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Assessment of ecological sustainability of the landscape of the Prypiat River basin within the Volyn region

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Abstract. The relevance of the research lies in the fact that, in the context of the global concept of sustainable development, one of the leading tasks is to maintain the sustainability of natural ecosystems by finding optimal strategies for the development of socio-economic systems. The purpose of the research is to assess the environmental sustainability of the landscapes of the Prypiat River basin within the territorial communities of the Volyn Oblast in the current conditions of the region's development. The methods used to achieve this goal included the calculation of the landscape

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ecological sustainability coefficient based on the systematization of statistical reporting data, followed by comparative geographical analysis and environmental mapping using ArcMap and ArcGIS Pro. The main results of the research show that the coefficient of ecological stability of landscapes in the Prypiat River basin is in the range of 0.22-5.39 and assesses landscapes from the level of "unstable with pronounced instability" to "stable, with pronounced stability". The distribution of land areas in the territorial communities located in the Tsyr sub-basin determines the landscape characterization at the level of "stable, with pronounced stability". Within the territorial communities of the Vyzhivka sub-basin and the upper reaches of the Prypiat River, the landscapes are "conditionally stable" – "stable". Within the communities of the Turia sub-basin – from "unstable" to "stable, with pronounced stability". Within the communities of the Stokhid sub-basin – from "unstable" to "stable, with pronounced stability". The territorial communities of the middle part of the Styr sub-basin are represented by landscapes ranging from "unstable, with pronounced instability" to "stable, with pronounced stability". In general, more ecologically stable landscapes are located in the northern part of Volyn Oblast, due to the large areas of forested land. Environmental instability of landscapes is typical for the southern part of the region due to large areas of ploughed land. The practical value of the work lies in obtaining regional variations in the assessment of ecological stability of landscapes, which is important to consider when developing coordinated concepts between communities and environmental management bodies on a basin basis to achieve sustainable development goals in socio-ecological systems

Keywords: river basin; sub-basin; land use; ecosystem services; management decisions

INTRODUCTION

The river basin with its constituent components (channel, floodplain, terraces, slopes) is a self-regulating system that is able to function regardless of the impact of external factors. The basin approach to water resources management involves the creation of organized management entities that intervene in individual ecosystem components and the landscape structure of the basin. In particular, the redistribution of water and land resources in terms of quantity and quality negatively affects the sustainability of landscapes, which can lead to errors in management decisions. As a result, there is a need to determine the limits of permissible economic use of river basin areas and assess their current state in order to optimize water and land management for the formation, use, and protection of the landscape.

Modern researchers agree that the ecological sustainability of a river basin landscape refers to the ability of this basin to maintain its natural functions, biodiversity, ecosystem services, and ability to recover from anthropogenic impacts (Abalo *et al.,* 2021; Ma *et al.,* 2023). K.G. Sreeja *et al.* (2015) find that most anthropogenic factors within a river basin are caused by agriculture through the reconfiguration of landscape elements. In particular, agriculture requires significant space for growing crops and grazing livestock. This leads to the reduction of natural ecosystems such as forests, meadows, and marshes and their replacement with arable land and pastures. The misuse of land for agriculture can lead to soil erosion, desalination, waterlogging and other forms of degradation that alter soil structure and lead to loss of fertility. E. Soulé *et al.* (2023) note that the use of pesticides, herbicides, mineral fertilizers and agricultural waste can lead to water pollution in river channels, and changes in landscape structure due to agriculture can lead to a decrease in the biodiversity of many plant and animal species.

An equally significant impact of agriculture on river basins is the loss of natural ecosystem services of the landscape. Agriculture can lead to the loss of natural ecosystem services, such as air and water purification, erosion prevention, soil fertility and other processes that are important for ecosystem health. Some authors suggest increasing the area of forests as an eco-compensation for agricultural land use within river basins. For example, using the example of the Grain-for-Green Programme (GFGP) in China, B. Xu and J. Pan (2022) showed that adjusting the structure and scale of forest and grass plantations in the Jinghe River basin during 2000-2015 reduced sediment yield and removal by 36.2% and 60.7%, respectively, and increased carbon storage by 2.4%.

Y. Li *et al.* (2023) found that the spatial spillover effects of urbanization exacerbate the spatial heterogeneity of biogeochemical, physical, ecological and hydrological processes in their basins. The studies provide convincing evidence that catchment urbanization significantly increases the potential for riverine CH_4 emissions. Recent studies by J. Liu *et al.* (2021) also show that urbanization and anthropogenic disturbance of natural landscapes are increasing the amount of allochthonous organic matter entering aquatic ecosystems. And domestic and industrial wastewater inhibits the self-purification capacity of rivers by introducing significant amounts of nutrients, heavy metals, microplastics, medicines, etc.

Depending on the scale and intensity of landscape transformation, these changes can have serious consequences for the ecological sustainability of the river basin. According to A. Tønnesen, *et al.* (2023) argue that avoiding such consequences depends on sustainable land and resource management at the level of urban and rural communities. The tools of such approaches include accounting and mapping of different contexts of community territories to make spatial decisions in landscape

planning, outlining potential impacts on river basin ecosystem services, identifying cause-and-effect relationships with socio-ecological benefits and local as well as global development goals (Schmidt *et al.,* 2022).

The scientific approaches analysed above show that there is currently no single, universal methodology for assessing the ecological sustainability of landscapes at spatial and temporal scales. In each case, researchers use different approaches, but what they have in common is the analysis of complex interrelationships between environmental conditions and anthropogenic factors. Taking into account the interests of territorial communities (TCs) in such cases, the distribution of natural elements that support the sustainable functioning of the entire ecosystem (meadows, forests, wetlands, etc.) and elements that meet the socio-economic needs of communities (arable land, pastures, buildings, etc.) is assessed. Ultimately, this allows for modelling scenarios of environmental change in river basins to support the optimal distribution of landscape elements and ensure a balance between conservation and development throughout the region. The aim of the study was to assess the environmental sustainability of the landscapes of the Prypiat River basin and its tributaries in the context of the administrative boundaries of territorial communities of Volyn Oblast, as one of the regions of Ukraine that is actively changing in the current conditions of the state's development in accordance with the Sustainable Development Strategy and support of its goals.

MATERIALS AND METHODS

The study area of the Prypiat River basin is located in two parts of the south-western part of the Eastern European Plain – Polissya and Podillya. The northern part of the basin is located within the Volyn Polissya physiographic region, and the southern part is located within the Volyn Upland. According to the administrative division, the study area belongs to the Volyn region, which is divided into 4 rayons, comprising 54 territorial communities (Passport of Volyn region. 2022) (Fig. 1).

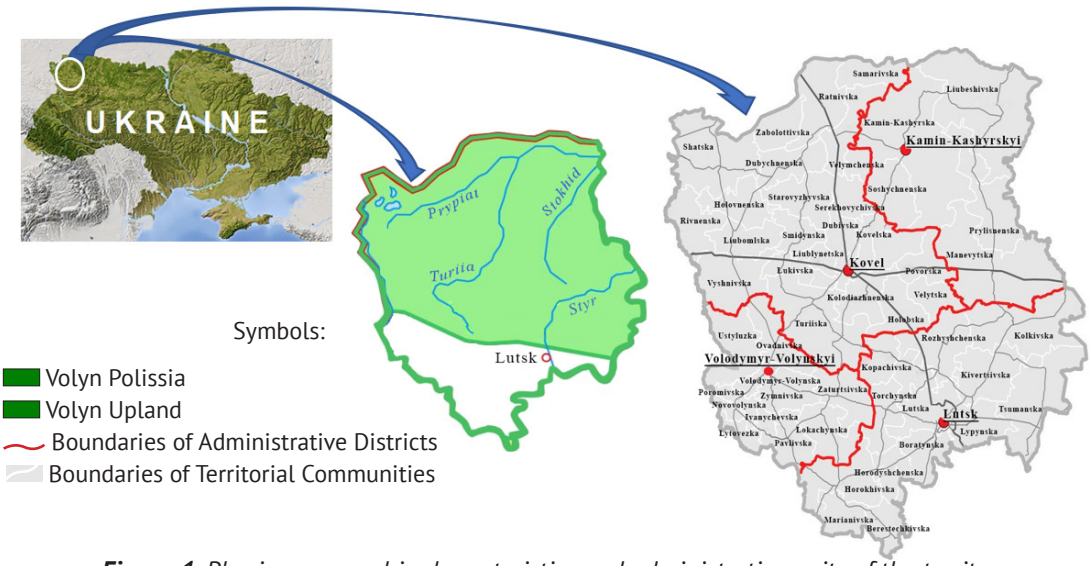

Figure. 1. *Physics-geographic characteristics and administrative units of the territory of the Prypiat River basin within the Volyn region of Ukraine*

Source: *based on author's research*

The Prypiat River originates from its source near the village of Budnyky in the Kovel district of Volyn region. On the territory of the Kamen-Kashyrskyi and Kovel districts, the river flows in a southeasterly direction. Not far from the village of Senchytsi in the Varash district of Rivne region, the Prypiat River crosses the state border of Ukraine with the Republic of Belarus. Within that territory, the river flows through the Polissya Lowland, which is represented by the poorly defined valley of the Pinsk bogs. The last 50 km of the Prypiat riverbed are located within the Kyiv region of Ukraine, in the lower reaches of the terrain. The mouth of the Prypiat River is located near the town of Chornobyl, where it flows into the Kyiv Reservoir on the Dnipro Riverbed (Khilchevskyi *et al.*, 2022).

The total length of the river is 775 km, of which 254 km is in Ukraine. The Prypiat River basin covers 114.3 thousand km^2, of which 68.37 thousand km^2 is in Ukraine. According to the hydrographic zoning of Ukraine (2016), the Prypiat River is a separate sub-basin of the Dnipro River basin. A part of the Prypiat riverbed in Volyn Oblast, with a total length of 72 km, has been transformed into the main channel of the Upper Prypiat drainage system, which is one of the largest in Europe (Khilchevskyi *et al.*, 2019).

The environmental sustainability of the landscape of the study area was assessed based on the methodology of E. Klementova and B. Geynige (1995), the essence of which is to determine the coefficient of ecological sustainability of landscapes k_{ESL1} by the distribution of

areas occupied by different landscape elements, taking into account their positive or negative impact on the environment:

$$k_{ESL1} = \sum_{i=1}^{n} F_{stb\,i} \Big/ \sum_{j=1}^{m} F_{stb\,j}, \quad (1)$$

where $F_{stb\,i}$ is the area of agricultural plant species that have a positive impact on the landscape (stable landscape elements): forests, green plantations, natural meadows, areas of nature conservation status, hayfields and arable land used for growing perennial grasses – alfalfa, clover, grass mixtures, etc., ha; $F_{stb\,j}$ is the area of land with low environmental sustainability, represented by landscape elements of unstable structure: actively exploited arable land, areas with high density of overgrowth, land with little grass cover, street and road network, silted and overgrown water bodies, mining sites and other lands subject to anthropogenic impact, causing environmental tension that can negatively affect landscape sustainability, ha.

The calculated values of k_{ESL1} were used to provide a qualitative description of the ecological stability (territorial integrity) of the landscape on the scale "unstable, with pronounced instability" – $k_{ESL1} \leqslant 0.51$; "unstable" – k_{ESL1}=0.51-1.0; "conditionally stable" – k_{ESL1}=1.0-3.0; "stable" – k_{ESL1} = 3.01-4.5; "stable, with pronounced stability" – $k_{ESL1} \geqslant 4.5$.

The initial data for the calculations were statistical reports of the Department of Ecology and Natural Resources and the Department of Agricultural Development of the Volyn Oblast State Administration, which constituted a database for solving environmental problems (Stock Materials, n.d.), both in the Prypiat River basin and in Volyn Oblast in particular, within the framework of the implementation of the National Target Programme for the Development of Water Management and Environmental Improvement of the Dnipro River Basin for the Period up to 2021 and the Regional Environmental Programme "Ecology 2016-2022" (Passport of Volyn region, 2022) consolidated database of relevant data and calculations was also used for spatial analysis and environmental mapping of the distribution of different types of landscapes within the study area, using geographic information software MapInfo and ArcGIS Pro.

RESULTS AND DISCUSSION

The mapping of the hydrographic network of the study area shows that most of the territorial communities of the Volyn Oblast are located within the upper reaches of the Prypiat River basin. In particular, the upper reaches of the basin in the Volyn Oblast include sub-basins of the Prypiat River tributaries: the Tsyr, Vyzhivka, Turia, Stokhid, Styr, and the Prypiat River itself. The territorial communities located along the north-western and western borders of the region, in hydrographic terms, belong to the Western Bug River basin (Fig. 2).

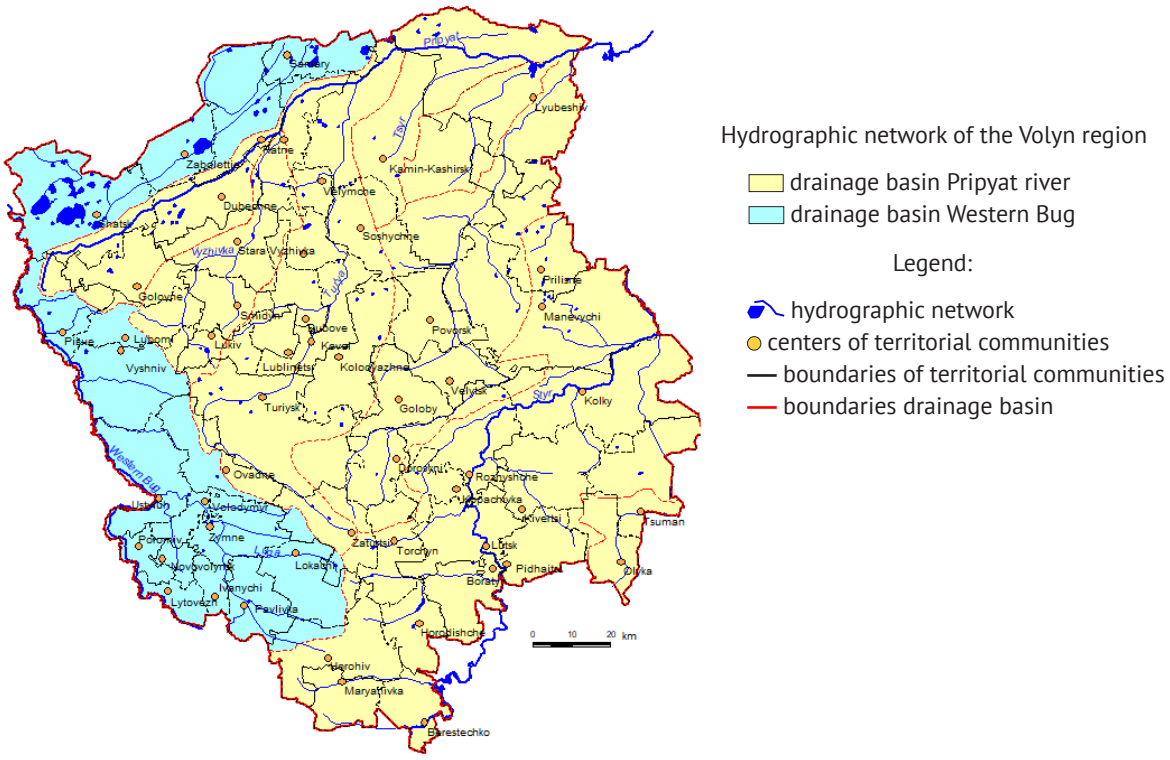

Figure 2. *Hydrographic network of the upper reaches of the Prypiat River basin*
Source: *based on author's research*

An analysis of the structure of land within the territorial communities of the study area revealed that the areas occupied by unstable landscape elements (annually cultivated arable land, land with unstable grass cover, under buildings and road networks, mining sites, etc.) are overwhelmingly located in the southern part of the basin. A significant part of the area of most territorial communities is occupied by agricultural land. At the same time, there is an uneven distribution of arable land between different parts of the region (Fig. 3).

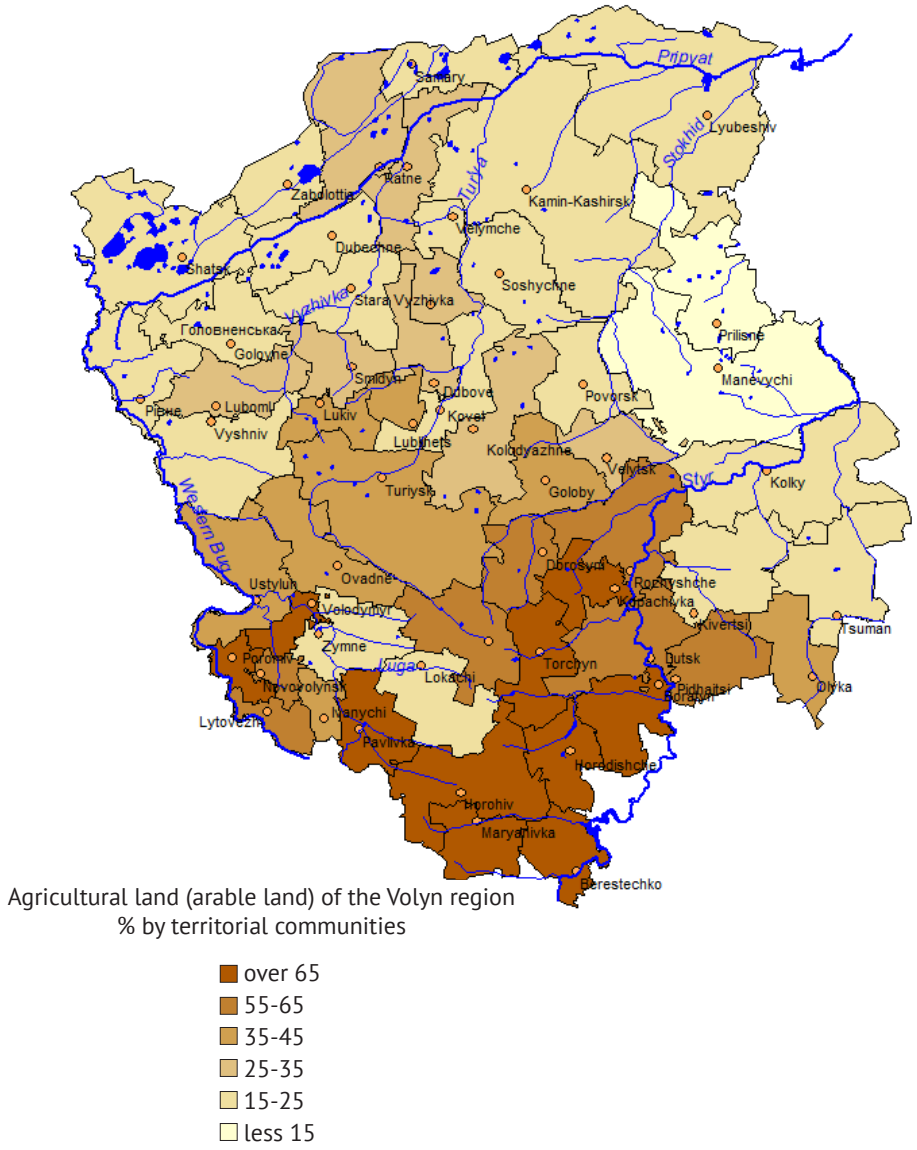

Figure 3. *Agricultural land (arable land) of the Volyn region in the section of the TC*
Source: *based on author's research*

Thus, the land allocated for arable land in the communities of the northern part of the region does not exceed 35%. In the central part of the region, there is an increase in the area of arable land, which ranges from 35 to 65% in the spatial distribution. Territorial communities located in the southern part of the study area are characterized by the highest level of agricultural land development. In particular, the ploughed area of their territories exceeds 65%. It is worth noting that it is here, within the Volyn Upland, that the tributaries of the Prypiat River originate.

The areas under plant communities that have a positive impact on the landscape (forests, green spaces, natural meadows, nature reserve fund (NRF) objects, perennial grasses, etc.) are mostly located in the northern part of the basin within the Polissya Lowland where the mouths of tributaries are located — the Vyzhivka River, the Turia River, the Tsyr River, the Stokhid River and the source of the Prypiat River itself. In particular, there is a clear tendency for forested landscapes to gravitate towards the northern and central-eastern parts of the Volyn Oblast (Fig. 4).

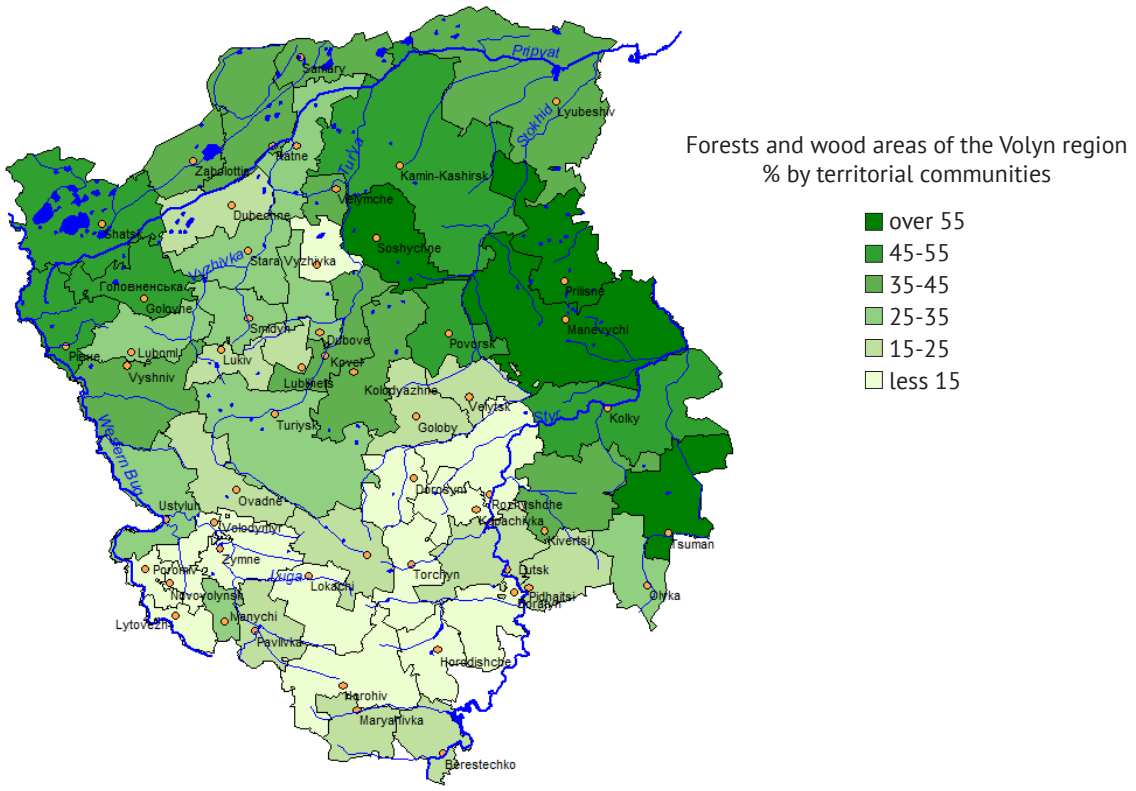

Figure 4. *Forests and wooded areas of the Volyn region in the section of the TC*
Source: *based on author's research*

In terms of spatial distribution, forests cover 45 to 55% or more of the area of territorial communities located in the northern and central-eastern parts of the region. In particular, more than 55% of the area is covered by forests within the Manevychi, Tsumanska, Prylisnenska and Sochyshnenska territorial communities. The calculation of the quantitative assessment of the ecological stability of landscapes in the Prypiat River basin revealed that the value of the k_{ESL1} coefficient within individual territorial communities ranges from 0.22 to 5.39. That is, the landscapes of the basin can be assessed from "unstable, with pronounced instability" to "stable, with pronounced stability" according to the administrative boundaries of territorial communities (Table 1).

Table 1. *The results of determining the ecological stability of the landscapes of the Prypiat River basin within the Volyn region (in terms of administrative entities of the TC)*

Territorial community	Area, ha	k_{ESL1}	Landscape stability	Territorial community	Area, ha	k_{ESL1}	Landscape stability
Berestechko	22198.40	0.54	Unstable	Zaturtsi	36399.30	0.90	Unstable
Boratyn	28194.00	0.34	Unstable with pronounced instability	Ovadne	35726.10	1.27	Conditionally stable
Horohiv	49455.80	0.28	Unstable with pronounced instability	Velymche	11087.50	2.66	Conditionally stable
Dorosyni	23490.30	0.72	Unstable	Velytsk	21157.50	1.69	Conditionally stable
Kivertsi	47061.00	2.83	Conditionally stable	Goloby	29815.70	1.3	Conditionally stable
Kolky	76449.15	2.99	Conditionally stable	Golovne	32473.60	4.35	Stable
Kopachivka	17923.68	0.49	Unstable with pronounced instability	Dubechne	24643.70	2.1	Conditionally stable
Lutsk	38457.60	0.74	Unstable	Dubove	20322.90	1.82	Conditionally stable
Maryanivka	22977.00	0.76	Unstable	Zabolottia	20406.10	3.6	Stable
Olyka	27030.20	1.01	Conditionally stable	Zabrody	33423.60	2.57	Conditionally stable
Pidhaitsi	28443.39	0.75	Unstable	Kovel	26849.90	3.02	Stable

Table 1, Continued

Territorial community	Area, ha	k_{ESL1}	Landscape stability	Territorial community	Area, ha	k_{ESL1}	Landscape stability
Rozhyshche	46105.52	0.99	Unstable	Kolodyazhne	46630.10	2.19	Conditionally stable
Senkevychivka	21213.70	0.22	Unstable with pronounced instability	Lukiv	16277.90	1.18	Conditionally stable
Torchyn	26439.70	0.38	Unstable with pronounced instability	Lublinets	11460.00	1.34	Conditionally stable
Tsuman	44708.00	4.46	Stable	Povorsk	29721.40	3.49	Stable
Kamin-Kashirsk	142527.60	3.86	Stable	Ratne	48066.10	2.53	Conditionally stable
Lyubeshiv	123949.00	5.39	Stable, with pronounced stability	Serehovichi	16767.00	1.43	Conditionally stable
Manevychi	110363.15	5.16	Stable, with pronounced stability	Smidyn	22697.10	1.72	Conditionally stable
Prilisne	52694.30	8.0	Stable, with pronounced stability	Stara Vyzhivka	28434.10	3.61	Stable
Soshychne	39699.90	4.37	Stable	Turiysk	86478.30	1.48	Conditionally stable
Luboml	29659.80	2.18	Conditionally stable	Shatsk	75074.92	4.11	Stable

Source: *based on the author's research*

Thus, in the sub-basin of the Tsyr River, from the source to the mouth, there are Kamen-Kashyrska and Lyubeshivska TC. The territories of these communities are characterized by a landscape stability coefficient (k_{ESL1}) value in the range of 4.90-5.39. The corresponding qualitative characteristic of the ecological sustainability of landscapes is defined as "stable, with pronounced stability".

In the sub-basin of the Vyzhivka River and the upper reaches of the Prypiat River, there are Lyuboml, Rivne, Lukivka, Holovne, Smidyn, Dubeche, Starovyzhivka and Ratniv TCs. Within their boundaries, k_{ESL1} varies from 1.18 to 4.35, which assesses the ecological sustainability of landscapes from "conditionally stable" to "stable". In particular, the ecological condition of the landscapes in the upper, lower reaches and near the mouth of the Vyzhivka River is classified as "conditionally stable", with k_{ESL1} values not exceeding 2.35, and in the upper reaches of the Prypiat River – as "stable".

The Turia River sub-basin includes the Zaturtsivska, Ovadnenska, Turia, Liublynetska, Kovelska, Kolodyazhchenska, Soshychnenska, Velymchenska, Starovyzhivska, and partially Smidynska and Kamen-Kashyrska TCs. Their landscape stability coefficient (k_{ESL1}) varies from 0.90 to 4.90. Accordingly, the qualitative characteristics of the ecological sustainability of the landscapes of these TCs are defined by the levels from "unstable" to "stable, with pronounced stability". In particular, the ecological state of landscapes in the upper reaches of the Turia River is assessed by the value of k_{ESL1} 0.90 and is classified as "unstable". The landscapes in the middle reaches of the river are characterized by k_{ESL1} values ranging from 1.72 to 3.61, which classify them as "conditionally stable" and "stable". The landscapes of the lower reaches and mouth of the Turia River have a k_{ESL1} value of 3.86 and are classified as "stable". The sub-basin of the Stokhid River includes Lyubeshivska, Povorska, Velytska, Holobska, Dorosynivska and partially Kamen-Kashyrska, Manevytska and Zaturtsivska TCs. The stability coefficient of their landscapes (k_{ESL1}) varies from 0.90 to 5.39, which corresponds to the levels of qualitative characteristics from "unstable" to "stable, with pronounced stability". The ecological condition of the landscapes in the upper and lower reaches of the Stokhid River is assessed with k_{ESL1} values ranging from 0.72 to 0.90, which classifies them as "unstable". The stability of the middle reaches of the river is assessed with k_{ESL1} values ranging from 1.69 to 3.86, which classifies their quality characteristics as "conditionally stable" to "stable". The landscapes of the lower reaches and the mouth of the Stokhid River are characterized by k_{ESL1} values of 5.39, which classify their quality characteristics as "stable, with pronounced stability". Thus, the Stokhid sub-basin contains 4 types out of 5 types of ecological sustainability of landscapes.

The Styr River sub-basin is located in Volyn Oblast only within the middle reaches, where Horodyshche, Horokhiv, Maryaniv, Torchyn, Boratyn, Pidhaitsi, Lutsk, Kivertsi, Kopachiv, Rozhyshche, Olytsia, Kolkiv, Prylisne and Manevychi TCs are located. The coefficient of landscape stability (k_{ESL1}) in their territories varies from 0.28 to 5.16. Accordingly, the levels of qualitative characteristics of environmental sustainability of landscapes range from "unstable, with pronounced instability" to "stable, with pronounced stability". The assignment of the boundaries of the territorial communities of the Volyn Oblast to the sub-basins of the Prypiat River tributaries allowed tracing certain features of the ecological stability of landscapes and visualizing the data in spatial location as of 2022 (Fig. 5).

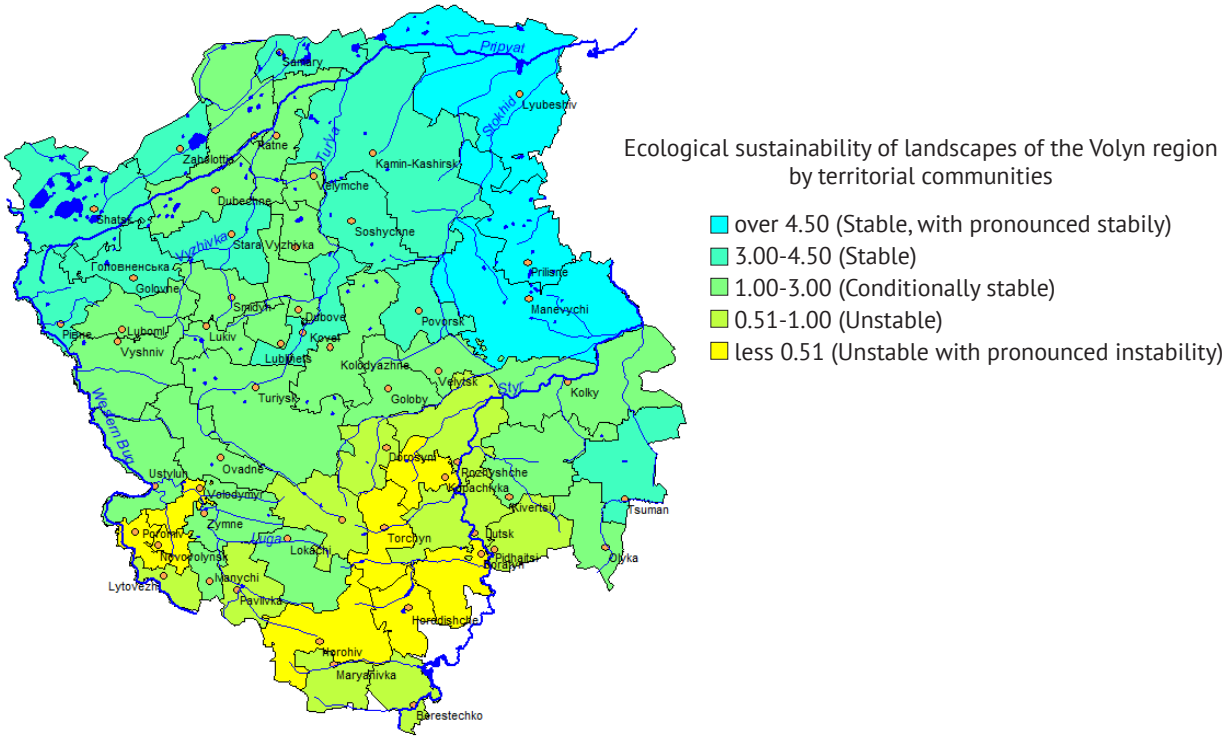

Figure 5. *Ecological sustainability of landscapes of the Volyn region in the section of TC (2022)*
Source: *based on the author's research*

For example, the southern part of Volyn Oblast is represented by landscapes in an "unstable state, with pronounced instability". Here are the TCs (Gorokhiv, Maryaniv, Rozhyshche, Horodyshche, Boratyn) with the largest percentage of agricultural land, namely arable land, which is over 65%, and the smallest part of forests and forested land — no more than 15-25%. In the middle part of the region (Kolkivska, Horobska, Velytska, Turiyska, Ustyluzka, Liubomylska TCs), the ecological condition of the landscapes is gradually changing to "conditionally stable". In the northern part of the region, the ecological stability of the landscapes becomes "stable, with pronounced stability", which is ensured by small areas of arable land (15-25%) and significant areas of forests and forest-covered land (from 45% to over 55%), as well as a sufficient number of protected areas, in particular in the Tsumanska, Manevytska, Prylisnenska and Kolkivska TCs.

The results of the spatial distribution of stable and unstable landscape elements in the upper reaches of the Prypiat River basin obtained in the course of the study allow generalizing that the basis of economic development of the territory is agricultural and forestry land use. This was facilitated by the natural conditions of the Prypiat River basin, which resulted in a diverse and unique landscape structure. This is also confirmed by modern ecological and geographical works by I. Myskovets & Ya. Molchak (2022), who shows that the landscape diversity of the upper Prypiat River basin is formed by zandra lowlands, sandy terraces, forest and meadow-marsh floodplains that have undergone significant agrogenic transformation.

In the south and east of the Prypiat River basin, agricultural use of natural resources prevails within the territorial communities of Volyn Oblast. This is due to the fragmented location of zandra lowlands in the structure of landscape formations, which form a flat-wavy land surface with a predominance of sod-podzolic and sod soils. The dominance of the agricultural type of natural resource use within the zandra lowlands is noted in the research of C. Gao *et al.* (2020), who explains this by the presence of fertile soils on their surface, which were formed in the post-glacial period on sand and gravel deposits.

The large-scale drainage reclamation that took place in the Volyn region during the second half of the 20th century led to the loss of the original appearance of natural watercourses, such as the Vizhivka River, Turia River, Tsyr River, Korostianka River, and Stokhid River. As a result, the landscape structures of the area have also changed, represented by lowland marshes, which occupy about 30% in the east and north of the study area of the upper Prypiat River basin. This is also evidenced by the studies of R. Koptyuk *et al.* (2023), who recorded the reduction of riverbeds in the region as a result of their transformation into main channels of drainage systems, which, against the background of climate change and a lowering of the groundwater table, has significantly changed the moisture supply of the soil and negatively affected its fertility. S. Tomscha *et al.* (2023) confirm the

importance of preserving natural wetland complexes, which constitute an important ecological component of the environment and contribute to landscape stability and ecosystem services, and are essential for the conservation of water resources, carbon stocks, and the preservation of plant and animal diversity. The significant impacts of climate change on the baseline environmental situation in river basins are also proved by M. Ben-Daoud *et al.* (2021), H. Ma *et al.* (2023), who outline that climate change affects the river flow regime by increasing or decreasing precipitation, which affects the stability of ecosystems within river basins and significantly complicates water management.

The results obtained indicate that the intensity of agricultural use of natural resources, in particular ploughed land, spatially ranges from 35 to 65% within the upper reaches of the Prypiat River basin. A similar situation is noted in the work of P. Volk *et al.* (2023), who believe that in order to preserve soil ecosystem services, including food services, within the Volyn region's TCs, adaptive measures of agro-melioration, agrotechnical and hydrotechnical directions should be introduced to optimize the functioning of drainage systems and the possibility of balanced management of moisture reserves on drained lands against the background of climate change. Keshtkar *et al.* (2023) also note that in recent decades, agricultural intensification, expanding urbanization, technological progress and economic growth, combined with the effects of climate change, have significantly altered the balance of relations between humans and nature and led to serious consequences and risks for landscape ecosystem services. The results of this study show that these issues are particularly acute and must be addressed for Pavlivka, Horokhiv, Maryanivka, Horodyshche and Torchyn communities, as well as other communities in the central and southern part of Volyn Oblast.

Within the Prypiat River valley and in the valleys of its tributaries, forest and meadow-marsh floodplains on alluvial deposits are quite common. These floodplains usually have more fertile soil than the surrounding areas and a greater diversity of vegetation. Research by J. Opperman *et al.* (2022) confirms the highest natural diversity of tree, shrub and herbaceous plants within such floodplains, which is explained by the intensive accumulation of organic material that supports the ecosystem services of the landscape. However, as a result of long-term urbanization and economic development of floodplains in the Prypiat River basin, the sustainability of landscapes is sometimes unstable, due to a number of environmental problems. A. Volchak *et al.* (2016) explain that the impact of artificially changing the conditions of river flow formation over decades has led to periodic floods and floods, and due to the flooding of settlements and agricultural land, a large amount of pollutants enters the rivers. A. Konoplev *et al.* (2021) observed that flooding of territories causes secondary contamination of surface waters in the Prypiat River basin with radionuclides that are still present in the soil profile after the Chornobyl nuclear power plant accident. Similar confirmations are provided by observations of Y. Grokhovska and S. Konontsev (2022), who prove that due to irrational use of natural resources within the Prypiat River catchment, regulation and straightening of small river channels, soil erosion is intensifying, siltation of channels occurs, water quality and the vital activity of aquatic organisms are changing.

K. Wang *et al.* (2023) confirm that in recent decades, agricultural intensification, expanding urbanization, technological advances and economic growth, combined with the effects of climate change, have significantly altered the balance of relations between humans and nature and led to serious consequences and risks for landscape ecosystem services. Taking into account the multitude of natural and anthropogenic factors in the Prypiat River basin, the impossibility of applying unified approaches to assessing the ecological sustainability of landscapes, as observed in the scientific literature, is confirmed. In addition, the presented experience shows that the completeness of the assessment model largely depends on the availability of data and their orderliness. Thus, in order to assess the environmental sustainability of the Prypiat River basin landscape within the Volyn Oblast, data within individual territorial communities were used, which are officially reported for environmental purposes.

The mapping of the assessment results on the administrative boundaries of the TC contributed to a clear visualization of the current environmental sustainability of the region in administrative and spatial terms. This situation coincides with the data of J. Jóźwik & D. Dymek (2021), who argue that landscape sustainability studies should be repeated periodically, as in the future this will allow communities to identify in advance natural structures that require preservation or restoration based on environmental conditions. Proposals X. Qiao *et al.* (2023) to optimize land use patterns in river basins by taking into account landscape structure are similar to the approaches used in this study. However, such assessments within river basins and sub-basins, which could facilitate management decisions on practical projects to preserve or restore their ecological status, are currently difficult in Ukraine due to the peculiarities of statistical reporting. These gaps can be filled by tracking the extent of anthropogenic landscape changes within territorial administrative units, while analysing the natural features of river catchment areas. Modern environmental mapping technologies can provide the necessary regional-scale variations in the environmental sustainability of landscapes, which will facilitate the development of coordinated concepts between communities and public environmental management bodies to achieve sustainable development goals in socio-ecological systems.

CONCLUSIONS

Based on the determinations of the coefficient of ecological sustainability of landscapes (k_{ESL1}) of the Prypiat River basin in the context of territorial communities of the Volyn Oblast, it was found that the landscapes of the study area have a qualitative characteristic ranging from "unstable with pronounced instability" to "stable, with pronounced stability". The ecological mapping showed that in the Tsyr sub-basin, from the source to the mouth, where Kamen-Kashyrska and Lyubeshivska TCs are located, the k_{ESL1} value is 4.90-5.39, which assesses the landscapes as "stable, with pronounced stability". In the Vyzhivka River sub-basin and the upper Prypiat River (Rivne, Holovnenska, Shatska, Zabolotnenska, Ratnivska TCs), k_{ESL1} varies from 1.18 to 4.35, which assesses the sustainability of the landscapes as "conditionally stable" – "stable". In the Turia River sub-basin (Turia, Lyublyntsi, Kovel, Sochyshne, Velymche TCs), k_{ESL1} ranges from 0.90 to 4.90, which means that the ecological sustainability of the landscapes is assessed as "unstable" to "stable, with pronounced stability". In the sub-basin of the Stokhid River (Prylisnenska, Kamyn-Kashyrska, Lyubeshivska TCs), k_{ESL1} has a value of 0.90-5.39, which means that the ecological sustainability of the landscapes ranges from "unstable" to "stable, with pronounced stability". In the middle part of the Styr sub-basin (Horodyshche, Lutsk, Torchyn, Horokhiv, Kivertsi, Kolkiv, Manevychi TCs), k_{ESL1} varies from 0.28 to 5.16, which assesses the ecological sustainability of landscapes as "unstable, with pronounced instability" to "stable, with pronounced stability". In general, the land areas of the TC administrative units in the Prypiat River basin within Volyn Oblast are represented by unstable landscape elements mainly in the southern part of the basin, within the Volyn Upland, where the tributaries of the Prypiat River originate. The areas under agricultural crops and plant communities that have a positive impact on the landscape are located mainly in the northern part of the basin within the Polissya Lowland, where the mouths of the tributaries (Vyzhivka, Turia, Tsyr, Stokhid) and the source of the Prypiat River itself are located. The variations in landscape stability obtained in the course of ecological mapping have the prospect of continuing such assessments to expand the spatial and temporal dimension of research. This will help to align the interests of socio-economic development of communities with the management decisions of state environmental agencies to preserve the stability of landscapes in river basins, maintain and restore their ecological condition.

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CONFLICT OF INTEREST

None.

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Оцінка екологічної стійкості ландшафту басейну річки Прип'ять у межах Волинської області

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Анотація. Актуальність досліджень полягає в тому, що в розрізі глобальної концепції сталого розвитку, одним із провідних завдань є підтримання стійкості природних екосистем через пошук оптимальних стратегій розвитку соціо-економічних систем. Мета досліджень – оцінка екологічної стійкості ландшафтів басейну річки Прип'ять у межах територіальних громад Волинської області в сучасних умовах розвитку регіону. Методи, що використовувались для досягнення мети, включали розрахунок коефіцієнту екологічної стійкості ландшафту на основі систематизації статистичних звітних даних, з наступним порівняльно-географічним аналізом і проведенням екологічного картографування засобом ArcMap та ArcGIS Pro. Основні результати досліджень свідчать, що коефіцієнт екологічної стабільності ландшафтів у басейні р. Прип'ять знаходиться у межах 0,22-5,39 і оцінює ландшафти від рівня «нестабільні з яскраво вираженою нестабільністю» до «стабільні, з яскраво вираженою стабільністю». Розподіл площ земель у територіальних громадах, які знаходяться у суббасейні р. Цир, зумовлює характеристику ландшафтів на рівні «стабільні, з яскраво вираженою стабільністю». У межах територіальних громад суббасейну р. Вижівка та верхів'я р. Прип'ять – «умовно стабільні» – «стабільні». У межах громад суббасейну р. Турія – від «нестабільні» до «стабільні, з яскраво вираженою стабільністю». У межах громад суббасейну р. Стохід від «нестабільні» до «стабільні, з яскраво вираженою стабільністю». Територіальні громади середньої частини суббасейну р. Стир представлені ландшафтами від «нестабільні,

з яскраво вираженою нестабільністю» до «стабільні, з яскраво вираженою стабільністю». У цілому, більш екологічно-стабільні ландшафти розміщені в північній частині Волинської області, що завдячує великим площам лісовкритих земель. Екологічна нестабільність ландшафтів характерна для південної частини області через значні площі розораних земель. Практична цінність роботи полягає в отриманні регіональних варіацій оцінки екологічної стабільності ландшафтів, що важливо враховувати при розробці узгоджених концепцій між громадами та органами управління природокористуванням за басейновим принципом, для досягнення цілей сталого розвитку в соціоекологічних системах

Ключові слова: річковий басейн; суббасейн; землекористування; екосистемні послуги; управлінські рішення