Theory and Building Practice

Vol. 3, No. 1, 2021

https://doi.org/10.23939/jtbp2021.01.072

Volodymyr Snitynskyi[1], Petro Khirivskyi[1], Ihor Hnativ[1], Roman Hnativ[2]

THE NEED TO PROTECT AREAS FROM FLOODING AND SHORE PROTECTION ON THE RIVERS OF PRYKARPATTIA

[1] Lviv National Agrarian University, Dubliany,
Department of Ecology
[2] Lviv Polytechnic National University,
Department of Hydrotechnics and Water Engineering,
gnativ.roman.m@gmail.com

Prykarpattia is one of the areas in Europe most prone to floods. Recent environmental research predicts a trend towards an increase in these dangerous phenomena in the Carpathian region of Ukraine. The analysis of the losses caused by floods in Lviv region shows that the allocation of funds for the elimination of the consequences of floods is growing every year. It is necessary to introduce comprehensive regulation of riverbeds, taking into account the development of channel processes and forecasting possible changes under the influence of hydraulic structures.

The purpose of the study is to analyse the factors influencing landslides and erosion in the foothills of the Ukrainian Carpathians and the choice of optimal flood protection of populated areas.

Key words: protection of territories, floods, flooding, erosion of territories, exogenous processes, shore protection, flood protection.

Formulation of the problem

Prykarpattia is one of the areas in Europe most prone to floods. Recent environmental research predicts a trend towards an increase in these dangerous phenomena in the Carpathian region of Ukraine. If earlier the frequency of floods was observed every thirty years, now – once every three or four years, or even more often. In the last decade alone, the Lviv region has suffered 5 catastrophic floods, the total damage from which, according to experts, amounted to about 100 million dollars USA (Burshtynska, 2012). In European countries, a comprehensive flood protection system is better developed and allows them to reduce the effects of floods. Most of the existing flood defenses in Ukraine are obsolete and partially destroyed.

The sharply dissected relief and insignificant thickness of the Carpathian soils in case of excessive atmospheric moisture create conditions for frequent floods, which are accompanied by erosion processes (Oliynyk, 2012). An important natural factor in preventing these negative phenomena is forest plantations and the lack of plowing of sloping areas.

Relevance of research

The critical situation with anti-flood measures in the Lviv region in previous years leads to significant financial losses for the state budget. The analysis of the losses caused by floods in Lviv region shows that the allocation of funds for the elimination of the consequences of floods is growing every year. In 2008 alone, the government spent about $ 43 million on restoration work and compensation for the damage caused by the catastrophic floods in the Carpathian region. Today, the government is spending more money and effort on overcoming the effects of floods than on eliminating their causes. Solving this strategic problem makes it one of the priorities in Ukraine's development program in the XXI century (Burshtynska, 2012).

To solve the problem of floods in Western Ukraine, the Cabinet of Ministers of Ukraine has developed and approved a State targeted comprehensive program of flood protection in the Dniester, Prut and Seret river basins. This program provides for the implementation of flood control measures in the amount of $ 3,914 million by 2025. Of the above amount, $ 500 million has been allocated for the implementation of flood control measures in the Lviv region (Resolution of the CMU, 2008).

Formulation of the purpose and objectives of the article

The purpose of the work is to study the influence of the main factors on the transformation of the channel, erosion and landslides in the Carpathians and analysis of the effectiveness of the existing flood protection of settlements from flooding and destruction.

The rivers of the Carpathian region are a zone of potential flood danger, so the objectives of the research are to scientifically substantiate the need to create an improved system for monitoring anthropogenic impacts to improve the environmental safety of hydroecosystems.

Analysis of recent research and publications

Over the past centuries, the natural-territorial complexes of the Bukovynian Carpathians and Precarpathians have undergone significant quantitative and qualitative negative changes that have led to the ecological imbalance of natural ecosystems and the formation of existing and potential threats to humans and biotic objects. Mountain ecosystems, which are reserves of natural biodiversity and have significant economic value, are very sensitive to any impact that alters the ecological balance and causes negative destructive processes (Solodky, 2013).

An important consequence of channel erosion in the river basins of the Carpathians is the intensification of dangerous geomorphological and hydrological processes. These are bank erosion, landslides in the lower parts of the valleys along the river, landslides and mudflows on steep slopes. In the study region, these geomorphological effects are particularly amplified in the conditions of uncontrolled deforestation and development in coastal protection zones of mountain rivers. Due to the high probability of progression of erosion upstream to the upper part of the Stryy river basin with decreasing forest cover area, the probability of intensification of landslides and mudslides during extreme precipitation and intense snowmelt increases (Mykhnovych, 2017).

An integral indicator of the hydrological role of the forest is the degree of its influence on the formation of the river flow regime. Therefore, when assessing the hydrological role of forests for river basins, it is proposed to take into account the main factors of the water regime of the mountain area. As the main indicator of the absorptive capacity of the forest cover in such catchment areas, it is recommended to take the percentage of forest cover, and indicators of its efficiency. This is a decrease in the maximum water runoff during floods and an increase in the limited runoff in the dry seasons of the year (Rak, 2018).

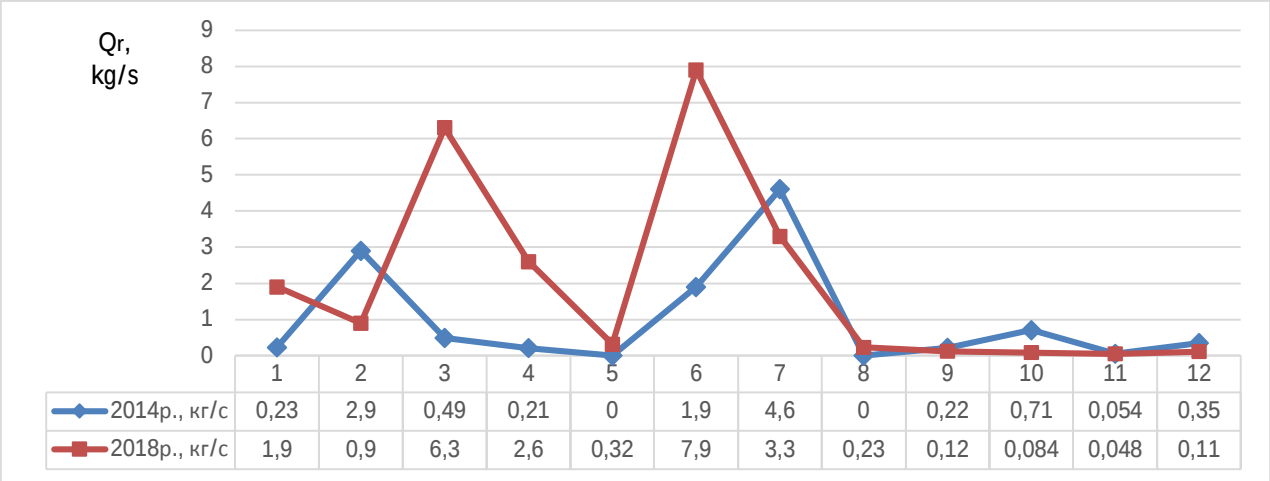
Presenting main material

Mechanical denudation processes in mountainous areas contribute to the transit movement of large masses of solid material down the slopes, their accumulation at the foot, in hollows and other relief elements, as well as the ingress of erosion products into the river network. Mechanical denudation processes cause degradation of the soil cover, and solid particles of rocks entering the water deteriorate its quality due to increased turbidity of the watercourse and adsorption of particles of harmful compounds. Many scientists believe that the denudation depression of the Carpathians is approximately 0.11 mm/year at average tectonic uplift rates of 2.2 mm/year (Kovalchuk, 2010).

The causes and factors that cause mechanical denudation are varied, but they are all natural or anthropogenic. The products of basin erosion enter, first of all, the upper links of the river network, and the runoff of suspended sediments of small rivers serves as the best indicator of the intensity of

denudation in basin systems. At the same time, sediment runoff in basins with an unchanged or slightly altered human natural landscape and with a predominance of channel erosion characterizes its natural component. As plowing increases and forest cover decreases, basin erosion intensifies, the runoff of suspended sediments naturally increases, and this growth determines its anthropogenic component (Dedkov, 2005).

We conducted a study of changes in the seasonal flow of suspended and mobile sediments in the river Stryi in 2014 and 2020. Measurements were carried out near the village. B. Bluish, and the results of research are shown in the graphs of Fig. 1. We see an increase in seasonal costs in March and June, which in our opinion is caused by snowmelt in spring and summer floods. We also see an increase in sediment costs in 2018 compared to previous years.



	1	2	3	4	5	6	7	8	9	10	11	12
2014р., кг/с	0,23	2,9	0,49	0,21	0	1,9	4,6	0	0,22	0,71	0,054	0,35
2018р., кг/с	1,9	0,9	6,3	2,6	0,32	7,9	3,3	0,23	0,12	0,084	0,048	0,11

Fig. 1. Change in seasonal costs of suspended and mobile sediments of the Stryy River in 2014 and 2018 (V. Sinyovidne township)

In the Carpathian region, we have a close relationship between hydrometeorological and topographic conditions. With an increase in the average height of the watershed per 100 m, the average annual rainfall increases by 68 mm, and the surface runoff ratio by 0.1. Increasing the tilt angle by 5 % adds 77.5 mm to the surface runoff. The interaction between factors causes dangerous exogenous processes in river basins. Heavy rainfall leads to a 10-100-fold increase in water discharge and floods. Due to the significant slope of the channel, the flow rate increases and destruction occurs. Streams move significant bottom sediments, facilitating the migration of riverbeds. This causes the destruction of buildings and engineering structures, causing landslides, mudslides, landslides and erosion on the slopes (Kovalchuk, 2012).

a *b*

Fig. 2. Changes in the shoreline of rivers due to floods in 2020: a – Ivano-Frankivsk region; b – Chernivtsi region (https://news.24tv.ua/)

Heavy rains in June 2020 led to large-scale floods in Ivano-Frankivsk, Chernivtsi, Lviv, and Zakarpattia regions. The most difficult situation was in Prykarpattia and Bukovyna, where a "red" level of danger was announced (Fig. 2).

13.000 houses were flooded in Ivano-Frankivsk region. In some cases, the water just went into the backyards and into the rooms. Significant damage was inflicted on the houses, in some cases the houses actually collapsed (Fig. 3, *a*). In the Stryi district of the Lviv region, after heavy rains, two rivers overflowed – Turyanka and Svicha, as a result of which about 100 residential buildings were flooded (Fig. 3, *b*).

In total, only in Ivano-Frankivsk region, 110 km of roads were destroyed, 427.5 km of roads were damaged, 90 bridges were destroyed, 130 bridges were damaged (Fig. 4) and 1850 meters of shore protections were destroyed (Ukravtodor press service, 2020).

a *b*

Fig. 3. Flooding of residential buildings as a result of the flood of 2020:
a – Ivano-Frankivsk region; b – s. Zarichne, Stryi district

The main reasons for the transformation of the river system structure and intensive deformations of the riverbed are settlements in the coastal protection zones of the river, agricultural, hydraulic impacts on the catchment and intensive gravel-sand mixture extraction within the riverbed and floodplains (Snitinskyi, 2020).

Fig. 4. Damage to transport infrastructure due to floods in Western Ukraine in 2020

Gravel mining in open pits of the riverbed downstream has a very strong effect on the deformation of the riverbed up in the river basin of the Carpathians. During the extraction of gravel in the channels and floodplains, deep depressions up to several kilometers wide are formed. Open pits significantly change the morphometric parameters of the river bed and the characteristics of the flow, cause a shortage of suspended sediments downstream and intense erosion upstream.

The Stryy River is the largest of the right-bank tributaries of the Dniester. The sources of the Stryi are at an altitude of about 1000 m. The river flows through a wide valley in a rather unstable, gravel bed. The banks of the channel are in most cases steep, often rocky, in the upper reaches up to 40 m. The upper reaches of the river are characterized by the highest in the Dniester basin values of the runoff modulus 20–21 l / s. The river is characterized by great variability of the level regime (Khilchevsky, 2013).

Maximum annual levels are usually associated with floods. In some years, the levels are higher during the spring floods. However, there are cases when the level rises due to the formation of congestion and congestion. Studies of maximum annual water levels over a long period of time performed by P. F. Vyshnevsky confirms that the fluctuations of the maximum annual water levels on the Dniester and its tributaries are caused by natural fluctuations of climatic factors, which change from year to year.

The relatively small channel capacity of the river contributes to the preservation of significant level rises in the Carpathians. The banks of the Dniester are mostly steep, the floodplain is narrow or absent.

Against the background of difficult natural conditions of the Carpathians, the forest weakens the role of climatometeorological and soil-lithogenic factors in the formation of the water regime of the mountain area. Compared to field lands, it improves the regulation of river runoff by 1.6 times. The hydrological role of the forest increases with increasing age of plantations. This is more intense in beech forests and slower in spruce forests. But under extreme weather conditions, the protective role of the forest, regardless of its age, decreases sharply, resulting in intensified floods and accompanying erosion-landslides and landslides, which occurred during the last catastrophic floods in 1998, 2001, 2008. An important factor in changing hydrological conditions is economic activity. Studies in hospitals show that the most significant effect on the water regime is continuous felling, which is able to increase the slope runoff of floods almost twice. The negative hydrological consequences of gradual and selective felling are 2.5 and 10 times smaller, respectively.

The formation of surface waters is significantly influenced by the geological structure, the basis of which is formed by the Carpathian flysch, ie the rhythmic alternation of shales, sandstones and marls. It does not contribute to the deep infiltration of precipitation and groundwater accumulation over large areas, but only enhances the role of meteorological factors in the formation of an extensive hydrographic network of surface water runoff. This is most pronounced on slopes with the presence of waterproof clay shales in the soil. An important stock-forming factor is the mountainous terrain. The steeper the slopes, the more intense the runoff is known (Oliynyk, 2012).

In mountain conditions, an important role belongs to technical methods of protection against dangerous natural phenomena. Thus, in vulnerable areas, especially in river valleys and streams, floodplains of agricultural lands and settlements, road network and other communications, it is necessary to build protective hydraulic structures – retaining walls, dams, drains, etc. Bridges must have a maximum capacity. Strengthening drainage and drainage is very important for landslide-prone areas of mountain slopes. In the upper part of the mountain slopes with the formation of avalanches, the leading importance belongs to engineering structures – snow shields, avalanches, galleries and avalanche extinguishers. It should be noted that it is impossible to completely avoid negative natural phenomena in ecologically unstable mountain conditions with the help of forests and hydraulic means, as such processes are one of the geological factors of landscape rejuvenation and ecosystem functioning. In this aspect, it is necessary to adapt man and his activities to cataclysms, reducing the anthropogenic pressure on mountain ecosystems, especially on vulnerable areas of mountain slopes and river valleys (Oliynyk, 2011).

The intensification of slope erosion and landslide processes was facilitated by catastrophic floods that occurred in the Carpathian region in 2008 and 2010. They were due to the fact that global climate change and natural conditions of the Carpathians cause heavy rainfall, and anthropogenically damaged forest cover of the mountains does not protect watersheds from the destructive effects of water. Frequent small earthquakes occurring in the study region can also contribute to the activation of negative slope processes (Solodky, 2013).

According to the conclusions of the intersectoral group of experts of the Government and the National Academy of Sciences of Ukraine, catastrophic natural disasters in 2008 and 2010 in the Carpathian region were caused by the simultaneous action of natural factors (wet summer and autumn, over-saturation of the soil moisture, reducing water transpiration capacity of ability of vegetation, powerful shower) and strengthened factors human impact. However, this coincidence of negative natural factors was not yet the most dangerous.

In general, the development of negative slope processes and soil degradation of the Bukovynian Carpathians and Precarpathians requires the development and implementation of priority measures for ecologically balanced and integrated management of natural resources of the mountain region. Experience has shown that narrow-minded programs of measures on these issues are ineffective.

Conclusions

Studies have shown the possible complication of the general water and environmental situation, especially in water bodies with significant anthropogenic load with deteriorating water quality due to limited dilution of polluted wastewater and the impossibility of natural leaching of riverbeds, until dry watercourses.

The need to prevent soil erosion processes by introducing soil protection technologies and other measures to preserve and restore soil fertility has been identified. To preserve the drainage function of forests, it is necessary to use gradual and selective methods of felling instead of continuous felling, without allowing the reduction of forest cover. When planning forest management activities, it is necessary to take into account the state of forest cover and the development of natural phenomena at specific watersheds.

The spread and activation of exogenous geological processes (EGP), the study of conditions for the development and resumption of observations of them, are becoming a priority, urgent measures. With the intensive conduct of economic activity in the regions in recent decades, there has been a deterioration of the geo-ecological situation with a steady tendency to develop EGP. The intensity of the latter significantly increases under the influence of man-made factors that cause disturbances in the natural balance of the environment.

References

Burshtynska Kh. V., Shevchuk V. M. (2012). Methods of research of displacements of the Dniester riverbed. Geodesy, cartography and aerial photography: interdepartmental scientific and technical collection. Lviv: Lviv Polytechnic Publishing House. – Issue 76. – P. 102–110. (in Ukrainian).

Oliynyk V. S. (2012). Factors of flood runoff in the mountain forests of the Carpathians. Scientific Bulletin of NLTU of Ukraine. Vip. 22.2. P. 21–26. (in Ukrainian).

RESOLUTION of December 27, 2008. No. 1151. Kyiv “On approval of the State target program of integrated flood protection in the basins of the Dniester, Prut and Siret rivers”. https://www.kmu.gov.ua/npas/182120430 (in Ukrainian).

Solodky V. D., Bespalko R. I., Kazimir I. I. (2013). Exogenous geodynamic processes of the Bukovynian Carpathians and Precarpathians. Ecological safety and nature management. V. 13. P. 54–63. – Access mode: http://nbuv.gov.ua/UJRN/ebpk_2013_13_9 (in Ukrainian).

Mykhnovych A. V., Pylypovych O. V. (2017). Riverbed deformations in the upper Dnister catchment under gravel-pits exploitation. Problems of geomorphology and paleogeography of the Ukrainian Carpathians and adjacent territories. – 2017. – 1. – P. 112–122. Access mode: http://nbuv.gov.ua/UJRN/prgeomorpal_2017_1_11

Rak A. Yu. (2018). Interrelation and interdependence of natural phenomena in mountain-forest ecosystems. Scientific Bulletin of NLTU of Ukraine. v. 28, № 3. P. 67–72. https://doi.org/10.15421/40280314 (in Ukrainian).

Kovalchuk I., Pylypovych O., Venhrynovych O. (2010). Quantitative assessment of mechanical denudation in the Carpathian part of the Dniester basin: natural and anthropogenic components. Physical geography and geomorphology. Vip. 1 (58). P. 76–85. (in Ukrainian).

Dedkov A. P., Gerasimova T. V. (2005). Erosion and runoff of suspended sediments in the forest belt of eastern Europe: natural and anthropogenic components. Erosional and channel processes. Issue. 14. S. 330–337. (in Russian).

Kovalchuk Ivan, Mykhnovych Andriy, Pylypovych Olha, Rud'ko Georgiy (2012). Extreme Exogenous Processes in the Ukrainian Carpathians. Publisher: Springer Netherlands. Geomorphological impacts of extreme weather. Chapter 4. P. 53–66. https://doi.org/10.1007/978-94-007-6301-2_4

https://espreso.tv/news/2020/06/24/povin_znyschyla_110_km_dorig_ta_90_mostiv_na_ivano_frankivschyni_ukravtodor (in Ukrainian)

Snitinskyi V. V., Khirivskyi P. R., Hnativ I. R. (2020). Features of surface runoff formation of mountain rivers during deforestation and plowing of slope areas. Scientific and practical journal "Environmental Sciences". No. 3 (30). P. 73–77. https://doi.org/10.32846/2306-9716/2020.eco.3-30.12 (in Ukrainian).

Khilchevsky V. K., Gonchar O. M., Zabokrytska M. R. etc. (2013). Hydrochemical regime and surface water quality of the Dniester basin on the territory of Ukraine. For order. V. K. Khilchevsky and V. A. Stashuk. K.: Nika-Centr. 256 s. (in Ukrainian)

Oliynyk V. S. (2012). Factors of flood water runoff in the mountain forests of the Carpathians. Scientific Bulletin of NLTU of Ukraine. V. 22.2. P. 21–26. (in Ukrainian)

Oliynyk V. S. (2011). Harmful natural phenomena in the forests of the Carpathians, their distribution and ways to prevent them. Scientific Bulletin of NLTU of Ukraine. V. 21.13. P. 47–54. (in Ukrainian)

В. В. Снітинський[1], П. Р. Хірівський[1], І. Р. Гнатів[1], Р. М. Гнатів[2]
[1] Львівський національний аграрний університет, Дубляни
кафедра екології
[2] Національний університет "Львівська політехніка",
кафедра гідротехніки та водної інженерії

НЕОБХІДНІСТЬ ЗАХИСТУ ТЕРИТОРІЙ ВІД ПІДТОПЛЕННЯ ТА БЕРЕГОУКРІПЛЕННЯ НА РІЧКАХ ПРИКАРПАТТЯ

Прикарпаття є однією з територій у Європі, які найбільш схильні до паводків та повеней. Останні екологічні наукові дослідження прогнозують тенденцію до почастішання цих небезпечних явищ у Карпатському регіоні України. Якщо раніше повені спостерігали раз на тридцять років, то тепер – раз на три–чотири роки, а то й частіше. В європейських країнах комплексна система протипаводкового захисту краще розвинена та дає змогу зменшувати наслідки паводків. Більшість з протипаводкових споруд в Україні застарілі та частково знищені.

Критична ситуація, що склалась з протипаводковими заходами на Львівщині у попередні роки, призводить до значних фінансових втрат для держбюджету. Аналіз збитків, спричинених паводками на Львівщині, показує, що виділення коштів на ліквідацію наслідків паводків зростає з кожним роком. Протипаводковий захист населених пунктів, територій та об'єктів від затоплення є актуальною проблемою. Необхідне впровадження комплексного регулювання русел річок з урахуванням розвитку руслових процесів і прогнозуванням можливих змін за впливу гідротехнічних та інженерних споруд.

Метою проведених досліджень є аналіз факторів, що впливають на зсувні та ерозійні явища на передгірських ділянках Українських Карпат, та вибір оптимального протипаводкового захисту населених територій від руйнування. Отримання достовірних даних про місце формування, фактори активізації та розвитку небезпечних екзогенних процесів може істотно впливати на прийняття рішень для недопущення і ліквідації негативних наслідків активізації цих процесів.

Ключові слова: захист територій, повені, підтоплення, ерозія територій, екзогенні процеси, берегоукріплення, протипаводковий захист.