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# Contemporary Geoinformation Technologies in Postmodern Education of Geographers, Hydrometeorologists, Land Surveyors

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**Abstract**: There is a problem of incision of rivers. To solve it, it is necessary to obtain and analyze objective information about the processes of incision and related processes of changes in morphology, structure, functioning of the flow-channel system, the young river landscape. The next step in solving the problem is an objective analysis of possible factors of incision. The main factor in the studied objects is the extraction of river alluvium for many decades. It is also important to identify and study the consequences and extent of changes in the young river landscape, to assess its condition. We propose a method of analysis of processes and factors of incision that can be applied to other rivers, it can also be supplemented and developed. It allows to put in perspective the situation and justify the necessary solutions in the process of planning integrated management of the young river landscape as an important component of the river basin system. Significantly anthropogenically altered sections of rivers, their channels and floodplains may occur as a result of incision. They need special public attention to restore the environmental properties of capacity building. This is an integral part of the culture of interaction between society and rivers, which primarily includes objective quality monitoring, availability and quality of all necessary information (its systematicity, system analysis) as a basis for effective decision-making. An important conclusion is the feasibility of monitoring changes in the vertical position of channels and floodplains, as well as changes in alluvial deposits as part of hydromorphological monitoring in general. In particular, conducting GPS surveillance.

**Keywords:** *Environmental problems, geo-ecological issues, river ecological corridors, homogeneous areas of the riverbed and floodplain, flow-channel-floodplain system, young river landscape, STEM-education.*

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## Introduction

In the process of professional and socially oriented training of students-geographers, hydrometeorologists, specialists in land management and other specialties an important methodological task is the research knowledge and skills integration with modern information technology with a deep understanding of sustainable development, environmental problematic aspects. Such approaches promote integration of students into social processes, their socialization, development of a creative personality capable of solving urgent problems of human interaction with the environment. The complexity of such issues also necessitates the use of interdisciplinary approaches, and hence interaction of specialists in different specialties, integration of relevant components of the educational process, teaching methods. Research of scientists, teachers of the Faculty of Geography of Yuriy Fedkovych Chernivtsi National University is aimed at solving regional problems of sustainable development, optimization of the environment and its components – geosystems. Students are involved in the research in the process of writing term papers, bachelor's and master's theses.

One of the urgent geo-ecological issues in the conditions of Precarpathia is deepening of channels, incision of rivers, which is primarily caused by human activities. As a result, the young river landscape and relevant ecosystems change significantly. The urgency is enhanced by the fact that the work is currently underway to monitor the status of waters (Cabinet of Ministers of Ukraine, 2018), assess their status, develop river basin management plans in connection with the implementation in Ukraine of EU water directives, including the EU Water Framework Directive (European Parliament and the Council, 2006). The issue of forming an ecological network, in which river ecological corridors are an important element, has not lost its relevance; the relevance is reinforced by the existing postmodern technologies, implementation of which requires study and testing (Nerubasska & Maksymchuk, 2020; Nerubasska, Palshkov, & Maksymchuk, 2020).

To analyze and solve this problem, it is important to apply a set of methods, to conduct comprehensive interdisciplinary research, in particular related to the use of modern geographic information technologies, to introduce postmodern IT technologies for effective monitoring of water status, assessment of their condition, development of river basin

management plans; introduction of postmodern geoinformation technologies to determine the heights of riverbeds and floodplains.

A rapid development of science and technology has caused not only scientific, technological and social progress, but also changed the requirements for the development of education at all levels, including higher education. Today, innovative technologies and teaching methods that are aimed at ensuring the implementation of personality-oriented system of current postmodern education are becoming more and more familiar to us. Such innovative approaches include Waldorf pedagogy, Montessori methodology, Guzyk's technology of level differentiation, Selevko's technology of self-development learning, color-blind technology, collective way of learning (Rivin, Dyachenko), game technologies (including team building), project technologies, technology of modular and modular-developmental learning, adaptive learning system of Granitskaya, problem-based learning technologies, interactive technologies and many others. In our opinion, special attention should be paid to STEM-education, which is widely implemented in natural sciences in order to integrate knowledge, skills and abilities, their practical implementation (Florida, 2003; National Panel Report, 2002). Therefore, the use of modern innovative technologies for teaching natural sciences in universities during the training of specialists in the field of geography, hydrometeorology, land boundary survey and other specialties is an extremely important and urgent task.

During the training of specialists in geography, hydrometeorology, boundary survey, etc., at the Faculty of Geography of Yuriy Fedkovych Chernivtsi National University, project techniques are widely used together with the methods of STEM-education. This primarily allows students to develop the ability to think logically, mathematically and creatively, forms a scientific understanding of nature and modern technologies, develops awareness and self-expression in culture, life, etc., and develops the ability to confidently use information and communication technologies, without which the presence is unthinkable.

One of the cross-cutting topics taught in all these specialties is the hydrological and hydroecological study of river complexes. Obviously, geographers, hydrometeorologists and specialists in land management face various challenges in their research and perception. Therefore, with the help of project teaching methods it is possible to involve students from different specialties in the so-called scientific problem groups, who, by studying the river complex, will pay attention to those features that they must study, analyze, monitor, design in their practice. This promotes creative thinking,

an integrated approach to solving the tasks, as well as a clear division of functions between the participants of such a project research group for a comprehensive study of the river basin using different research methods.

Interference of project-based learning with the methodology or direction of STEM-education will allow to conduct such research using S (Science) – modern scientific achievements and methodological foundations, T (Technology) – innovative technologies, E (Engineering) – showing technical creativity and M (Mathematics) mathematical abilities. That is why in our article, when disclosing such a project, we use GIS and technology, without which it is unthinkable to scientifically study any geographical object, place, territory or space. It is the methods of GIS application that solve the application of innovative technologies in STEM education, and also promote the development, together with the use of various measuring instruments, of the technical creativity of the student – a future specialist in the field of natural sciences. Any geographical research is not possible without the use of mathematical methods to process geographic databases about an object or process. Therefore, the project technology of higher education is designed to form in the student the ability to practically use the acquired theoretical knowledge, combine it in complex research or monitoring, as well as pay attention to the basic and secondary elements of complex natural systems.

*The purpose of this publication* is to highlight the methodological issues of the student's research work on "Analysis of changes in the altitude of riverbeds and floodplains and geoecological problems of transformation of the young river landscape", via examples of rivers in the Precarpathian region using current geoinformation technologies.

The main components of such a study are:

1. Substantiation of the relevance of the scientific-applied problem, critical review of scientific publications, formulation of the purpose and objectives of the study.

2. Critical review of existing publications on the research problem.

3. Characteristics of research methods.

4. Presentation of the main results of the study, conclusions, discussions.

The following foreign researchers have studied current geoinformation technologies for determining the height of riverbeds and floodplains in postmodern education: Andreev (2020) proved the effectiveness of GIS technologies in contemporary conditions of studying

geographic information technologies for determining the heights of riverbeds and floodplains; George, Arcement & Schneider (1989) saw the need for guidance on the choice of Manning roughness coefficients for natural canals and floodplains; Parker (1988) highlighted the unique qualities of the geographic information system, the importance of a cooperative GIS technology laboratory; uniqueness of research of Klikunova & Khoperskov (2020).

## Postmodern geoinformation technologies for determining the heights of riverbeds and floodplains

In the postmodern era the general interest in modern geoinformation technologies to determine the heights of rivers and floodplains in postmodern education is initiated by both users and providers of IT solutions.

There are several reasons for the interest of corporate users in geographic information technologies: geographic information technologies allow not only to achieve a significant end result, but also to visually reflect the state and behavior of administrative objects; geoinformation technologies present information and means of its processing in an understandable natural form - in the form of maps and diagrams, with the possibility of conducting spatial sampling of objects and the use of the original method of analysis; geographic information technologies offer a unique opportunity - to show the spatial distribution of infrastructure in a convenient way; the situation on the ground at different scales, in two- or three-dimensional representation, as close as possible to the real world.

In the postmodern era, interest in geographic information technology is growing among IT professionals for the following reasons: the effect of novelty, informal user interfaces and new ways of interpreting information through visual representation.

In addition, geoinformation technologies are part of the modern information mainstream in the postmodern era - they support all current information innovations: integrators of distributed computing, high interactivity, open systems, etc. (Gębica, 2013).

In the twenty-first century, the experience of implementation of corporate information systems projects shows that the ArcGIS platform from ESRI has all the necessary functions to design and build high-performance corporate information management systems: ArcGIS is a high-

performance contemporary platform that implements many functions necessary for users (Shevchuk, Burshtynska, Korolik, & Halochkin, 2021).

Ability to configure the system with integrated VBA (Visual Basic for Application) or develop using professional tools (com, .net, C ++, C #); wide possibilities of scaling solutions, their development from a local desktop to the distributed server systems; support for modern methods of system integration, work with XML; ability to work with data from different sources, in different formats, with maps in different projections and coordinate systems; good technical support, quality product documentation, user manuals and help system, the opportunity to get advice from ESRI specialists.

In other words, ESRI offers a complete set of advanced tools for solving GIS tasks of companies at all stages of creation and operation (Vaisala, 2012).

Geoinformation companies are based on high-performance data warehousing, ArcSDE technology, data models, ArcGIS Server solutions for data provision, publishing spatial data and solutions on the company's network and the Internet, and tools for integrating programs into other information systems used by the company. Effective management of the company's assets is impossible without accurate, reliable and constantly updated information about the location, spatial and technological characteristics and technical condition of the objects (Ghimire, Shrestha & Khanal, 2007).

Creating a corporate database of administrative objects is a very large amount of work that must be provided with quality topographic information, tools for collecting and processing geodetic data, data models that describe the spatial relationships and rules of behavior of objects, 2D and 3D visualization.

## Methodical aspects of the main components of the student's research work and examples of presenting its results

### *Characteristics of the student scientific and applied problem, its relevance.*

The selection, formulation of the problem, the characteristics of its relevance are comprehended by the student through the study of relevant scientific publications, involvement in research work by teams of departments, participation in seminars, conferences, etc. Regarding our chosen topic, it should be noted that the problem of the impact of channel

alluvium mining on the state of rivers, namely on their incision, lowering the position of the channel is known from the 70-80's of the XX century. It had a wide resonance due to the negative impact of the so-called "channel quarries" on engineering structures. In particular, the bridge crossings were destroyed. In this regard, a number of powerful scientific studies were funded and performed, which revealed the patterns of deformation of riverbeds, the peculiarities of the functioning of the flow-channel system (FCS) under the influence of channel quarries. Significant negative consequences, in particular on the rivers of Precarpathia, led to the ban on quarries in the late 80's. Part of the work was carried out beyond the floodplains. However, in the late 1990s, a new stage of channel alluvial mining began, characterized by a diffuse, local impact on riverbeds with a gradual increase in alluvial production. Currently, the work is carried out under the slogan "regulation of channels". This only exacerbates the problem of river incision. Also, unfortunately, for decades no effective system of accounting for alluvium production has been created. Much of the work is unauthorized or non-compliant. There is no effective system for monitoring the state of riverbeds, floodplains, surrounding areas, alluvial environment, groundwater, ecosystems. All this significantly complicates the task of analyzing the processes and consequences of the impact of channel alluvium mining on the young river landscape. In this situation, scientific and methodological developments that would contribute to solving a complex problem become relevant and necessary. At the same time, the relevance of such research is greatly enhanced in the context of sustainable development planning, implementation of European approaches, including those related to the EU Water Framework Directive, other Directives, Carpathian Convention provisions, development of integrated river basin management plans. An integral part of the latter is the planning of the management of river and related ecosystems, the young river landscape in order to achieve their good status, ecological potential. In the postmodern era, it is important to study and implement geographic information technologies by corporate users.

### *Critical overview of scientific publications on the problem of research, formulation of its purpose, tasks*

The research of changes in the elevation of the elements of riverbeds and floodplains is a component of comprehensive geoecological studies of rivers, river geosystems, landscapes, specifically young river landscap (YRL). In applied and general ecological terms, basin, landscape, spatial, strategic

planning, concretization of sustainable development goals at levels from regional to local territorial communities.

Scientific publications that are directly related to the consideration of the formulated specific problem cover the following main areas: analysis of the territorial structure of the young river landscape; hydrological and hydromorphological monitoring of its condition; application of current information technologies for detection, analysis of its changes, formation of the corresponding database including features of its representation; analysis of the consequences of changes, problems of risk management, quality and others. Actually, to analyze the changes in the altitude of the elements of riverbeds and floodplains, it is sufficient to analyze the publications of the first three directions.

Territorial, geospatial segments of river geocomplexes are studied in the landscape science (Denysyk & Lavryk, 2012; Hrodzynskyi, 2005; Milkov, 1990; Schvebs & Vasyutinskaya, 1979), channel science (morphologically homogeneous areas, floodplain complexes) (Chernov, 2009; Kondratev, Popov & Snishchenko, 1982), as well as in research. Territorial structure of the river landscape is most deeply substantiated. It is taken in particular in its development under the influence of natural and anthropogenic factors, that can be analyzed, recorded on the basis of paleogeographic and historical-geographical studies. At the same time, the hierarchical-taxonomic approach is an important methodological approach. It gives an opportunity both to structure clearly the young river landscape and valley-river geosystems in general (Yushchenko, et al., 2012). This approach should be used for the proper organization of morphological monitoring in general and the study of changes in the altitude of riverbeds and floodplains in particular.

The information of stationary hydrological observations on rivers is the basis of traditional methods of analysis of changes in their altitude. These are such methods during the observation period, analysis of changes in the position of flow curves and graphs of dependences of other characteristics on water levels, combined analysis of graphs of changes in time of minimum levels and water consumption with the detection of trends, etc. They provide high-quality and sufficiently complete information about the state of the flow-channel system, but only in the areas of observations.

Hydromorphological monitoring, in the modern interpretation (CEN 14614:2004. Water Quality, 2005; EN TC 230/WG 2/TG5: N53. Water Quality, 2007; EU Water Framework Directive, 2006; Water Code of

Ukraine (WCU). 2018), applies to all river flows. At the same time, the recommendations for its application (Methodological recommendations for hydromorphological monitoring of surface water massifs of the "river" category. Kyiv. 2019) do not clearly identify the issue of a full analysis of changes in the altitude of the channel and floodplain. Therefore, this issue needs to be developed, in particular with the use of modern information and geoinformation technologies.

In particular, these are in some way organized (methodically substantiated) GNSS-survey. This approach is new and has not yet been used to address the monitoring of riverbeds and floodplains. GIS technologies and other tools are now also widely used to process the analysis and presentation of research data.

To determine the object of study, it is important to perform a preliminary analysis of scientific publications, information about the state of rivers in the region. It is also necessary to assess, analyze the possibilities and features of the organization of observations, the availability of all necessary materials (Demchyk, Pasichnyk, et al., 2021).

In formulating the purpose of the study, it is necessary to take into account both methodological and pragmatic, socially significant aspects. Its main tasks include:

- the overview of scientific publications, as well as documents relevant to solving the problem;
- to analyze the available information on river incisions;
- to analyze the factors of river incisions and identify their effects;
- to describe the main consequences of the incision and assess the current state of the young river landscape by hydro-morphological indicators;
- to show the place of the problem of river incision in the planning of sustainable development of the river landscape, integrated river basin management and give recommendations on measures aimed at achieving a good status and ecological potential of the landscape.

## Characteristics of the research methodology

Determination and fixation of the territorial structure of river-valley geosystems is carried out using a three-level taxonomic system: homogeneous areas of the river valley (HARV) – homogeneous areas of the

valley bottom (HAVB) – homogeneous areas of the riverbed and floodplain (HARF).

The study of river valleys and their landscapes is an important area in geomorphology, hydromorphology, and landscape science. Any sufficiently large valley crosses or bypasses certain tectonic, geological, geomorphological structures and responds to them. This affects formation of the sequence of HARV. Valleys can be millions of years old. During this period, complex tectonic and geomorphological processes occur. Therefore, HARV bear the "imprint" of the whole spectrum of processes with the greatest manifestation of the main, most powerful. The bottoms of valleys develop mainly over tens and hundreds of thousands of years. The action of relevant factors is reflected on their structure, formation of a sequence of HAVB. But they act mainly in terms of HARV. Therefore, HAVB are embedded in them, forming a more detailed structure.

1. Accordingly, we consider HARF and on their basis – YRL. River floodplains are generally considered to be the product of river development during the Holocene (Huhmann, Brückner, 2002; Huhmann, Kremenetski, Hiller, & Brückner, 2004; Yushchenko, et al., 2017; Cabinet of Ministers of Ukraine, 2018).

For our region it is approximately 10-12 thousand years. The oldest formation is the first floodplain terrace. The boundary between them can be expressed more or less clearly. The history of their development is quite complex. The floodplain itself may consist of structures of different ages and may even contain the remains of the first or second terrace. The floodplain may have a different basis and may not manifest itself at all. Nevertheless, along each river there is a channel and floodplain development zone (if it is expressed), which are a sequence of HARF and subtly respond to local development conditions within the HAVB.

The very concept of HARF comes from the concept of morphologically homogeneous sections of riverbeds, which is often used in studies of riverbed development. Its content is the homogeneity of local geomorphological factors of channel formation, to which the river FCS naturally responds.

The task of applying the hierarchy of territorial formations (hydromorphological landscapes) HARV - HAVB - HARF is to identify and map the relevant boundaries. As we have noted, in different conditions, these boundaries are expressed with varying degrees of clarity. They can be blurred, with transition zones. However, in this problem, as well as in

landscape science, and even more so in landscape planning, mapping "allocations" is a necessary task. It can be done in different ways. Here we will focus on our specific object – part of the Prut River valley (which is quite typical for the region) and our specific task – mapping HARF (YRL) and identifying, revealing the patterns of their development. The geohydromorphological approach (analysis and synthesis) is used for this purpose (Yushchenko, 2005; Yushchenko, Kyrylyuk, et al., 2012; Yushchenko, Gonchar, et al., 2017). Methods of analysis of cartographic material, space photographs, archival materials, hydrological observation data etc., are also used. GIS methods are used for analysis and database formation.

In the conditions of Precarpathians, the bottom of river valleys contains the channel, floodplain, first and second floodplain terraces. The third terrace is distributed in fragments and is considered to be a transition to the sloping terraces of the Middle Ages. Its relative height is estimated at 15-25 m. In this regard, the allocation of the lateral boundary of the valley bottom takes into account either a relatively clear transition to the side (slope), or, as a guide, the relative height of 15 m. Additional information are features, relief details and hydrographic network. Topographic maps of a scale range from 1: 100,000 to 1: 25,000 of different years of publication, as well as space photographs are used for such analysis. After establishing the lateral boundaries, the approximate boundaries of the HAVB are set, which, in fact, leads to their actual selection and mapping. By this the hierarchical subordination of HARV is taken into account, i.e., analysis and synthesis are carried out taking into account the boundaries of the latter. The main ways of allocating HAVB are: 1) taking into account their configuration and orientation; 2) analysis of the relief and hydrography of the bottom of the valley; 3) taking into account the peculiarities of the location of the riverbed within the bottom; the nature of asymmetry; 4) taking into account the geomorphological zoning of the territory. Based on the fact that the conditions for the development of valley bottoms can be extremely diverse and complex, it is advisable to use the method of gradual approximation to identify the lateral boundaries and boundaries of the HARV. In addition, the specific methodology should take into account the type of valley and the characteristics of the region. Complex cases include sections of the channel transition from pressing to one side of the valley to pressing to another; the so-called confluence nodes, which relate to the confluence of large tributaries and the junction of valleys. It is known that rivers in their long-term development respond subtly to tectonic movements, distributed

according to the tectonic structure, the structure of the earth's crust. Therefore, the configuration, orientation, asymmetry and connection of the bottoms of the valleys together with their relief, their hydrography are good guidelines for the allocation of HAVB.

A similar technique is used to identify HARF, which are "embedded" in HAVB. The difference is that the main role is played by the actual geohydromorphological channel analysis and synthesis. It refers not only to the channel, but also to the floodplain, as it is known that formation of the floodplain is based on certain types of channel process (Chernov, 2009; Kondratev, Popov & Snishchenko, 1982). In particular, it is important to analyze the so-called long-term channel formation (LTChF). It is understood as detection on the basis of cartographic, aerospace and other information, as well as field research of the bottom of the valley, where for the last many decades or hundreds of years could have migrated the channel. (These periods of time are associated with the predominant rate of development of the main channel forms and lateral migrations of the channel).

The application of modern GIS technologies plays an important role in the methodology of selection, mapping, creation of a database on HARV, HAVB and HARF (YRL). In particular, in order to compare different time maps, it is necessary to perform their geographical reference, i.e., to bring them in line with a modern system of coordinates. Accordingly, it is advisable to start the binding and analysis of data from modern space imagery, remote sensing database of the Earth (remote sensing). To implement this task, there is a variety of GIS products, but experience shows that along with them it is advisable to apply the GNSS method involving sustainable local landmarks (planned field training points). It is also advisable to use the method of gradual approximation, at least in two stages, for the selection of HARF. At the first stage it is necessary to use survey topographic maps and space pictures of average spatial resolution (concerning size of a site of the river) space pictures; approximate boundaries and boundaries of HARF are carried out; LTChF is allocated; expert channel analysis is carried out. The second one uses medium-scale topographic maps and high-resolution space imagery, analyzes their content in more detail, and conducts the necessary field research to clarify data on HARF. In addition, there are different tasks. One type of task is simply the selection of HARF in order to account for them, approximate mapping, the primary general characteristics. Another type of task is detailed research on specific HARF (YRL). These tasks are close and largely coincide with the

study of floodplain complexes and detailed studies of the landscapes of riverbeds and floodplains.

Another important methodological and technological issue is the provision of names and / or indices of HARF (YRL), as well as HARV and HAVB. In fact, these are individual territorial formations, units. Therefore, individual names are appropriate for them. Names are given by local landmarks, toponyms. Where there are settlements, first of all their names are used. For small areas it can be one settlement or its part. For big – two. You can also add some site characteristics. The analysis of territorial units is somewhat similar to the analysis and accounting of area. In our opinion, YRLs are so important that they deserve to maintain an appropriate cadaster, which will be organically combined with the land and will be useful for local communities. Special approaches are used to maintain such a cadaster.

Field research is an important component of HARF (YRL) research. As already mentioned, appropriate groups of methods are used for their organization and implementation, in particular GNSS-survey. We will only note that protocols of field research are developed that are needed to be followed carefully.

The use of current research methods and technologies, work with information should be combined with traditional methods related to the processing of hydrological observations. It is also advisable to combine the approaches described above with the method of hydromorphological monitoring. As a result, we obtain a comprehensive database of the state and dynamics of the morphology of the young river landscape of the modern flow-channel-floodplain system (Shankaraiah, 2017).

For the complex solution of questions of a hydrological direction it is necessary to process considerable volumes of initial (first of all statistical) information. In many cases, its use is repeated: in the study of changes in the riverbed, the development of shore protection measures and forecasts for the development of river basins, in conducting comparative, in particular retrospective analysis, and so on (Zyhar, Savchyn, et al., 2021). An important condition for improving the efficiency of development is the widespread use of computer technology and automatic devices. The introduction of new technologies aims, first of all, to reduce the time of work, especially when there is a need to develop several options for the development of processes and phenomena in the region, provides new perspectives for wider and better use of geographic information systems (GIS) in hydrological practice (Bearman, Jones, André, et al., 2017).

The modern development of geographic information mapping as one of the components of GIS systems is represented by a wide variety of software. The GIS software products used in hydrology are quite diverse, but almost all of them, to some extent, give the user a tool to create and maintain digital maps, integrating information from different sources. In addition, the extensive use of literature and statistical sources requires the use of other software products that allow to process the existing primary and obtained results. Therefore, to conduct applied research at any territorial level, the following set of software products should be used, which include not only GIS tools, but also related software products, namely:

1. Office software that allows digitization and systematization of primary cartographic (ABBYY FineReader 12) and statistical (MS Office 2016, Statistica v 8.0) materials. Thus, compilation of an electronic map of each hydrological unit involves collection and scanning of the raster basis (topographic and thematic maps and plans; water use projects, projects of on-farm land management, soil survey materials; steepness of slopes, horizontals of a relief, general plans of settlements, basic and cadastral plans, town-planning substantiation and other town-planning documentation).

2. Raster image processing and editing packages. Extensive use of graphic editors (CorelDraw Graphics Suite X6, Adobe Photoshop CS5) makes it possible to form primary data banks, which are the basis for the development of the cartographic basis of the study area.

3. The use of tool GIS packages (ArcGIS v. 10.5 and MapInfo 12) involves downloading a bitmap image as a basis for vectorization and its geographic reference. Thus, the scanned material is uploaded into ArcGIS and the reference points are added using the spatial reference panel, specifying their coordinates. When linking an image, a Gauss-Krueger projection is chosen, a transverse-cylindrical equiangular cartographic projection that allows large areas of the earth's surface to be depicted without significant distortion. Pulkovo-1942 (SK-42) based on the Krasovskyi ellipsoid can act as a coordinate system (Simões, 2013).

Further work involves creation of a basic map, by sequentially creating layers of relevant elements of the terrain. At this stage, the created layers are alternately uploaded into ArcMap, where the raster image is vectorized using the editing panel. Thus, the key layers are the boundaries of oblasts, rayons, territorial communities and settlements, together with the road network formed the basis of the Basic Map, which is the basis for the application of applied hydrological information.

Using GIS only to compose vector cartographic images is impractical, so with the simultaneous creation of layers, vector objects are assigned attributive information. It is the integration of attributive data in GIS and the creation of cartographic data banks that increases the potential of natural sciences, which further makes it possible to supplement and expand existing spatially coordinated data and significantly increase the level of analytics in assessing natural economic indicators (Khatami & Khazaei, 2014).

Using a set of web-mapping tools Google Maps and SASPlanet together with space images of Landsat series satellites gives the opportunity to form a complete picture of quantitative indicators, first of all, to clarify the current boundaries and positions of natural-geographical and socio-economic mapping objects. In addition, the unlimited possibilities of overlay analysis and a wide range of visualization of the obtained results provides the leading places of GIS-tools in applied hydrological research.

**Example of presentation and analysis of research results**

The Prut River incision was analyzed using primary qualitative and quantitative information, including hydrological observations and GNSS surveys. The observation point on the Prut River is located in Chernivtsi. Analysis of changes in the cross sections of the river showed that in the 70s and 80s the riverbed narrowed from 200 to 120 meters. The narrowing was due to the increase of the left, less stable and lowered bank. It began to be intensively deposited by sediments.

Later, due to the concentrated flow of major floods, including the 2008 floods, the riverbed widened slightly, to about 140 meters. The main incision of the riverbed appeared in the period 1970-2000. The average rate of incision was up to 100 mm / year. Later, the rate dropped to 50-30 mm / year, probably due to the achievement of poorly eroding rocks. The total size of the incision for the period from 1970 to 2017 is more than 3.5 m. Thus it became highly bed-rock. This indicates a double mechanism of morphological changes in the young river landscape during river incision and concentration (and direction) of river flow.

In order to obtain a sufficiently accurate amount of information about the altitude position of the Prut riverbed and floodplain in 2019-2020, we conducted GNSS surveys. Their results showed an uneven distribution of the total value of the incision along the river flow.

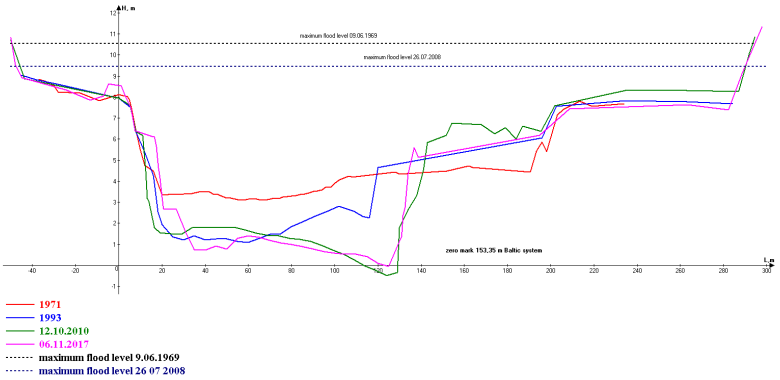



**Fig. 1.** *Transverse profiles on the hydraulic solution No. 7 on the river Prut- Chernivtsi for a longstanding period.*

On the Prut River, to the upper border of Chernivtsi, near the Lenkivtsi microdistrict, the size of the incision is relatively moderate (in this place it was 2.6 m).

It should be also noted that in this site bottom thresholds are also expressed. Actually, in Chernivtsi, in the area of hydrological observations, the data of GNSS surveys coincided with the data obtained from the cross sections of the river. Here, the total incision of the Prut was about 3.5 meters. Downstream of the city of Chernivtsi to Tsuren village it has increased again – to 4.4 m. At this site, significant work on the selection of channel alluvium and "regulation of the channel" is currently being carried out. Even further downstream, the Prut River flows within the Novoselytsia Basin. Here the channel meanders, forms islands, the floodplain is wide. The thickness of the alluvial strata below them is significantly increasing. Access to the channel is difficult and there are mining works.

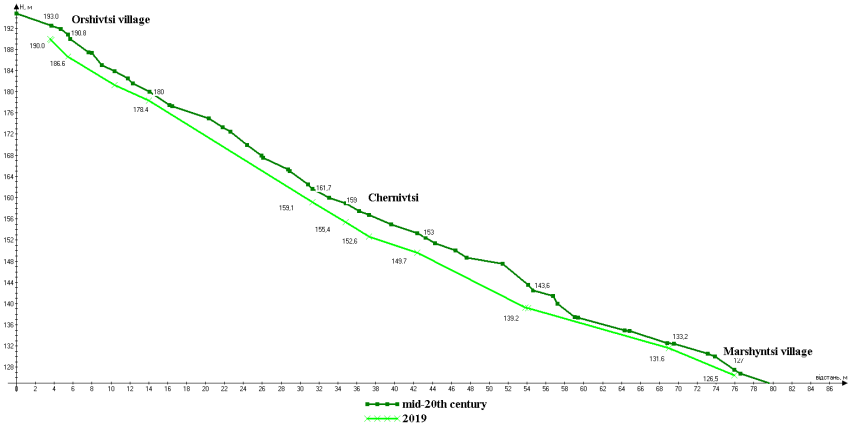



**Fig. 2.** *Combined longitudinal profile of the Prut River on the section of the flow from Orshivtsi village to Marshyntsi village*

We also conducted our own study of changes in the absolute heights of the Prut River along the channel within Chernivtsi oblast. The study involved the determination of modern absolute heights using GNSS-surveying and comparison with the heights indicated (at the appropriate points) on a topographic map at a scale of 1: 25,000 in the middle of the twentieth century. The position of the points was identified through a system of determining the corresponding coordinates, using the method of triangulation and the rate of incision. The results of the study are presented in Fig. 2.

## Conclusions

Thus, this article highlights the methodological issues of analysis of changes in the altitude of riverbeds and floodplains and geoecological problems of transformation of the young river landscape on the examples of rivers in the Precarpathian region using modern geoinformation technologies. The urgency of the scientific and applied problem is substantiated, a critical review of scientific publications is made, the material of the article gives grounds to conclude that the goals and objectives of the research have been achieved. Of particular value is the information on postmodern geoinformation technologies for determining the height of riverbeds and floodplains, as new technologies, methods and perspectives of

this problem are emerging that will help to effectively study the issue of determining the height of riverbeds and floodplains.

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Yuriy Yushchenko gave a critical review of the existing publications on the research problem, and proved that foreign researchers and scientists were involved in the study of determining the heights of riverbeds and floodplains in postmodern education and presented a description of their research. Dealt with important methodological and technological issues providing names and / or indices HARF (YRL), as well as HARV and HAVB - individual territorial entities, units.

Mykola Pasichnyk presented in the article methodological aspects of the main components of the hydrometeorologists student's research work using contemporary geoinformation technologies and gave examples of presenting its results. Participated in the study of changes in the absolute heights of the Prut riverbed along the flow within Chernivtsi Region.

Kostiantyn Darchuk presented in the article methodological aspects application of modern research methods and technologies work with geoinformation technologies and performance of geographic information mapping

Ivan Kostashchuk reviewed in the article the use of project methods and methods of STEM-education in the training of specialists in geography, hydrometeorology, land surveyor at the Faculty of Geography of Yuri Fedkovych Chernivtsi National University.

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