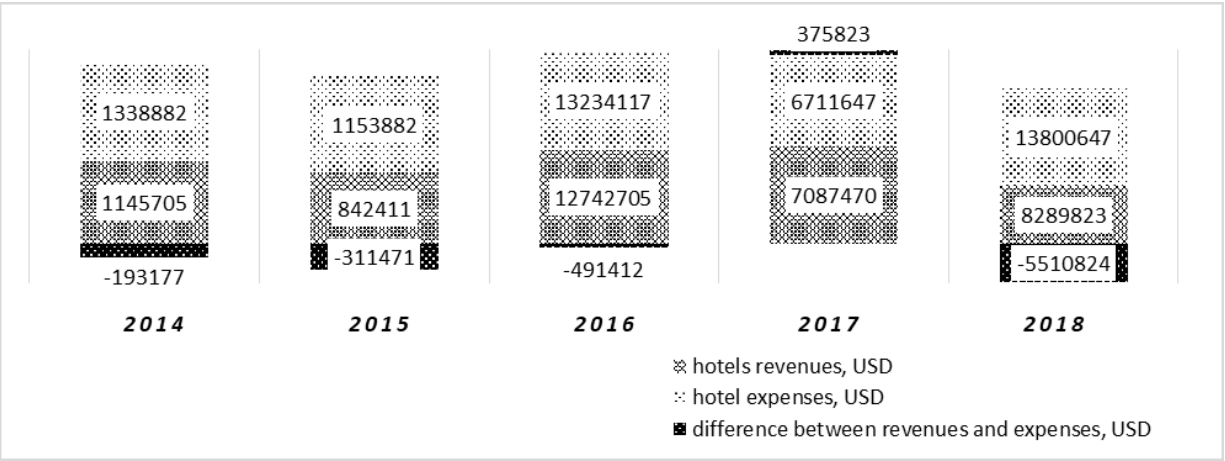

Fig. 1. Revenue and expenses of hotels and difference between them in Gusar region

Source: Tourism in Azerbaijan. Baku, 2019

Fig. 2. Zoning map of tourism and recreation resources of Gusar region

recreation resources. The first zone includes areas that are more developed than other areas in terms of the pace of development of the tourism sector; the second zone includes areas that are attractive and moderately developed in terms of ecotourism; and the third zone includes areas that are relatively underdeveloped despite their potential.

Tourism potential and forms of ***entrepreneurship*** develop faster as a result of effective activities. As a leading factor in tourism activities, small and medium enterprises should be expanded as a more efficient way. In particular, the use of small business products for consumption in the field of tourism can increase its potential and turnover by expanding the market of tourism services (Mammadov, 2013).

Tourism service is a labour-intensive field and opens wide prospects for the development of small and medium entrepreneurship. The income obtained in a short period is of interest to the entrepreneur. The development of tourism is of great importance in creating new jobs, reducing unemployment, preventing migration flows, and developing new housing. Some jobs in tourism enterprises are seasonal and in some cases require the use of more female labour (housekeeping, laundry, kitchen worker, etc.). This allows local residents to earn extra income, thereby improving the social situation of the family.

Labour resources are the main productive forces of society. The number, dynamics, and professional and educational level of these resources are the most important factor in the development of the economy in different regions of the country. The level of labour supply affects the formation and territorial organisation of the economy and allows the development of labour-intensive industries (Abbasov, 1998). Thus, the level of development of productive forces is related to the formation of life, spiritual and household traditions, the diversity of geographical conditions, and the possibility of its use.

At present, there are local tourist routes in Gusar region. However, although these routes mainly reflect historical, cultural and natural monuments, they are of local importance and can play an exceptional role in the employment of the population living in the region at any level. In addition to guiding activities, the locals help to meet the daily food needs of tourists and receive them at home as guests.

By conducting the ***SWOT analysis***, it is possible to identify its strengths and weaknesses, taking into account the positive and negative effects of the tourism sector. The analysis also identifies potential threats to the tourism sector and relevant opportunities for its development (Loudon et al., 2005). The advantage of SWOT analysis is that the strengths are further developed, appropriate measures are taken to eliminate the weaknesses, ways to address the threats to sustainable development are sought, a tourism strategy is developed, and maximum efforts are made to take advantage of local opportunities. In this case, there is a need to analyse the current state of tourism and recreation resources in Gusar region and their use by conducting the SWOT analysis.

It should be noted that as a result of the SWOT analysis, various options for linking the environment, competitive conditions, internal resources, and experience gained are developed, and specific tasks of marketing activities of the business unit are identified (Mammadov, 2007). Thus, their application is highlighted by identifying optimal ways to develop the tourism sector.

When conducting the SWOT analysis for Gusar region, the current state of hotels, along with more attractive natural and historical-architectural monuments, have also been studied. In this case, the main goal was to determine the dynamics of the development of the tourism sector (Table 2).

The results of the SWOT analysis show that despite the risks in Gusar region, there are favourable conditions for a high level of development of the tourism sector. To this end, the scientific basis and information provision of tourism development

Table 2. SWOT analysis of tourism-recreation resources and their use in Gusar region

Strengths	***Weaknesses***
- favourable economic and geographical position of the region; - unique natural and historical-architectural monuments; - natural and ecological conditions to ensure the rest of tourists; - preservation of national values, rich cultural heritage; - opportunities for the organisation of ecological, rural, religious, walking, and other types of tourism; - experience in conducting sports competitions (ice climbing); - state support for entrepreneurs for the development of the tourism sector.	- concentration of hotels mainly in the district centre; - insufficient promotion of tourist places; - non-use of springs for tourism purposes; - regular deterioration of roads in mountain villages during natural disasters; - poor level of service and professional training; - lack of guide staff; - lack of monitoring to measure the level of tourist satisfaction.
Opportunities	***Threats***
- high tourism potential; - improving the level of service in hotels; - organisation and development of local tourist routes; - abundance of labour resources; - allocation of investments to stimulate the work of travel agencies	- aggravation of the geopolitical situation in the border areas; - intensive nature of natural disasters; - other specific risk factors that depend on the professional training of travel agencies and tour operators.

strategy should be strengthened, foreign and local investors should be attracted to the region, the number of hostels and guesthouses should be increased, their service should be improved, and the tourism infrastructure should be mobilised, using the existing potential fully and effectively. Thus, the growing attention to the tourism industry will also play a supporting role in solving the employment problem.

Results

Assessment of tourism and recreation resources, their integrated use from an economic and environmental point of view affect the formation and development of the modern tourism market. Taking into account the natural conditions and economic potential of Gusar region, the zoning of tourism and recreation resources was carried out and the following results were obtained:

- Climatic conditions and relief factors of Gusar region, as well as the fact that a part of Shahdag National Park is in the territory of the region open wide opportunities for the development of the tourism sector. At present, ecological tourism routes operate in the National Park. At the same time, numerous waterfalls, springs around villages, as well as archaeological and historical-architectural monuments on large rivers such as Samur, Gusarchay, and Guruchay, and their tributaries prove the high tourism potential of the region.

- Although the performance of hotels in Gusar (number of rooms, full hotel capacity, and number of overnight stays) is high, the difference between the income and expenses of hotels has been negative in all years except 2017. As this indicator has a negative impact on the development of the tourism sector, it has weakened the service sector. To solve the problem, small motels, hostels, and recreation centres have been established in the region, and state support is provided to local entrepreneurs.

- Zoning of tourism and recreation resources of Gusar region was carried out, and according to the pace of development, the region's territory has been divided into three zones: highly, moderately, and relatively poorly developed zones. The first zone includes Gusar city, surrounding areas and "Shahdag" winter-summer tourism complex; the second zone includes forests, rivers, waterfalls, springs, etc., which are more attractive in terms of the development of ecological tourism; and the third zone includes areas with high tourism potential, but poorly developed.

- SWOT analysis of the tourism sector in Gusar region determined that the area had sufficient potential for high-level development of the tourism sector. Effective use of these opportunities would allow Gusar region to become one of the most popular tourist areas in Azerbaijan in the future.

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Geoinformation technologies as a basis for research of the optimal location of general secondary education institutions (on the example of Chernivtsi city territorial community)

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Abstract. GIS technologies allow an analyzis of large data sets at the lowest cost. To date, when forming a network of secondary schools, almost no geographic information systems have been used. GIS plays a special role in the study of transport and walking accessibility to GSEI. The article analyzes the theoretical, methodological and practical problems of using geographic information systems in studies of walking accessibility to general secondary schools of Chernivtsi city territorial community and describes the general secondary education institutions of the studied community. Based on geoinformation systems developed in Open Route Service and QGIS, the areas of the community with the best and worst walking accessibility to secondary schools were identified, which is certainly of great practical importance in creating pivotal institutions, their service zone and overcoming the problem of overcrowding in some schools. The most convenient location of the general secondary education institutions of Chernivtsi city territorial community was observed in the central part of the city, as well as in microdistricts Prospect and Boulevard, where there is a fairly dense arrangement of general secondary education institutions. There are also areas in the community that are outside the 2-kilometer walking accessibility zone and require transportation for students. Such areas are the Shantsi, Tsetsyno and Slobidka and Rohizna microdistricts, which have a cottage type accommodations. In general, most of the community is within walking accessibility. An important aspect of the location of GSEI is the availability indicator, which ranges 0.2 to 0.81. The average rate of accessibility to GSEI in the Chernivtsi city territorial community is 0.65. It should be noted that in the community there is a relevant problem of providing students with places in GSEI in those areas, where today the construction of new residential areas is actively carried out, while educational institutions are not expanding and not being built.

Keywords: geographic information systems, Open Route Service, QGIS, ArcGIS, walking accessibility, secondary education, general secondary education institution (GSEI)

Геоінформаційні технології як основа дослідження оптимального розташування закладів загальної середньої освіти (на прикладі Чернівецької міської територіальної громади)

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Анотація. В статті проаналізовано теоретичні, методичні та прикладні аспекти використання геоінформаційних систем з метою вивчення та аналізу оптимального розташування закладів загальної середньої освіти Чернівецької міської територіальної громади, визначення пішохідної доступності учнів до них; а також можливості їх застосування для проектування освітньої мережі. На основі побудованих цифрових картографічних моделей за допомогою веб-сервісу OpenRouteService та геоінформаційних систем ArcGIS та QGIS, визначено межі та структурні елементи територіальної громади, проаналізовано особливості функціонування загальноосвітньої мережі на території дослідження та виявлено зони з найкращою та найгіршою пішохідною доступністю до закладів загальної середньої освіти. Найкраще розташування закладів загальної середньої освіти Чернівецької міської територіальної громади спостерігається в центральній частині міста, а також у південних спальних мікрорайонах міста – Проспект та Бульвар, де відстежується досить щільне розміщення закладів загальної середньої освіти, що пояснюється в центральній частині історичними процесами формування міського простору, а в спальних районах – високою густотою населення та відповідно і чисельністю дітей шкільного віку. Встановлено, що в громаді наявні території, що знаходяться поза межами 2-х кілометрової зони пішохідної доступності та потребують організації підвезення учнів. Такими територіями є мікрорайони з котеджним типом забудови – Шанці, Цецино Слобідка та Рогізна, а також сільські населені пункти. Загалом більша частина території громади знаходиться в межах пішохідної доступності. Важливим аспектом розміщення

закладів загальної середньої освіти є показник доступності, який коливається від 0,2 до 0,81. Середній же показник доступності до закладів загальної середньої освіти в Чернівецькій міській територіальній громаді становить 0,65. Слід відмітити, що окраїнні рурални райони міста потребують підвезення учнів шкільними автобусами, що потребує вирішення міською владою. ГІС технології дозволяють проводити оцінку освітньої мережі, що дозволить запропонувати вирішення складних питань, які виникли в умовах реформування освіти.

Ключові слова: геоінформаційні системи,OpenRouteService, QGIS, ArcGIS, пішохідна доступність, середня освіта, заклад загальної середньої освіти

Introduction

High quality education is a precondition of the successful economic and social future of the state, and one of the most important factors of acquiring it is accessibility to students of the education institutions of various forms and types. In Ukraine, there are clearly outlined sanitary norms of locations and accessibility of institutions of general secondary education (IGSE), which should be taken into account when optimizing their network. Up to now, the geoinformational systems for studying transportation and walking distances have been almost unused during planning or optimizing the network of institutions of general education, which were then and now based rather on economic parameters. Research of walking accessibility to IGSE using the methods of spatial analysis is quite important and necessary, first of all in order to determine the territories with their various parameters, which has a practical significance for creation of pivotal schools [pivotal school refers to the main school of a community, education center in each administrative-territorial unit, where education is also provided to children of small surrounding settlements – *Translator`s note*] and strategic development of the general education network. Such an approach would allow our country to develop an optimum educational network, provide every student with access to high-quality education and multi-faceted development of his or her talents, based on principles and requirements of the New Ukrainian School. This in turn would increase the national security of the state (and particularly its economic and social constituents), and will contribute to sustainable development of the state, described in the Resolution of the General Assembly of the UN "Transforming our world: the 2030 Agenda for Sustainable Development", specifically goal 4 of this agenda, which is to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all", and therefore the topic has both scientific-theoretic and practical significances.

Review of the literature, materials and methods of research

Research of optimum locations for institutions of general secondary education is a relatively new direction in socio-geographic science. Most scientific research has focused on the territorial differentiation of the educational network. Today, an important aspect is monitoring and justification of creating pivotal schools of the IGSE in spite of the ongoing de-centralizing processes in Ukraine. This issue has been studied the most by economists and geographers. Among economists, we should note the research of such scientists as Harchenko M., Pashkevych M., Bienovsky L., Palchuk V., Savchuk D. and others. Other research has focused on generalization and development of scientific-methodological development of the network of pivotal schools in the conditions of decentralization reform. Specifics of functioning national and regional educational complexes have been researched by geographers, particularly Oliinyk Y., Niemets L., Homra O., Statsky V., Melnychenko T., Kornus O., Nych T., Flint N., Zaiachuk O., Kostaschyk I., and many others. Among foreign researchers, we should note the works by Lakhotia S., Lassarre S., Rao K. R., Tiwari G., Colclough J. G., Owens E., Martínez-Jiménez E., Salinas-Pérez J. A. and others. Analysis of walking distance to the culture-educational network of Córdoba (Spain) using geodata technology is presented in the research by Enrique Martínez-Jiménez and Jose A. Salinas-Pérez. In their works, Shovan Ghosh, Sanat Kumar Guchhait and Susmita Sengupta reveal spatial peculiarities of development of infrastructure and level of development of secondary schools in India. Also, important researches were carried out by Colclough J. G.and Owens, E., which analyze the specifics of cartography of walking time using the methods of network models of GIS.

GIS-technologies are actively used in the development of urban planning, land use, development of hospital districts, etc. In general, use of geoinformational technologies is seen in different spheres of human activity. On the other hand, these technologies are poorly incorporated in research on educational networks, including locating educational institutions and planning the parameters of their optimum location.

The researches was conducted based on analysis of existing literature data in this topic, cartographic dimensions and use of GIS-technologies. We analyzed statistical materials related to the characteristics of the institutions of general secondary education in

Chernivtsi City Territorial Community, and using geoinformation systems, we developed zones of accessibility to educational institutions in the initial administrative-territorial unit. The best way of researching walking and riding distances is to use geoinformation systems, of which there currently are dozens of software products. Among them, we selected ArcGIS and QGIS to achieve the goals. Complex use of QGIS and ArcGIS solved the tasks of various complexity, particularly determining the coefficient of accessibility of the institutions, analysis of their spatial arrangement and identifying territories with varying degrees of accessibility, and the use of Open Route Service web service allowed us to solve those problems in interactive regime. At the moment, within the framework of Open Route Service, the following functions were implemented: directions, matrix of temporal distance; point of interest; Pelias geo-coding; elevation; isochrones (HeiGIT, 2020).

To study accessibility to IGSE by riding and walking, we propose using the method of structure of isochrones (zones of accessibility), which help determining from which points the students are able to walk to school in a certain time, as well as distance. When building isochrones, the following parameters are taken into account: steepness of slopes, types of roads, types of cover, complexity of roads and others. Accessibility zones can be made for cars and large vehicles (including buses, which is important when planning routes for driving children), travel distances by cycling and walking, and also moving in wheelchair. Polygons can be made according to distance or time, which is quite convenient and allows taking into account children's walking speed related to age. We think that research on local territorial communities with well developed transportation infrastructure and dense ISGE network on one hand, and uneven ISGE network on the other hand, should pay more attention to walking accessibility, rather than accessibility by cycling or riding. This will help planning not only the educational network, but help in the necessary process of organizing the transportation of children, and also help Chernivtsi Local Council in dividing the city into educational districts. On the other hand, in village communities, one should focus more on transportation infrastructure and optimization of financial expenditures for transportation of children to the pivotal schools.

The main material

Currently, Ukrainian society is at the stage of carrying out a de-centralization reform, which implies changes in the administrative-territorial structure of our country and imposes most duties (including provision and development of the education) of the state on the bodies of local government, which, together with receiving budget preferences and management obligations, should take on the complex task and responsibility of creating effective management of systems of education, medicine, culture and other spheres in their communities. An important aspect in this context is effective planning of arrangement of IGSE, optimization of their network, which manifests today in the creation of pivotal schools and their branches (Ridosh (Ed.), 2021).

After introduction of de-centralization reform, communities began to actively use data and geoinformational cartography software in the sphere of mana-

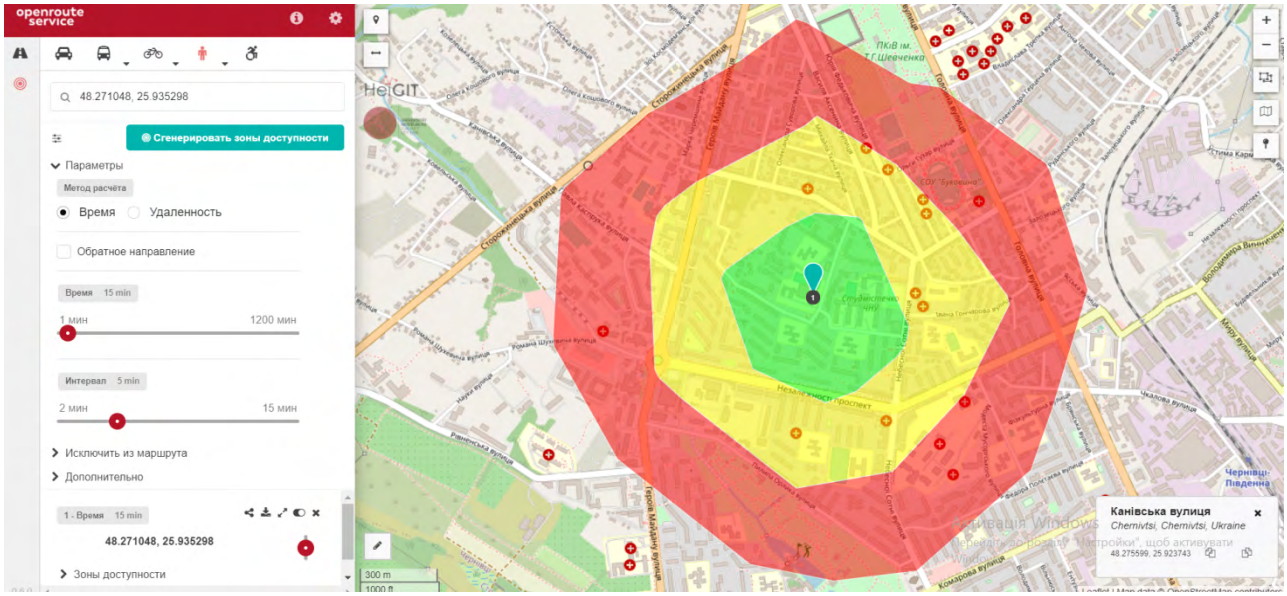

Fig. 1. Interface of Open Route Service web service for determining accessibility to the IGSE

gement of territories of inhabited areas. In most cases when they are being implemented, the "map and data base" approach is used ,which involves storing maps and attributive information in a data base. The main feature of GIS is using geospatial data base for presenting the data in the following forms: various documents based on developing maps; developing tables; texts using selections from the data base and geospatial modeling and analysis of the data obtained using the results of selection (Honcharov&Oliinyk, 2016).

Despite broad introduction of information technologies, geoinformation technologies are practically unused during planning of the educational network, and particularly creating pivotal institutions and optimizing the network of ISGE, especially at the local level. Therefore, it would be practical to consider these issues within separate territorial communities.

According to the new administrative-territorial structure, in Chernivtsi Oblast, 52 territorial communities have been created, including 34 village, 7 posyolok and 11 urban. For the research, we selected the Chernivtsi Local Territorial Community, which is the largest in Chernivtsi Oblast according to the population, number of students and number of the ISGE. The community includes three local settlements, namely Chernivtsi city and Chornivka and Koroviya villages. The area of the community is 181.6 km^2, and the population is 272,180 people (local population – 267,060 people and rural population – 5,120 people) (Ridosh (Ed.), 2020). Therefore, the average population density is 1,498.8 people/km^2.

During optimization of the general educational complex of the community, we took into account the number of factors: educational needs of students; organization of pre-profile training and profile (professional) education; qualification of pedagogic staff; material-technical base; presence and convenience of roads; transportation distance to education institutions, etc (Bilous, 2020). In general, within the Chernivtsi Territorial Community, there are institutions of general secondary education, institutions of pre-school educations, and also inclusive resource centers operate, institutions of pre-school education and institutions of higher education.

An important aspect in the development of education comprises parameters of dynamics of population and its sex-age structure, which form the specifics of the demographic process, which in turn determines the share of students in the age structure. The population of Chernivtsi city has continuously grown since 2002. As of 1 January 2019, 266,5 thou people lived in the city, which is almost 26 thousand more than in 2002 and almost 13 thousand more than in 2011 (Fig. 2). In the sex structure, women prevail (847 men per 1,000 women, which is 16 less compared with 2002). Age structure of the population is as follows: 0-14 years – 14.9%; 15-64 years – 71.9%; 65 and older – 13.2%, indicating regressive type of reproduction of the population.

The number of students in ISGE in Chernivtsi city starting from 2010-2011 school year has continuously grown. As of September 1, 2009, 27,649 students studied in these institutions of Chernivtsi city, which was over 5 thou students more compared with September 1 2020 (Fig. 3). Currently, 28,457 students are studying in the Chernivtsi Territorial Community, most of them (over 1,000 students) are in ZOSh (Middle School of General Education) of levels I-III: № 24 School named after Olha Kobylianska,

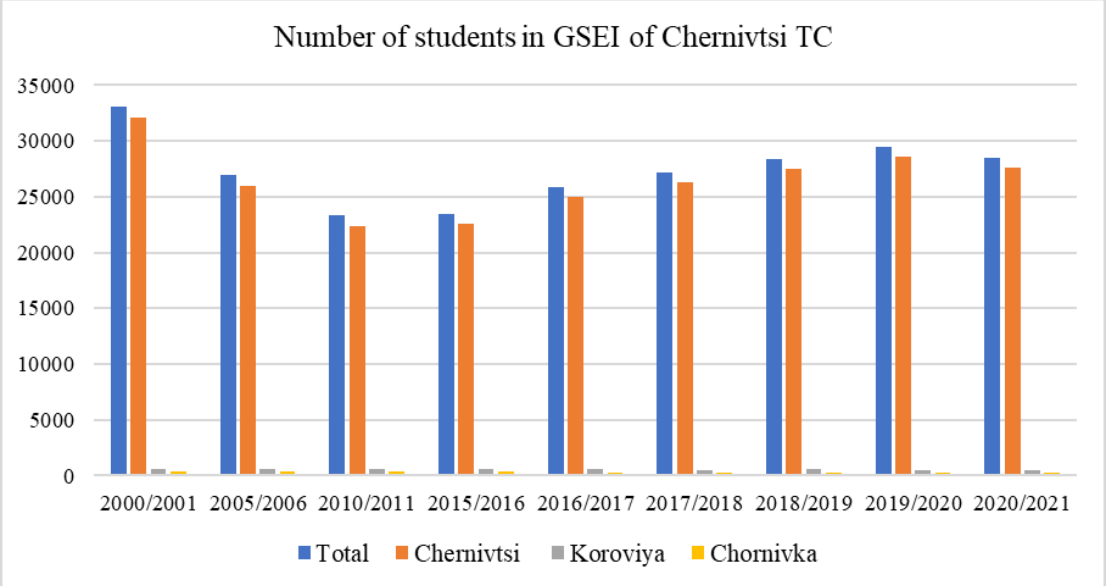

Fig. 2. Dynamics of number of population of Chernivtsi city

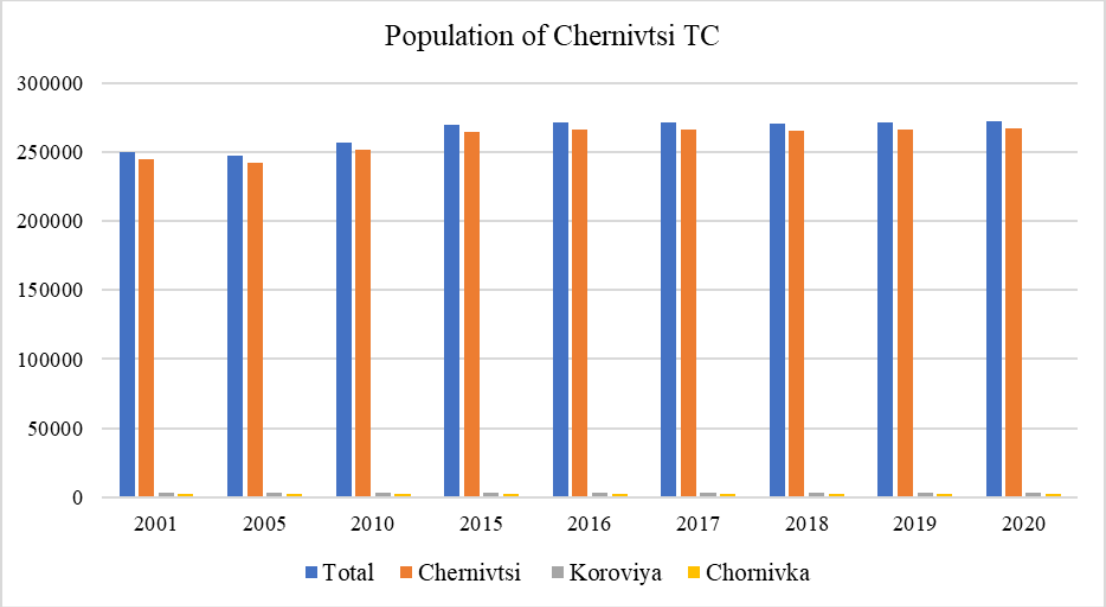

Fig. 3. Dynamics of the number of students in the institutions of general education in Chernivtsi city

ZOSh of levels I-III № 27, ZOSh of levels I-III №28, Chernivtsi ZOSh № 6, Chernivtsi Specialized School of levels I-III № 22, and the loweat number (less than 200 students) are in the Harmonia Private Specialized School of levels I-III, ZOSh of levels I-II №17, ZOSh of levels I-II №13, Chernivtsi Gymnasium №6 named after Oleksandr Dobry with teaching in Romanian, the Military and Sport Boarding Lyceum, ZOSh of levels I-III № 10, ZOSh of levels I-III № 40, located in the rural part of the city, Chernivtsi Specialized School of level I №29. According to the levels of education, the largest number of students studies at level II (13,064 students), and the least at level III (2,877 students).

An important element in the organization of high-quality education is the size of the class, which affects various constituents of educational space. The average class in the schools of the Chernivtsi Community comprises 27.3 students, and most optimum parameter ranges within 20-25 students (Kostashchuk & Bilous, 2014). It has to be noted that in the educational institutions of the Chernivtsi Community, the size of the groups is higher than average, and it also varies depending on the part of the city (central, rural, commuter towns, etc). The largest groups (over 35) are in 4 educational institutions, whereas the smallest (less than 20) are in 6 educational institutions. Only 6 institutions have optimum parameters of the groups, particularly: Chornivsky Training-Educational Complex (TEC), ZOSh of levels I-III - №40, Chernivtsi Gymnasium №6 named after Oleksandr Dobry, ZOSh of levels I-III stages №30, Koroviya ZOSh of levels I-III and the Chernivtsi Specialized School of level I №29.

One of the most important factors of optimizing secondary education is location of the institutions, and also accessibility to them by walking or riding. According to the sanitary norms, the radius of walking distance to secondary education institutions should be 2 km. Students who live at the distance more than 2 km away from the school should be provided with transport according to the regulations of the founder (founders) of the educational institution in correspondence with the current legislation. Transportation is carried out according to the designated plan of stops. The distance from accommodation to the gathering place for students at the stop should not exceed 500 m (Pro zatverdzhennia Sanitarnoho rehlamentu dlia zakladiv zahalnoi serednoi osvity, 2020).

To implement the goals, as already mentioned, we used Open Route Service, and also geoinformational systems ArcGIS and QGIS. In ArcGIS v.10.5 environment, particularly ArcMap app, we downloaded initial cartographic data: Shuttle Radar Topography Mission (SRTM), cosmic images in Natural Spectrum (Landsaat) and various raster tiles (OSM). Also, by applying Field Calculator, we have separately developed a geospatial set of data (Fig. 4), which included 721 linear objects of street network and courtyard passages (730.38 km) of the Community and 56 point objects of secondary education (Fig. 5 and 6). Every object was given an attribute, regarding its name, type, population living around it, and the number of students studying in it. Then, vector data were overlaid on the corresponding rasters.

Based on these data, using NeworkAnalyst tool, we developed graphs of the route network, with almost 5,000 binding and turning points. They will serve as

Table

Point_school

FID	Name	Area	Accessibility	Type	Num_Popul	Num_Pupil	Num_ZZSO	Adress	Shape *	Id	Name2	Degree
33	Gymnasium №5	10,206	0,812	gymnasium	51989	452	29	Dmytra Zagula str., 3	Point	0	#5G	
52	School №23	10,206	0,812	school I-level	51989	301	29	Dmytra Zagula str., 3	Point	0	#23	
22	School №4	10,112	0,805	school	53466	626	28	Shevchenka str., 16	Point	0	#4	I-III
29	Gymnasium №1	9,897	0,788	gymnasium	49282	623	21	Nezalezhnosti av., 68	Point	0	#1G	
0	School №1	9,816	0,781	school	48310	634	21	Eminesku str., 1	Point	0	#1	I-III
54	School №7	9,898	0,78	school I-level	49282	752	21	Nezalezhnosti av., 68	Point	0	#7	
31	Gymnasium №3	9,748	0,776	gymnasium	52438	409	28	Golovna str., 131	Point	0	#3G	
53	School №26	9,748	0,775	school I-level	52438	402	28	Golovna str., 131	Point	0	#26	
25	School №5	9,721	0,774	school	47840	846	24	Lesi Ukrainky str., 1	Point	0	#5	
40	Lyceum №4	9,633	0,767	lyceum	43155	964	18	Nebesnoi Sotni str., 18	Point	0	#4L	
44	Garmonija	9,633	0,767	education complex	43155	57	16	Nebesnoi Sotni str., 18	Point	0	Ljubystok	
9	School №20	9,603	0,764	school	49491	446	21	Glibova str., 21	Point	0	#20	I-III
11	School №24	9,564	0,761	school	48360	1183	17	Fizkul`turna str., 5	Point	0	#24	
8	School №2	9,539	0,759	school	48679	726	27	Golovna str., 87	Point	0	#2	I-III
37	Lyceum №1	9,545	0,759	lyceum	44735	323	22	Shtejnbarga str., 2	Point	0	#1L	
16	School №30	9,524	0,758	school	51785	447	23	Sherbanjuka str., 4	Point	0	#30	
39	Lyceum №3	9,287	0,739	lyceum	52246	434	23	Zalozec`kogo str., 13a	Point	0	#3L	
27	School №8	9,201	0,732	school	35807	585	20	Dzerzhyka str., 22	Point	0	#8	
49	School №9	9,19	0,73	school I-level	41839	484	22	L. Ukrainky str., 29	Point	0	#9	I
23	Jewish school №41	9,114	0,725	school	44230	347	20	Shkil`na str., 2	Point	0	JS#41	
32	Gymnasium №4	9,027	0,718	gymnasium	40574	629	19	Shepkina str., 2	Point	0	#4G	
15	School №3	8,885	0,707	school	46850	662	25	Hercena str., 36	Point	0	#3	
26	School №6	8,829	0,703	school	30757	1063	14	Komarova str., 26b	Point	0	#6	
38	Lyceum №2	8,617	0,686	lyceum	43305	232	25	L. Kobylyci str., 88a	Point	0	#2L	
4	School №14	8,595	0,684	school	41698	576	19	Shkil`na str., 3	Point	0	#14	I-III
12	School №25	8,596	0,684	school	33789	453	17	Ivana Mazepy str.	Point	0	#25	I-III
30	Gymnasium №2	8,4	0,668	gymnasium	43541	407	22	Golovna str., 73	Point	0	#2G	
51	School №35	8,4	0,668	school I-level	43541	248	22	Golovna str., 73	Point	0	#35	
2	School №11	8,387	0,667	school	25191	762	11	Pivdennokil`ceva str., 5	Point	0	#11	
34	Gymnasium №6	8,283	0,659	gymnasium	41140	152	18	A. Sheptyc`kogo str., 19	Point	0	#6G	
55	School №29	8,283	0,659	school I-level	41140	192	18	A. Sheptyc`kogo str., 19	Point	0	#29	
46	Nadija	8,015	0,638	private institution	18292	202	2	Moskovs`koi Olimpiady str	Point	0	Nadija	
35	Gymnasium №7	7,998	0,636	gymnasium	39629	752	21	Nezalezhnosti av., 88d	Point	0	#7G	
50	School №15	7,998	0,636	school I-level	39629	597	21	Nezalezhnosti av., 88d	Point	0	#15	
19	School №37	7,847	0,624	school	22061	622	3	Ivana Pidkovy str., 9	Point	0	#37	
1	School №10	7,74	0,616	school	22206	180	5	Gorihivs`ka str., 31	Point	0	#10	
41	Military lyceum	7,722	0,614	lyceum	26234	172	8	Lukovec`ka str., 29	Point	0	Military liceum	
18	School №33	7,685	0,612	school	33484	623	24	Heroiv Majdanu str., 152a	Point	0	#33	I-III
13	School №27	7,385	0,588	school	26416	1313	13	Vorobkevycha str., 19	Point	0	#27	
43	Ljubystok	7,345	0,584	education complex	27040	815	4	Rus`ka str., 228a	Point	0	Ljubystok	
42	Lider	7,226	0,575	education complex	22375	321	5	Berezhans`ka str., 25a	Point	0	Lider	
47	Solomon	7,199	0,573	private institution	25436	270	5	Korostyshevs`ka str., 6a	Point	0	Solomon	
10	School №22	7,026	0,559	school	21752	1438	9	Pivdennokil`ceva str., 17	Point	0	#22	I-III
20	School №38	6,784	0,54	school	18990	553	3	Jana Nalepky str., 3	Point	0	#38	I-III
45	Glorija	6,636	0,529	private institution	21594	18	11	Kovel`s`ka str., 25	Point	0	Glorija	
17	School №31	6,571	0,523	school	18229	758	0	Dibrovec`ka str., 5a	Point	0	#31	I-III
28	Beregynja	6,308	0,502	education complex	19846	237	3	Karbulyc`kogo str., 2	Point	0	Beregynja	
3	School №13	6,301	0,501	school	16370	151	3	Nemyrivs`ka str.,3	Point	0	#13	I-II
6	School №17	6,215	0,495	school	12037	87	5	Sokyrjans`ka str., 18	Point	0	#17	I-II
14	School №28	6,063	0,482	school	14141	1097	2	Rus`ka str., 257a	Point	0	#28	
7	School №19	6,009	0,478	school	25779	245	2	Hotyns`ka str., 23	Point	0	#19	I-III
21	School №39	5,866	0,467	school	18489	315	3	Karbulyc`kogo str., 4	Point	0	#39	
48	Chornivka school	5,761	0,458	education complex	1353	286	0	Chornivka, Golovna str., 13	Point	0	School of Chor	
5	School №16	5,297	0,421	school	17199	582	5	Bilorus`ka str., 77	Point	0	#16	
36	Korovija school	5,276	0,419	school	3171	522	0	Korovija, Shkil`na str., 1a	Point	0	School of Koro	
24	School №40	2,538	0,202	school	8442	182	0	Osinnja str., 58	Point	0	#40	I-III

Fig. 4. Attributive table with ranking according to accessibility parameters

benchmarks for establishing routes for walking and driving (Fig. 7).

Therefore, using Open Route Service and QGIS, we developed isochrones of 2-km zone of walking accessibility to the schools of secondary education of levels I and II-III for the Chernivtsi Local Community. Using QGIS Desktop, generalized data of the accessibility were overlaid on the map of the Chernivtsi Local Territorial Community with identified zones of walking accessibility.

After analyzing the map of walking accessibility to education institutions of the Chernivtsi Territorial Community, we identified the territories where the students need transport, and also territories with a quite dense arrangement of IGSE. The best arrangement of IGSE is in the central part of the city, and also in Prospect and Bulvar microdistricts, where several educational institutions are located within the radius of 2 km. Therefore, within the catchment area of School №4, Chernivtsi Gymnasium №3, Primary School № 26, Chernivtsi Gymnasium № 5, Chernivtsi Specialized School of level I № 23, there are 28 institutions, providing the students with a broader choice of education institution, and therefore increasing competition and quality of providing education services. At the same time, the worst situation is in ZOSh of levels I-III № 31, School №40, Koroviya ZOSh of levels I-III, Chornivsky TEC, for the number of IGSE there within the 2km zone, is 0, i.e. these institutions are the only ones within the 2 km-radius catchment area. On average, the number of IGSE within the 2 km zone of a certain institution is 14.7. Also, there are territories in Chernivtsi, where the students need transportation. The territories of Tsetsyno and Slobidka microdistricts are completely beyond the walking distance to IGSE. Partial coverage of walking distance zone is in microdistricts Dolishni Sherivtsi, Rohizna and Kalichanka (Fig. 8).

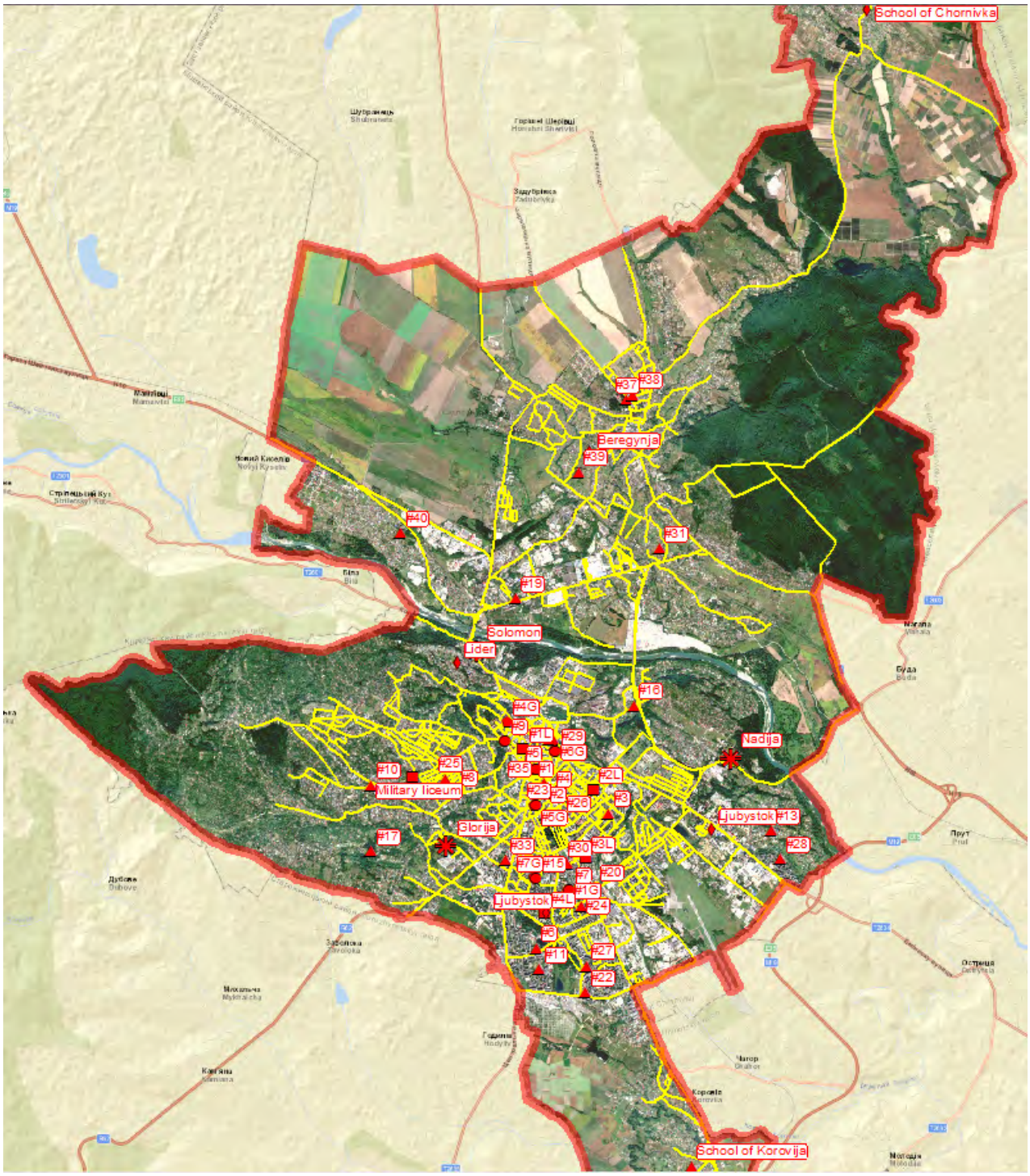

Fig. 5. View of the basic set of layers in ArcMap app

An important aspect of formation of a high level of knowledge in students at the current stage of development of education is specialized education and pre-specialized training, and gymnasiums with in-depth study of separate subjects. These institutions allow the students to better demonstrate their intellectual capacities. In the Chernivtsi Territorial Community, the walking accessibility to these education institutions greatly varies. In general, in Chernivtsi, there operate 5 lyceums and 7 gymnasiums. The zone of walking accessibility to those institutions covers the central part of the city and microdistricts Prospect and Bulvar. On the other hand, Chornivka and Korovia villages, Sadroga, Slobidka, Nova Zhuchka, Hraviton, Stara Zhuchka, Rohizna, Lenkivtsi and Kalichanka microdistricts are beyond the zone of 2 km zone of walking accessibility (Fig. 9).

In total, in Chenivtsi city, 1,567 students who live out of the zone of walking accessibility need to

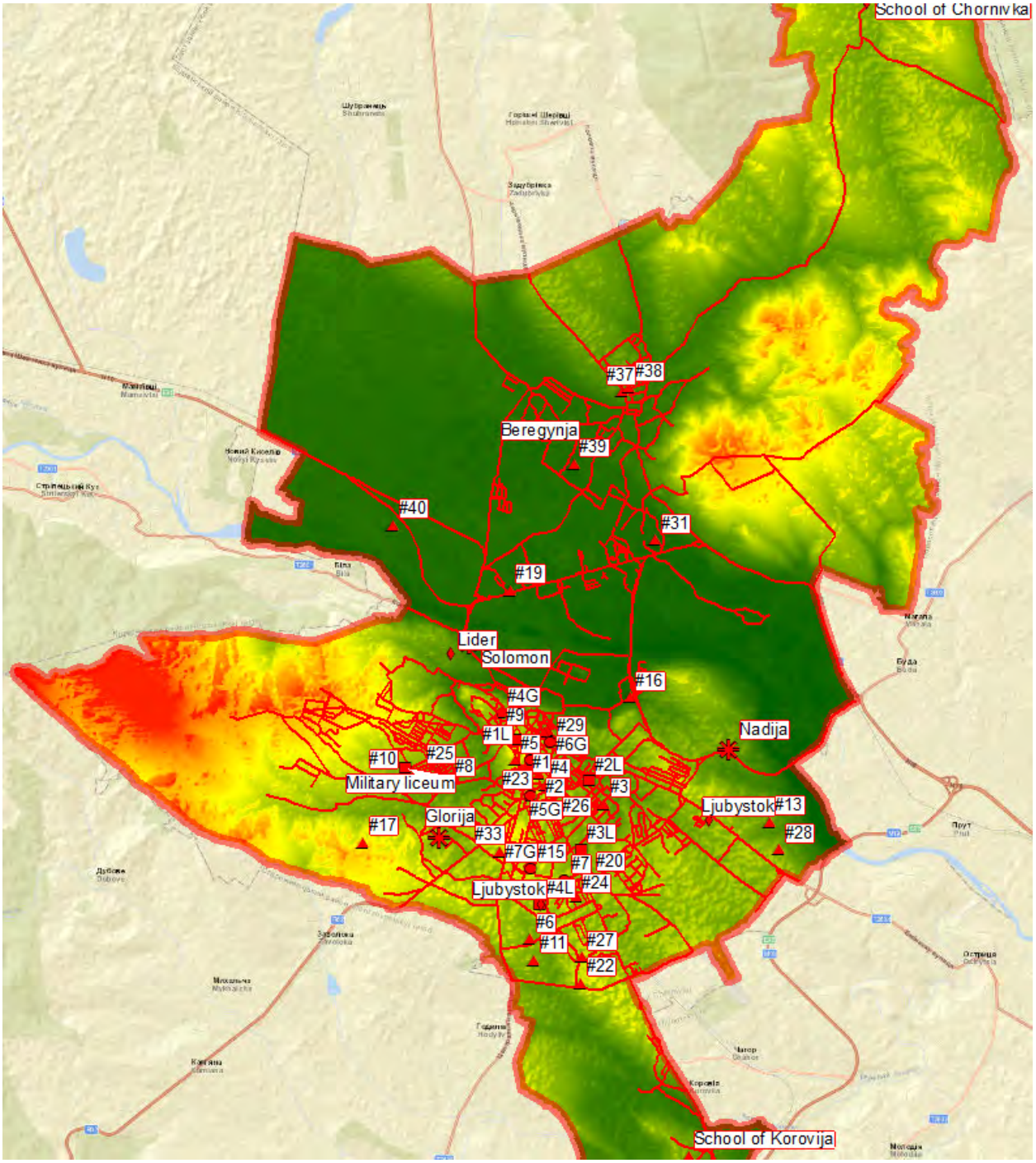

Fig. 6. Digital model of the area with vector layers, developed in ArcMap app.

be driven to schools. The children are transported by minibuses and trolleybuses of Chernivtsi. The highest number of students who need transportation, 180 children, comprises those studying in GSS №8 and gymnasium №5.

An important parameter of functioning of the institutions is the area of the zone of walking accessibility and the number of population living within its range. These parameters are important in the context of formation of number of students in the educational institutions. The area of the zones of walking accessibility to IGSE of the Chernivtsi Community ranges within 5.29 km^2 to 10.2 km^2. The greatest area of 2 km zone of walking accessibility, particularly more than 10 km^2 were determined for School №4, Chernivtsi Gymnasium № 5 and Chernivtsi Specialized School of level I № 23. On the other hand, 6 schools in the Chernivtsi Territorial Community have an area of accessibility of less than 6 km^2 (School №40, Koroviya ZOSh of levels I-III, School №16, Chornivsky TEC and School №39). Population in the zone of walking distance ranges 1,353 (Chornivsky TEC) to 53,466 people (School №4).

An important parameter in research on territorial

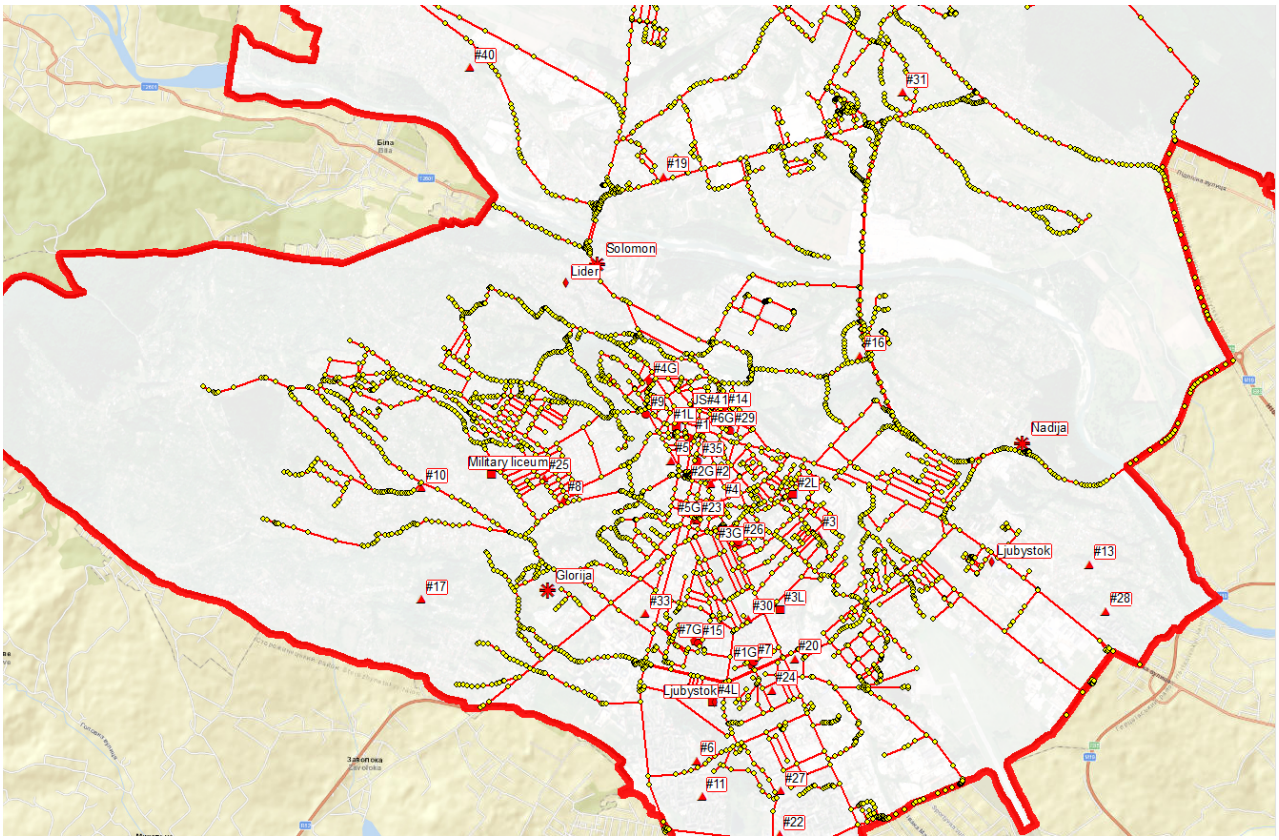

Fig. 7. Graphs of the road network

arrangement of the institutions of education is coefficient of accessibility, which we determined using Open Route web service. The parameter of accessibility may equal 0 (worst accessibility) to 1 (best accessibility). The parameter of accessibility to the educational institutions of the Chernivtsi Territorial Community is quite high (over 0.75) for 16 institutions (School №30, ZOSh №2, Chernivtsi Lyceum №1, Chernivtsi ZOSh № 24, Chernivtsi ZOSh № 20, Lyceum №4, Harmonia Private School, School №5, Chernivtsi Gymnasium №3, Primary School № 26, School №1, Chernivtsi Gymnasium №1 named after T. H. Shevchenko, School №7, School №4, Chernivtsi Gymnasium № 5, Chernivtsi Specialized School of level I № 23), and the lowest parameter was obtained for 8 institutions (Schools №40, №16, №17, №19, №28, №39, Koroviska ZOSh of levels I-III and Chornivska TEC) – less than 0.5. The average parameter of accessibility to the educational institutions of the Chernivetska Territorial Community is 0.65.

A special aspect in research of geospatial arrangement of educational institutions is determining local specific of walking accessibility. For this purpose, we selected one of the most populated housing districts of the Community – the Pivdenny Housing Estate, within which there are 4 institutions of general education. This stage allowed us to distinguish the shortest routes to school, and therefore to chose the smallest distance – 0.5; 1.0; 1.5 and 2.0 km (Fig. 10).

The provided cartographic model presents distance from the IGSE taking into account streets and courtyard passages, and also the extent of capacity to pass through. At the same time, there is a distinct ramification of 500 m zone along the highway streets and communication lines adjacent to the IGSE. Quite disproportionate is the coverage of peripheral parts of the housing estate, though they are included in the 2 km zone.

Conclusions

In the process of reforming the education sphere, an important aspect is the accessibility of high-quality education for all participants of the education process. Researches on this problem is impossible without modern scientific-informational approaches. Therefore, the geoinformation approach made it possible to plan and project the general education network of territorial communities, making it possible to analyze optimum arrangement of IGSE in the territorial community, and at the same time determine the territories from where the students should be transported. The advantages of GIS are the speed, reliability and accuracy of the obtained data, complexity of the selection, analysis and visualization, while the overlay properties of GIS apps allow

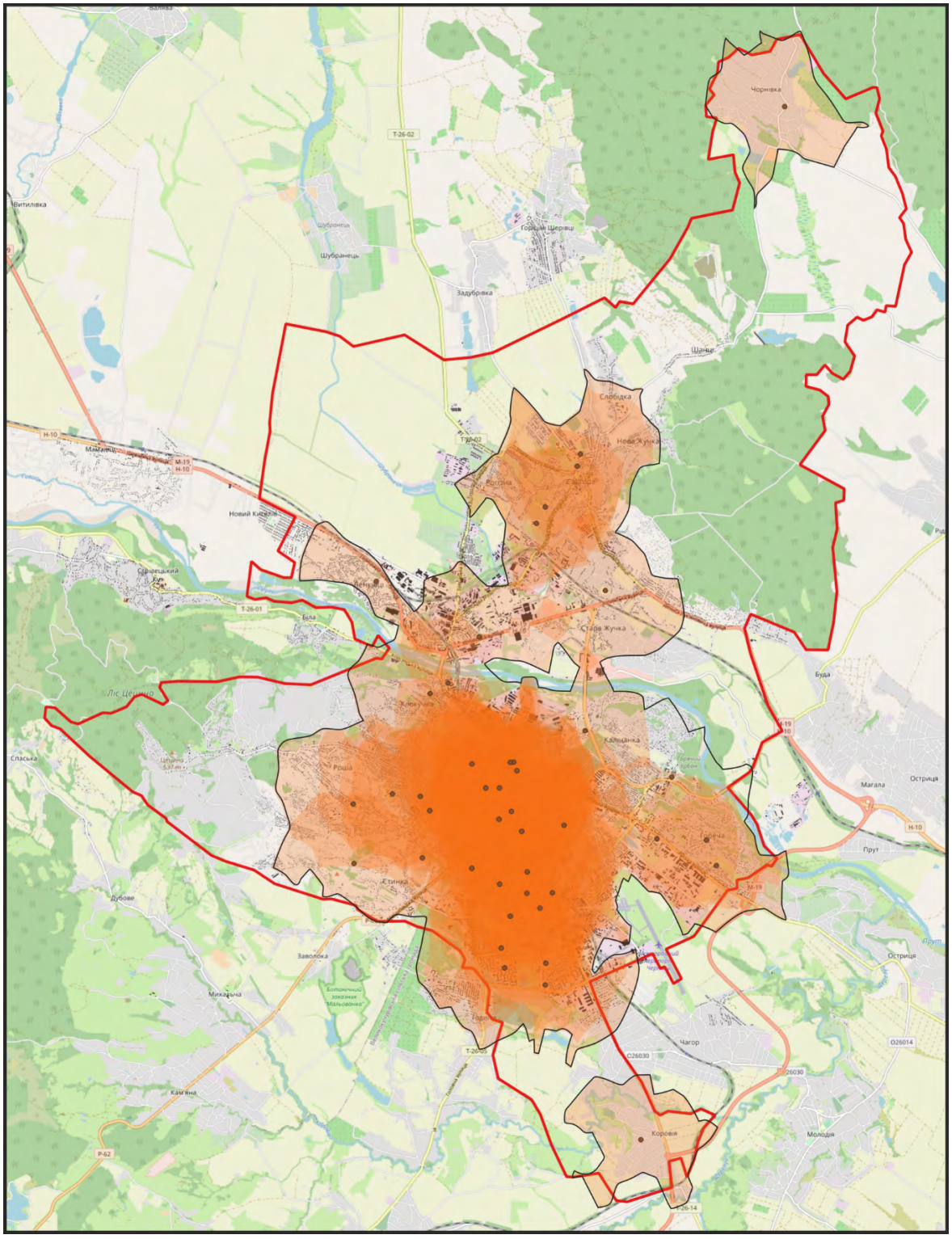

Fig. 8. 2 km zone of walking accessibility to a IGSE in Chernivtsi City Territorial Community

consideration of numerous factors. The disadvantages of using such an approach are dependency on relevant statistical data, as well as initial geospatial data.

Web-service Open Route allowed us to develop isochrones of walking accessibility of the students and analyze the arrangement of IGSE of the Chernivtsi City Territorial Community. Complex involvement of QGIS and ArcGIS gave an opportunity to create a data base and visualize the obtained data as cartographic models so as to determine the coefficient of accessibility to the institutions, analyze their geospatial arrangement and determine territories according to different levels of accessibility.

The observed territorial disproportions in the provision of equal access of the students to high-quality education, on the example of Chernivtsi

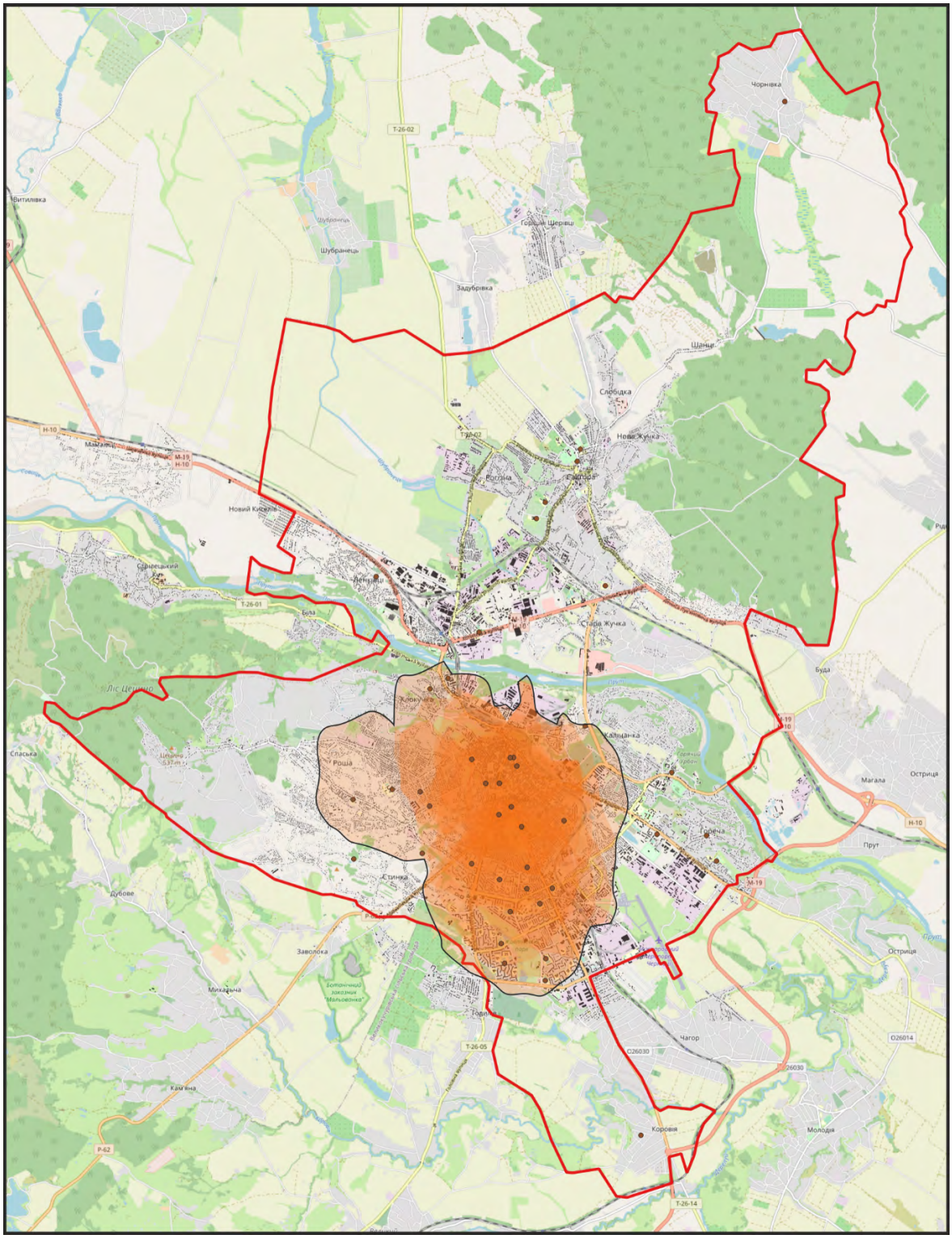

Fig. 9. 2 km zone of walking accessibility to lyceums and gymnasia of Chernivtsi City Territorial Community

Territorial Community, allowed us to understand that there are notable differences between the central part of the city and its rural zones and villages included in the city community. This problem is relevant for almost all communities established around large cities.

The proposed coefficients of accessibility to education institutions and methods of their determining using GIS technologies have essential practical significance during projecting the education network. Such research is especially relevant for analysis and re-planning of education networks of territorial communities that include over five settlements of various sizes and with various populations in them. Using GIS-technologies, we determined territories of the Chernivtsi Territorial

Fig. 10. Walking distance to institutions of secondary education in the Pivdeny housing estate

Community located beyond the 2 km zone of walking distance, and also accessibility to each IGSE in the Community. The coefficient of accessibility in Chernivtsi City Territorial Community ranges 0.2 to 0.8, and the average parameter of accessibility is 0.65. This indicates that most part of the territory of the Chernivtsi City Territorial Community is within walking accessibility distance.

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