

12. *Khilchevskiy V. K., Zabokrytska M. R.* Osnovni aspekty morfometrii ta hidrokhimii Shatskykh ozer [Basic aspects of morphometry and hydrochemistry of Shatsk lakes]. *Hidrolohiiia, hidrokhimiiia i hidroekolohiiia*. 2020. № 3(58). P. 92–100.

13. *Chunarov O. A.* Porivnialne otsiniuvannia vnutrishnorichnoho rozpodilu stoku vody richok Rosi ta Uborti [Comparative assessment of intra-annual distribution of water runoff of the Ros and Ubort rivers]. *Hidrolohiiia, hidrokhimiiia i hidroekolohiiia*. 2020. № 3(58). P. 72–80.

14. *Khilchevskiy V. K., Netrobchuk, I. M., Sherstyuk N. P., Zabokrytska M. R.* Environmental assessment of the quality of surface waters in the upper reaches of the Pripyat basin in Ukraine using different methods. *Journal of Geology, Geography and Geoecology*. 2022. 31(1). P. 71-80.

15. *Rokochinskiy A., Shevchenko O., Volk P., Turchenyuk V., Koptjuk R., Volk L.* Hydrogeological action of drainage and drainage systems of Polissia zone in changing climatic conditions. *Visnyk Kyivskoho natsionalnoho universytetu imeni Tarasa Shevchenka. Heolohiiia*. 2020. № 4 (91). P. 74–84.

Assessment of water resource potential and water use dynamics in the pripyat river basin under low water conditions

Pryhornytska O.S., Khilchevskiy V.K.

The article presents a comprehensive study of the current state and management of water resources in the Prypiat River sub-basin, which is a strategic transboundary region for Ukraine. The research methodology is based on the analysis of long-term hydrological data, assessment of groundwater potential, and water management balance calculations. Using the method of difference integral curves of runoff for key monitoring posts (Prypiat–Richytsia, Styr–Shchurovychi, Sluch–Hromada, Uzh–Korosten), the cyclical nature of water content fluctuations over the last 50 years was analyzed. It was identified that since the early 21st century (specifically from 2002), the region has entered a stable and prolonged low-water phase caused by regional climate changes (temperature rise, uneven precipitation). This natural factor is defined as a critical constraint for future water management planning.

The study characterizes the hydrogeological conditions of the sub-basin, highlighting the significant potential of groundwater resources (prognostic resources are estimated at 7200 thousand m³/day). Special attention is paid to the Upper Cretaceous aquifer, which serves as the main source of drinking water for large cities (Lutsk, Rivne) due to its high natural protection from surface pollution. The current level of groundwater development remains low (2.7–9.6%), indicating a significant strategic reserve.

The dynamics and structure of water use in the sub-basin for the period 2019–2023 were analyzed. Sectoral disparities were revealed: the industrial sector (energy) dominates in water withdrawal (41.8%), predominantly using surface water for cooling processes. At the same time, the housing and communal services sector (30.5% of withdrawal) is the main source of anthropogenic load, generating about 97% of polluted wastewater discharges into surface water bodies due to the worn-out state of treatment facilities. The analysis of forecast scenarios for water withdrawal up to 2030, defined in the approved Dnipro River Basin Management Plan, indicates a likely increase in water consumption to 273.4 million m³ under the realistic scenario of post-war recovery. The study substantiates the necessity of adapting the water management complex to low-water conditions through the modernization of treatment infrastructure and the priority use of protected groundwater reserves for drinking water supply.

Key words: Prypiat sub-basin; water resources; runoff cyclicity; low water; groundwater; water use; river basin management; RBMP.

Надійшла до редколегії 12.12.2025

DOI: <https://doi.org/10.17721/2306-5680.2025.4.2>

UDC 528.8:556.53(477.85)

Pasichnyk Mykola, Hryhoriichuk Vitalii

Yuriy Fedkovych Chernivtsi National University

HIGH-RESOLUTION DIGITAL HYDROGRAPHIC MODEL OF A SMALL AGRICULTURAL CATCHMENT: AN OPEN-SOURCE GIS INVENTORY FOR THE SOVYTSIA KITSMANSKA RIVER BASIN (UKRAINE)

The article presents a reproducible GIS-based approach for producing high-resolution digital hydrography for a small lowland catchment subject to substantial agricultural transformation, demonstrated for the Sovytsia Kitsmanska River basin (Ukraine) within the Prut River catchment. The objective was to obtain a consistent vector stream network and derived morphometric metrics suitable for subsequent hydrological and hydromorphological assessments. Copernicus DEM (30 m) was used as the primary elevation dataset and processed in SAGA GIS 9.8 (Terrain Analysis – Hydrology) to derive Flow Accumulation, generate an initial stream network, and refine catchment boundaries (Watershed Basins). Subsequent desktop verification and editing were performed in QGIS 3.34.10 using Sentinel-2 L2A imagery (True Color) and online basemaps (including OpenStreetMap and Visicom) as independent sources for spatial cross-checking. To ensure methodological consistency, a conservative classification rule for temporary streams

ISSN:2306-5680 **Hydrology, Hydrochemistry and Hydroecology. 2025. № 4 (78)**

was applied and a working definition of a temporary watercourse was adopted as a non-perennial channel with seasonal or episodic flow discontinuity, consistent with contemporary terminology (intermittent/ephemeral). All network elements were organized into unified vector layers: perennial streams (*hydro_in_streams_perennial*), temporary streams (*hydro_in_streams_temporary*), and a technical layer representing the channel axis through ponds (*hydro_in_perennial_axis_ponds*), which ensured topological connectivity and unbiased length accounting. According to QGIS measurements, the basin area is approximately 271.40 km²; the total length of perennial streams is 137.274 km, temporary streams 45.338 km, and the additionally accounted channel axes within ponds 62.571 km. Consequently, drainage density is about 0.90 km/km² when pond axes are included and about 0.67 km/km² under a conventional approach that ignores pond-covered channel segments. The contribution of network components to total length is strongly uneven: perennial streams account for about 56.0%, temporary streams for 18.5%, and impounded channel segments represented by axes for 25.5%, which substantially affects the interpretation of morphometric indicators in catchments with numerous regulated reaches. The resulting hydrographic geodatabase provides a robust spatial baseline for further analyses of runoff organization, anthropogenic pressures, and basin-scale water-management decision support.

Key words: high-resolution hydrography; small agricultural catchment; QGIS; SAGA GIS; Copernicus DEM; Sentinel-2; drainage density.

Introduction. Modern hydrology and water management in Ukraine are increasingly shifting their focus toward small river basins, since these basins largely determine the quality and sustainability of local runoff, the water security of communities, and the ecological condition of agricultural landscapes. In the context of implementing the approaches of the EU Water Framework Directive, ongoing climate variability, and the rising frequency of hydrometeorological extremes, such basins prove to be the most sensitive to anthropogenic pressures, including intensive ploughing, transformation of hillslopes and valley bottoms, activation of erosion processes, and the impact of ponds and small dams that alter the natural runoff structure. Under these conditions, substantiated management cannot rely solely on descriptive characteristics or generalized maps; instead, it requires an up-to-date digital geoinformation basis capable of reproducing the actual configuration of relief, the river network, the pond complex, and elements of the drainage/melioration system, and of supporting reliable quantitative calculations of morphometric and hydrological parameters.

The Sovytsia Kitsmanska River basin is a representative example of a small left-bank tributary of the Prut River within the forest-steppe part of Chernivtsi Oblast, where low forest cover, a high share of agricultural land use, a well-developed gully–ravine network, and densely distributed ponds combine to substantially transform the water regime [5, 8, 11, 19, 20]. The catchment is located in the forest-steppe zone of Chernivtsi Oblast and lies within the present-day Chernivtsi District (formerly the Kitsman and Zastavna Districts). The length of the main channel is 39.4 km, while the largest tributary, the Sovytsia Zastavniivska, is 15.3 km long; the area of the Sovytsia basin is 267 km², and the Sovytsia Zastavniivska catchment covers 61.8 km². The source of the Sovytsia is associated with the outskirts of the Sheptany railway station (≈300 m in the Baltic Height System), whereas the headwater reach of the Sovytsia Zastavniivska forms near the village of Verbivtsi (≈290 m BHS). The basin's river network is highly branched: in addition to the main channel, one tributary longer than 10 km is distinguished (the Sovytsia Zastavniivska), together with another 17 small watercourses up to 10 km long; the drainage density of the basin equals 0.94 km/km² and reflects the substantial role of small streams in dissecting the territory. The total fall of the Sovytsia from its source to its mouth reaches 136.3 m, and the weighted mean channel slope of the main river is 2.69 m/km, which overall characterizes it as a small lowland tributary with moderate gradients and locally steeper segments determined by valley morphology and lithology. The basin is characterized by low forest cover (6.9%) and high ploughing intensity (63.3%), which results in the predominance of agriculturally transformed landscapes and the concentration of anthropogenic impacts within valleys and floodplain terraces; another important feature is the presence of a considerable number of channel ponds and small water bodies that redistribute runoff throughout the year and modify the natural hydrological regime, which should be taken into account in further assessments of the status and functioning of the river system [5].

According to the “Management Plan for the Pilot Prut River Basin” (Fig. 1) [19], 7 heavily modified water bodies/surface-water bodies have been identified within the Prut River basin, which is about 6% of the basin. These include, in particular, the Sovytsia Kitsmanska River, which is characterized by a high degree of flow regulation by dikes and fish-farming ponds.

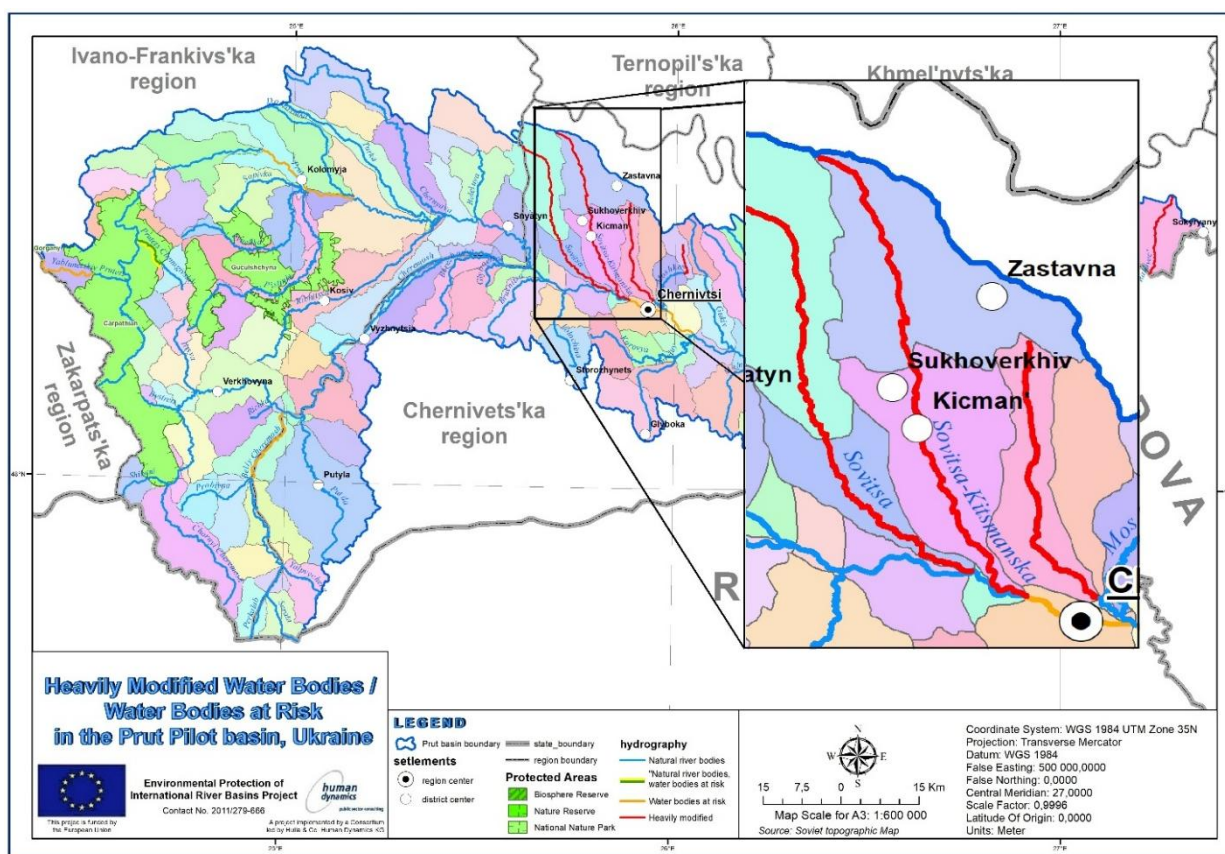


Fig. 1. Heavily Modified Surface Water Bodies / Surface Water Bodies at Risk in the Prut Pilot Basin, Ukraine [19]

In the Danube River Basin Management Plan for 2025–2030 (Prut and Siret sub-basins) [10], which concerns the water-management complex of the oblast, work in the Sovytsia Kitsmanska River basin is directly aligned with regional priorities recorded in the official program document of the Chernivtsi Oblast Council. In particular, the following should be noted as the program framework: the “Comprehensive Program for the Development of Water Management and Flood Protection in Chernivtsi Oblast for the period up to 2021”, approved by Decision of the XXVI session of the Chernivtsi Oblast Council of the VI convocation dated 11.06.2014, No. 61-26/14. Within this program, among the environmental actions, a separate direction is envisaged that directly corresponds to the subject of our study and the practical needs of water management at the local level, namely: “Measures for the revival of small rivers. Sovytsia Kitsmanska River of the Kitsman District of Chernivtsi Oblast”. The inclusion of the Sovytsia Kitsmanska in the list of such measures means that the river basin is considered a problematic yet promising area for restoration, where systematic actions are required to improve ecological status, increase the water-protection efficiency of land use, and reduce risks associated with runoff transformation. Therefore, the creation of an up-to-date digital hydrographic baseline for the basin, refinement of the structure of watercourses and the pond complex, and calculation of derived indicators (lengths, network density, river-network connectivity) can be presented not only as a scientific result, but also as information support for implementing the specified environmental measure and for preparing well-grounded management decisions for territorial communities and water-management organizations [10].

The available cartographic materials, produced mostly several decades ago [5], do not reflect current changes in the channel network and the drainage/land-reclamation (melioration) network, the system of artificial water bodies, and land-use structure. At the same time, the availability of open digital elevation models (Copernicus DEM) [3,4], high-resolution satellite data (Sentinel-2) [12,13], and modern desktop GIS (QGIS 3.34.10, SAGA GIS) [14,15,21] makes it possible to carry out detailed digital mapping of the basin and to increase the reliability of subsequent hydrological assessments.

The relevance of this work is determined by the need to create a modern digital map of the Sovytsia Kitsmanska basin that integrates morphometric, hydrographic, and hydrological information into a single, reproducible geoinformation structure and can be used as a baseline material for analyzing hydromorphological status, assessing the impact of in-channel ponds on runoff, and supporting decisions of local self-government bodies and water-management organizations. The aim of the qualification work is to build a detailed digital model of the Sovytsia Kitsmanska River basin based on the combination of Copernicus DEM, Sentinel-2 imagery, open cartographic services (in particular OpenStreetMap and Visicom), and hydrological-analysis tools in the SAGA GIS and QGIS environments [12,13,14,17], as well as to provide a generalized analysis of natural conditions and factors of runoff formation within the catchment. The object of the study is the Sovytsia Kitsmanska basin as a natural-territorial system, and the subject is the structure of its river network, the pond complex, and key hydrological characteristics reproduced by means of digital modeling.

To achieve the aim, the work included preparation of spatial data (DEM, satellite materials and online maps, vector layers), DEM-oriented modeling in SAGA GIS, and the development of a structured database of vector layers of watercourses (with separation of perennial and temporary streams), ponds, and basin boundaries in QGIS, followed by morphometric and geostatistical calculations of derived indicators (primarily the lengths of the hydrographic network and parameters derived from them). The methodological basis consists of a literature-descriptive approach, GIS-based cartographic modeling, and quantitative morphometric calculations, which together ensure the production of an up-to-date and verifiable geoinformation baseline for further studies of small basins in the region.

Methodology and data. Hydrological modelling of small river basins, including the Sovytsia Kitsmanska, is most appropriately organized as a sequential workflow implemented in two desktop geographic information systems, QGIS 3.34.10 and SAGA GIS. These platforms complement each other in a functionally coherent way: QGIS provides a convenient environment for data management, connection of web-based cartographic services, visualization of intermediate and final outputs, and “manual refinement” of the final hydrographic framework, whereas SAGA GIS performs the core computation based on a digital elevation model, offering a full suite of hydrological algorithms. For a relatively small yet strongly anthropogenically transformed basin such as the Sovytsia Kitsmanska, this combination makes it possible not only to model runoff mathematically, but also to adjust the derived digital river network so that it matches the actual on-the-ground pattern as closely as possible.

Within this workflow, the role of QGIS 3.34.10 consists primarily in working with background and reference datasets and in producing the final vector layer of the hydrographic network. In QGIS, all key resources used for interpretation and refinement of basin structure were connected, including Google satellite basemaps via XYZ tiles (lyrs=s), the OpenStreetMap basemap, detailed Visicom Maps layers, Sentinel-2 L2A imagery (True Color) for 26 October 2025, and the Copernicus DEM with a 30 m spatial resolution that had been pre-processed in SAGA GIS (Fig. 2) [2, 7]. This environment enabled spatial comparison of DEM-based modelling results with real-world land-surface features such as field boundaries, roads, drainage (melioration) channels, ponds, shelterbelts, and built-up areas. By overlaying hydrological rasters produced in SAGA GIS onto satellite imagery and vector layers in QGIS, the final hydrographic network was edited and harmonized: the position of the Sovytsia Kitsmanska channel, catchment boundaries, small tributaries, water-diversion channels, as well as the locations of headwaters and confluence points were refined.

Processing of the Copernicus DEM (30 m) was carried out directly in SAGA GIS using specialized modules of the Terrain Analysis – Hydrology toolset [12, 14].

Within the study, for a catchment characterized by drainage (melioration) systems, a DEM was prepared by applying an appropriate depression-filling procedure (Fill Sinks) [12] in order to distinguish real closed depressions (ponds, quarries, water-filled pits) from DEM artefacts and thus avoid distortions in subsequent runoff modelling. Next, on the basis of flow directions determined with the D8 algorithm (Flow Direction), a flow accumulation surface was computed (Flow Accumulation; Fig. 3). The values of this raster are interpreted as the contributing catchment area “feeding” each grid cell, and it was precisely this surface that was used to set a threshold for extracting a linear drainage network and for distinguishing between perennial and temporary

channels. At the following stage, the Channel Network and Drainage Basins module was used to automatically generate a synthetic channel network together with its hierarchy (stream orders) and the boundaries of drainage sub-basins, resulting in vector layers of river polylines and catchment polygons. These outputs were then transferred to QGIS and refined through visual cross-checking against Google imagery, OpenStreetMap, and Visicom datasets. In this way, SAGA GIS provided the computational core of DEM-oriented hydrological modelling (from terrain preprocessing to automated river-network extraction and related analytical procedures), while integration with QGIS and multi-source basemaps converted these results into a validated, interpretable digital model of the Sovytsia Kitsmanska catchment.

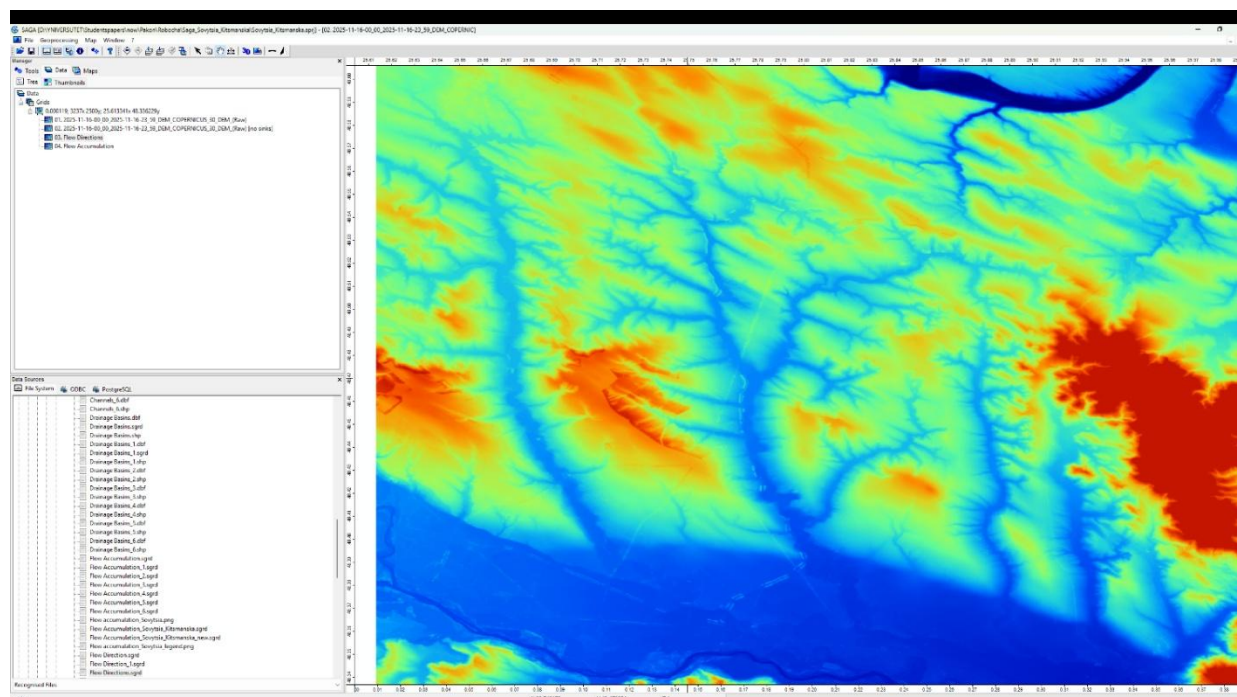


Fig. 2. Digital surface model of the Sovytsia Kitsmanska River basin generated from the Copernicus DEM (30 m) dataset.

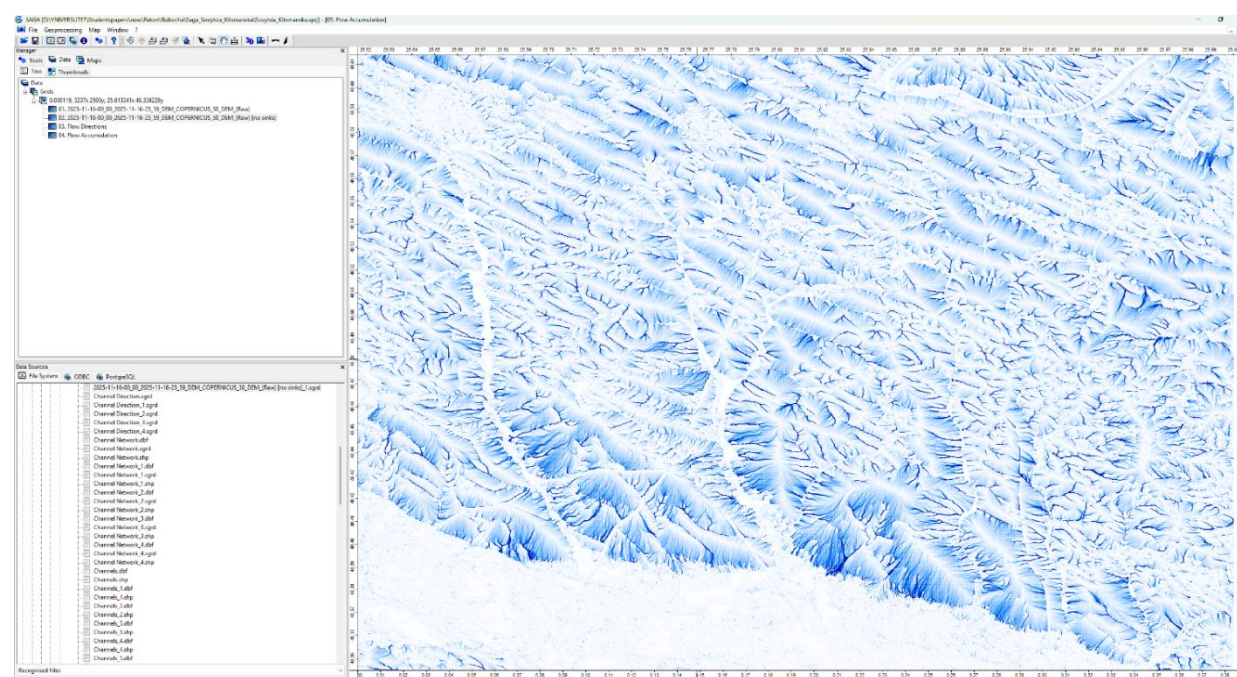


Fig. 3. Spatial pattern of flow accumulation (contributing area) in the Sovytsia Kitsmanska catchment based on the Copernicus DEM (30 m).

The development of a digital map of the Sovytsia Kitsmanska River basin is based on a harmonized system of spatial datasets of different nature and origin, integrated within a single QGIS 3.34.10 project and complemented by hydrological analysis in SAGA GIS. The input layers can be conditionally divided into four main groups: a digital elevation model, satellite imagery, online cartographic basemaps, and vector layers describing the administrative and hydrographic structure of the territory. Taken together, these datasets provide a comprehensive information framework for catchment modelling, river-network extraction, and the subsequent cartographic representation of results.

The key elevation source is the Copernicus DEM (<https://browser.dataspace.copernicus.eu>) with a spatial resolution of 30 m, built on the basis of a combination of several global DEMs using WorldDEM™ as the reference layer. The DEM was downloaded in GeoTIFF format, reprojected into a unified coordinate system consistent with the other layers, and clipped to the boundaries of the study catchment.

To characterize the current state of river systems, land use, floodplains, ponds, and waterlogged areas, Sentinel-2 L2A satellite imagery (True Color) for the interval 26.10.2025 (00:00–23:59) was used, obtained from the Copernicus platform [13].

Online cartographic services connected to QGIS 3.34.10 via the XYZ tiles mechanism play an important role in building the digital map. Google satellite basemap in the `lyrs=s` mode was loaded via the URL <https://mt1.google.com/vt/lyrs=s&x={x}&y={y}&z={z}> [11]. These images clearly show field boundaries, shelterbelts, gullies, channels, cascades of ponds, and built-up areas, which allowed Google imagery to be used as an operational tool for validating modelling outputs: simulated channels, watersheds, and runoff-concentration zones were compared with the real patterns visible in satellite images [13, 16, 17].

The OpenStreetMap basemap was connected as an XYZ service via <https://tile.openstreetmap.org/{z}/{x}/{y}.png> and served as a vector-oriented “framework” of the territory. It displays the road network, settlement boundaries, hydrographic objects, and engineering infrastructure lines.

A detailed national source was provided by the Visicom Maps service, connected to QGIS as a separate large-scale cartographic basemap via the web interface <https://maps.visicom.ua/>. Visicom maps contain a much higher density of information on buildings, the block structure of settlements, field roads, drainage (melioration) channels, individual engineering structures, forest patches, and other small elements. For the Sovytsia Kitsmanska basin, these data proved to be crucial for refining the configuration of small watercourses, engineered drainage channels, cascades of ponds, and local watershed divides.

The structure of vector data in the project was organized in such a way as to ensure full support for hydrological analysis. Separate layers represent the boundaries of administrative units, the outline of the Sovytsia Kitsmanska basin obtained from DEM-based modelling and refined using cartographic materials, the river network with separation into the main channel and tributaries, the extents of ponds and artificial water bodies, and the boundaries of delineated drainage sub-basins. All these vector datasets are stored in GeoPackage / ESRI Shapefile format and are referenced to a single coordinate system—EPSG:3857, WGS 84 / Pseudo-Mercator [16].

Results and discussion. The development of a digital hydrographic model for the Sovytsia Kitsmanska basin consisted of two logically interconnected blocks: automated derivation of the primary river network from the DEM in SAGA GIS and subsequent creation of a structured database in QGIS 3.34.10 [16], where the lines of perennial and temporary watercourses, pond outlines, and other hydrographic elements were refined.

At the first stage, based on the Copernicus DEM, the following operations were performed in SAGA GIS: Fill Sinks, Flow Direction, Flow Accumulation, Watershed Basins, and Channel Network and Drainage Basins [5]. The outcome of this block was a synthetic “skeleton” river network in the form of a linear layer and polygon boundaries of drainage sub-basins.

The second stage involved creating a thematic hydrography database directly in QGIS [12, 13, 14, 16]. Several key vector layers were produced: the main river channel and tributaries, as well as the basin boundaries.

Before starting the refinement of the river network and the inventory of water bodies, it was fundamentally important to establish the correct catchment boundaries of the Sovytsia Kitsmanska River. The basis for delineating the boundary was provided by the results of

hydrological modelling in SAGA GIS 9.8, where a standard sequence of operations for preparing the digital surface model [12, 13, 14, 16, 17] and forming the runoff structure was performed step by step. The raster and vector layers produced in SAGA were exported to the QGIS 3.34 environment and used as a “framework” for subsequent manual refinement of the basin boundary. The key technique at this stage was the combination (overlay) of the exported Flow Accumulation and Watershed Basins layers (Fig. 4): the accumulation field clearly represents the spatial organization of runoff and makes it possible to see the “logic” of the catchment along watershed divides, while the basin layer from SAGA provides an initial automated outline that can be critically checked and refined. Next, by analyzing these layers in relation to cartographic basemaps—primarily OpenStreetMap, and additionally cross-checking the configuration against Visicom maps—the boundary was refined by adjusting it to real landscape elements (watershed ridges, relief forms, boundaries of the gully–ravine network, and anthropogenic transformations). As can be seen from Figures 4 and 5, the layers created in SAGA GIS provide sufficient detail and reproducibility to reliably refine the basin outline so that it correlates with the actual morphology of the territory and corresponds to reality, while the use of OpenStreetMap at the stage of visual verification made it possible to minimize boundary-positioning errors in problematic areas (in particular, in locations of anthropogenically altered runoff and near artificial water bodies). As a result, the delineated and refined catchment boundary of the Sovytsia Kitsmanska became the initial spatial framework for the subsequent correct refinement of the river network and water bodies in QGIS.

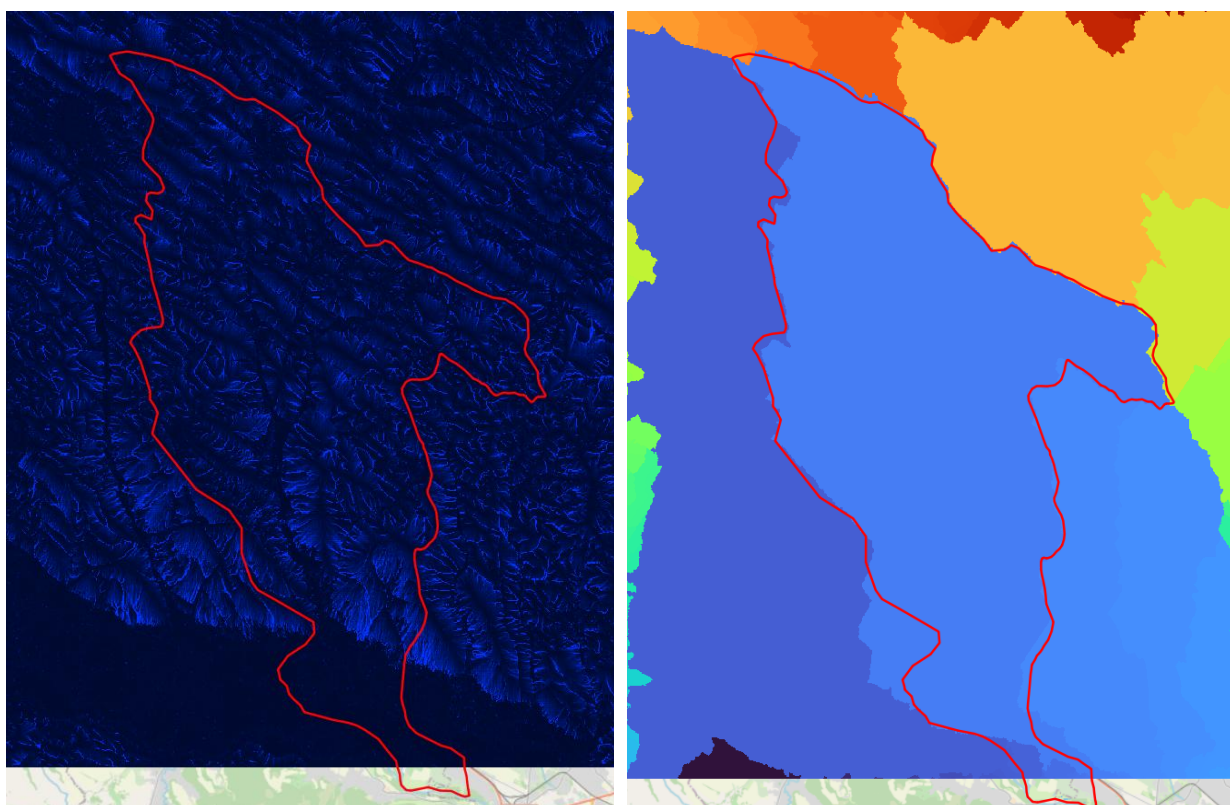


Fig. 4. From SAGA to QGIS: Flow Accumulation and Watershed Basins outputs generated in SAGA GIS 9.8 and transferred to QGIS 3.34

During the work, a key stage was the construction of a unified digital river network of the Sovytsia Kitsmanska River basin through the comparison and integration of different sources of geospatial information. For this purpose, Sentinel-2 satellite images, Google online basemaps, OpenStreetMap and Visicom, as well as the created vector layers of hydrography and administrative boundaries, were successively combined in QGIS 3.34. These layers were subsequently merged into a single GeoPackage database with the *.gpkg extension, which served as a unified container for all spatial information for the basin.

In the study, a digital elevation model (DEM) downloaded from the Copernicus Browser portal with a spatial resolution of 30 m was used as the source relief model. This DEM was adopted as the basic raster foundation for further hydrological modelling in SAGA GIS, since its level of detail is sufficient for generating derived runoff surfaces and delineating watershed lines within a small catchment. On this basis, standard operations of terrain preparation and analysis were performed in SAGA GIS (in particular, removal of local depressions and calculation of runoff characteristics), and the resulting outputs were subsequently used in QGIS during the delineation of catchment boundaries and the spatial verification of hydrographic objects.

In parallel, a set of online basemaps was connected to the project, serving as detailed background and reference material: Google satellite imagery, the OpenStreetMap basemap, and the detailed Visicom cartographic basemap. All of them were loaded into QGIS in the form of XYZ tiles services using the corresponding URL templates. The use of several independent basemaps made it possible, within one working environment, to compare the geometry of vectorized objects with real landscape references and to control their positional accuracy. In practice, this approach was used to refine the position of the channel, the shorelines of ponds and dams, and to tie hydrographic elements to road lines and settlement boundaries, which often serve as stable spatial reference markers during desktop editing.

It should be emphasized separately that, for verification and refinement of hydrographic objects, specific Sentinel-2 scenes at the L2A processing level in the True Color visualization for 26 October 2025 (Fig. 5) were used, downloaded specifically for the territory of the Sovytsia Kitsmanska River basin. The date of 26 October is also suitable for desktop interpretation of small water bodies under forest-steppe conditions: during this period, the influence of dense deciduous foliage on masking channel sections and the water surface is often reduced, and the contrast between the water surface, riparian vegetation, and exposed soils becomes more distinct, which facilitates identification of stream linearity and pond outlines.

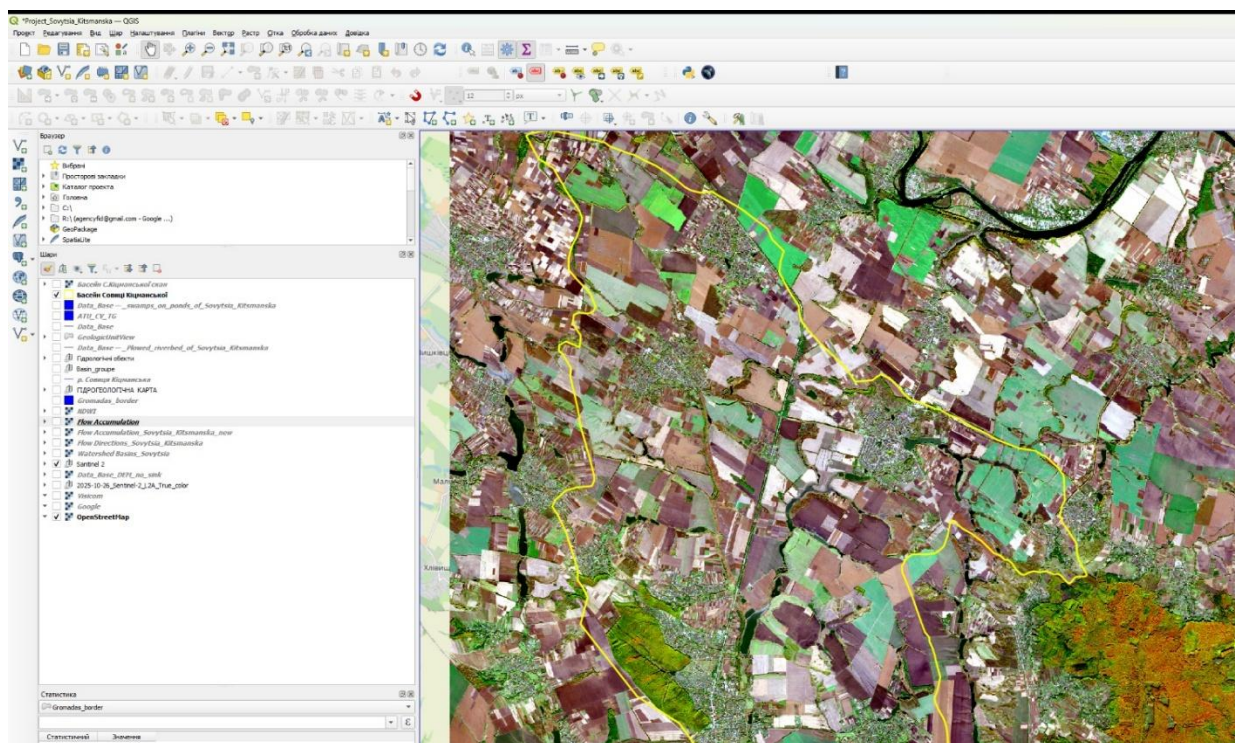


Fig. 5. Visual baseline for basin mapping: Sentinel-2 L2A (True Color) imagery covering the Sovytsia Kitsmanska catchment on 26 October 2025 (00:00–23:59)

Refinement of spatial decisions was performed through comprehensive cross-comparison: Sentinel-2 L2A (True Color) scenes were compared with high-detail Google imagery and detailed Visicom cartography, as well as with the OpenStreetMap basemap. On the basis of the assembled raster and cartographic framework, a system of vector hydrography layers was created. Initially, water objects were digitized as linear layers of the river network (the main

non-perennial and, according to the USGS glossary [18], they cover at least two practically important situations: episodic/ephemeral streams, which exhibit flow only in direct response to precipitation (“flow only in direct response to precipitation”), and intermittent streams, which may flow only during part of the year and are sustained by rainfall runoff, snowmelt, or local springs; in contrast to perennial streams, in which water is present in the channel throughout the year under normal conditions. For desktop interpretation and vectorization in a small forest-steppe catchment, this gradation is important primarily as a methodological safeguard: minor thalwegs, ditches, and gullies may be depicted differently across basemaps, and an uncritical assignment of disputed linear elements to the “perennial” network inevitably inflates the total channel length and drainage density and affects derived morphometric indicators. Therefore, we applied a conservative classification rule for delineating such watercourses in our study: if a stream/tributary on one basemap (Visicom (Fig. 7) or OpenStreetMap (Fig. 6)) was marked as temporary or was present, while on the other it was absent or not confirmed, the object was assigned to the temporary category until it was unequivocally confirmed by independent data, primarily Sentinel-2 L2A (True Color) scenes from 26.10.2025 and Google satellite imagery (Fig. 8). Where discrepancies in channel position occurred, priority was given to the configuration consistent with the visual channel features on Sentinel-2 and Google (Fig. 8), after which the geometry was corrected using QGIS editing tools.

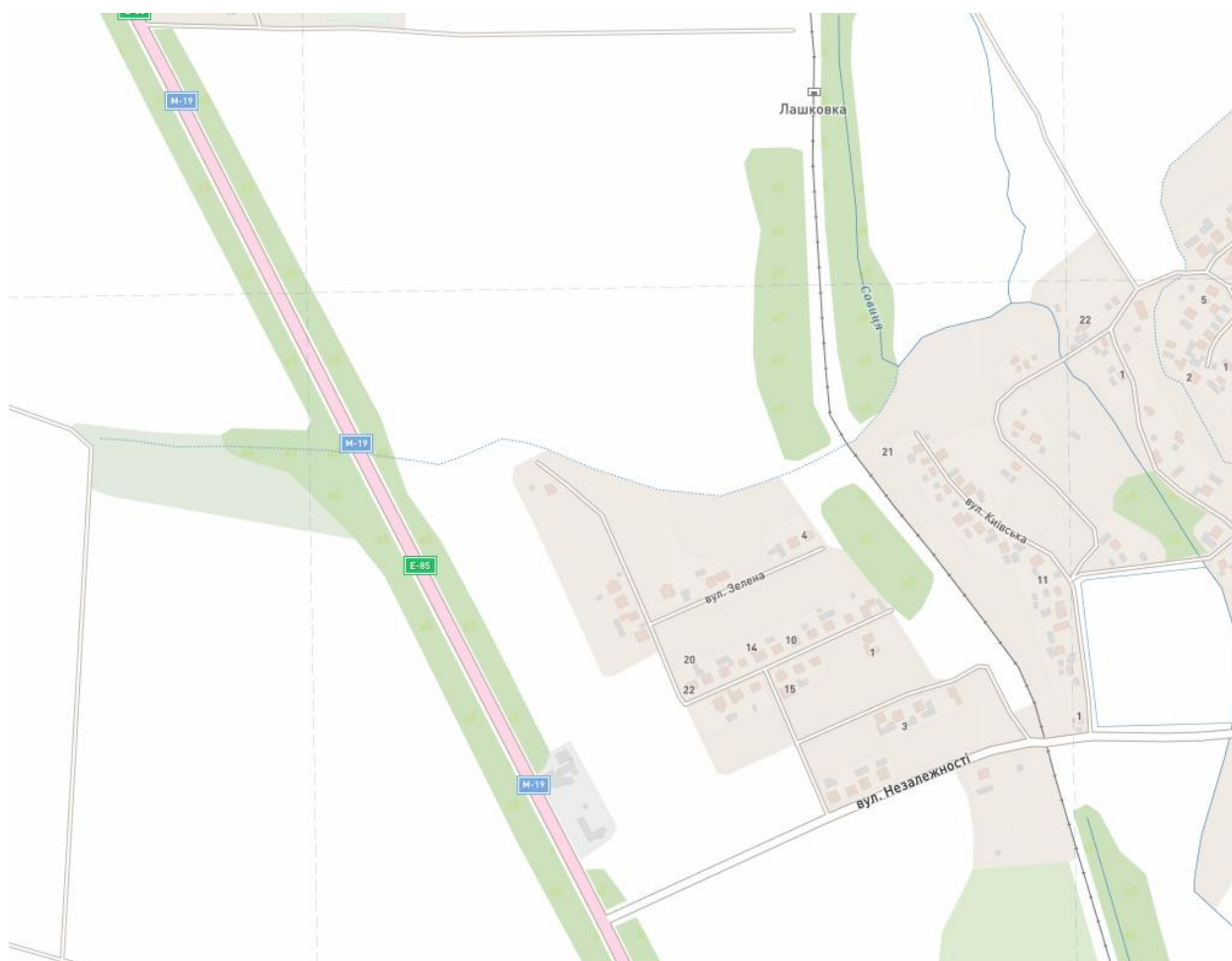


Fig. 7. Visicom map view of a Sovytsia Kitsmanska basin fragment near the village of Vytylivka

After harmonizing the vector river network, a separate task was to determine drainage density as a derived indicator (the ratio of the total length of watercourses to the basin area). To avoid systematic underestimation of channel lengths in a basin with a large number of ponds, we accounted for “hidden” channel segments beneath the water surface. If a pond is created on a watercourse, then the channel upstream and downstream of the pond is fully counted, while the segment within the pond is counted specifically as the length of the watercourse along the channel

axis (a line connecting the inflow and outflow of the stream across the water area), rather than as the pond area. If, however, a pond is off-channel (quarry pond, dugout pond, storage pond) and is not integrated into a flowing watercourse, it is not included in the channel-network length. In QGIS practice, this was implemented by preserving the topological continuity of the stream line through the pond polygon without “cutting” the channel line at the shoreline, while the pond itself was recorded as a separate polygon object for the purposes of inventorying areas and riparian zones. Collectively, these decisions allowed us to delineate the Sovytsia Kitsmanska basin river network as an integral, internally consistent system suitable for subsequent analytical calculations and interpretations.



Fig. 8. Google Maps satellite view of a Sovytsia Kitsmanska basin fragment near the village of Vytylivka

To ensure methodological reproducibility and unambiguous further calculations in the QGIS environment, all elements of the river network were organized into a system of thematic vector layers with standardized names. In particular, perennial watercourses in the project were consolidated into the line layer `hydro_In_streams_perennial`. Linear runoff elements that, based on comprehensive verification, lacked sufficient evidence of permanence or differed between data sources were assigned to the layer `hydro_In_streams_temporary` as temporary watercourses. Separately, in order to correctly account for impounded (pond-regulated) channel reaches and to preserve network topological connectivity when calculating lengths, a technical layer of the watercourse axis within ponds was created—`hydro_In_perennial_axis_ponds`—in which flowing channel segments within water bodies are represented by an axial line connecting the stream inflow and outflow points. As a result, the prepared river network became not only a cartographic product but also a correct analytical basis for calculating drainage density and interpreting the spatial organization of runoff in the Sovytsia Kitsmanska River basin (Fig. 9).

The next stage involved developing a methodology for determining the lengths of watercourses in the Sovytsia Kitsmanska River basin. In QGIS, this approach is based on the principle of metric correctness of measurements and subsequent aggregation of the results using

the program's standard statistical tools. Since the initial project was created in WGS84 (geographic coordinates in degrees), all vectorized linear objects of the river network were first transformed into a metric coordinate system in order to measure lengths correctly.

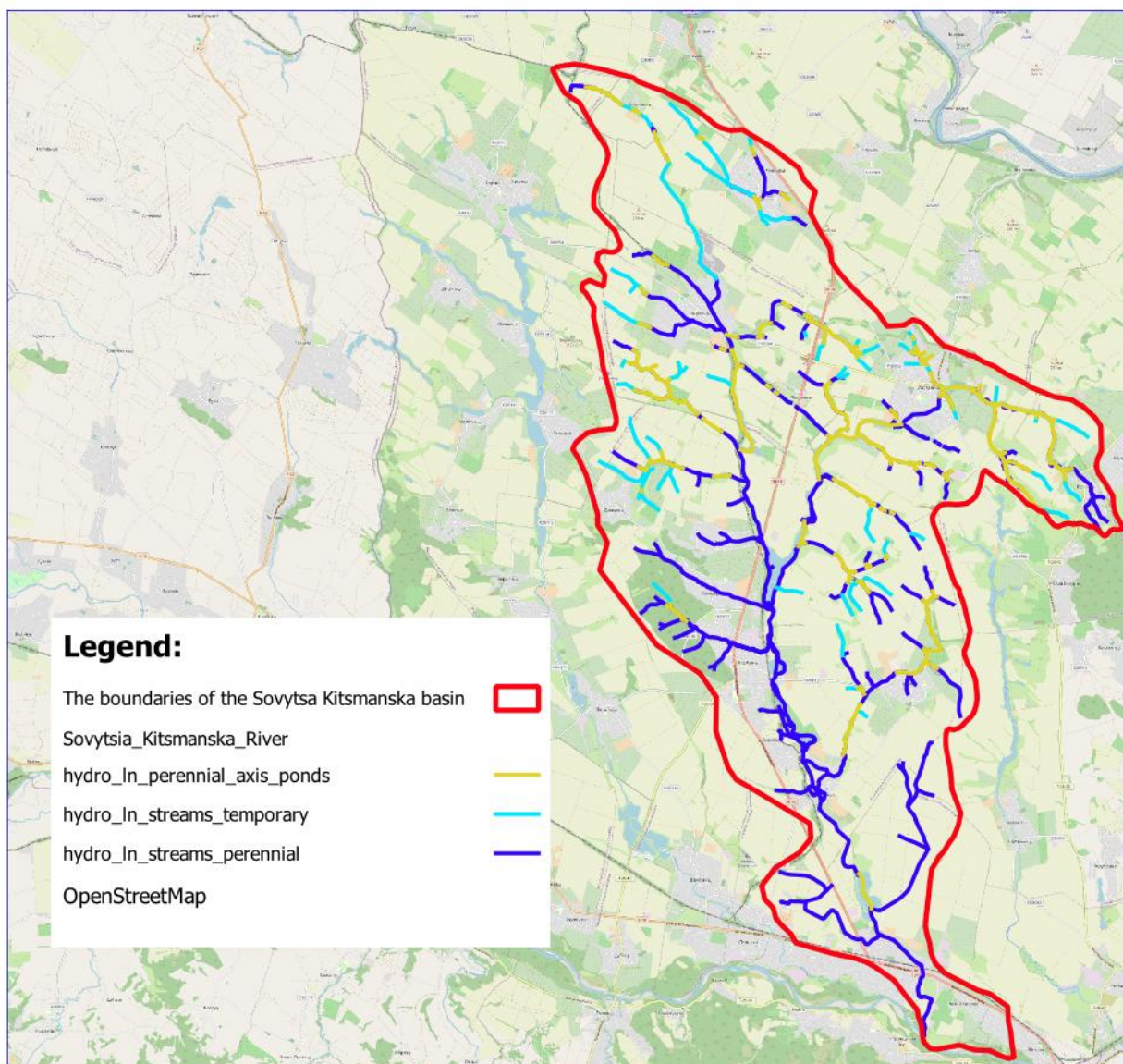


Fig. 9. Building QGIS 3.34.10 layers representing perennial and temporary streams in the Sovytsia Kitsmanska River basin

For this purpose, the source hydro-network layers were exported and saved as a separate layer in the WGS 84 / UTM zone 35N (UTM 35N) projection, which was then used as the baseline for calculations. In the layer properties (the “Fields” section), editing mode was enabled and the “Field Calculator” was opened, where a new field named length was created with the Decimal (double) type and with specified field length and precision to ensure storage of fractional values and sufficient accuracy for short segments. At this stage, it was advisable to create the field as a virtual field so as not to modify the structure of the source data and to be able to quickly recalculate values in the event of geometry or projection corrections. In the expression, the geometric function \$length was applied and the conversion from meters to kilometers was performed using a conversion factor, i.e., the formula $\$length / 1000$ was used. Before running the calculation, it was verified that “Only update selected features” was not enabled (or, alternatively, that all features in the layer were selected), after which the calculation was confirmed, yielding for each linear feature its length in kilometers. Next, the attribute table of the layer was opened and the correctness of filling the length field was visually checked (absence of continuous zeros and negative values);

where necessary, individual zero values were interpreted as short artefactual segments and their location on the map was additionally verified. To obtain the total length of the hydrographic network, the “Statistics” tool/panel (statistical report) was used for the length field, where the key summary indicator is the “Sum” row that displays the total length of all segments within the layer. The same sequence of actions was performed for the temporary watercourses layer: the corresponding length field was created using the same expression $\$length / 1000$, after which the “Statistics” tool was used to determine the total length of the temporary network. As a result, the methodology makes it possible to obtain comparable length values for the perennial and temporary components—137,274 km and 45,338 km, respectively—as well as the length of the axis of watercourses within ponds, which is 62,571 km.

Next, for integral assessments of the river-system configuration (in particular, the total length of ≈ 245.2 km) and derived indicators such as drainage density or the share of temporary watercourses, it is important to ensure that the length attribute can be reused without repeated recalculation. If the length indicator needs to be applied multiple times, it is advisable to convert the virtual field into a regular one: either by rerunning the “Field Calculator” and writing the results into a physical field, or by exporting the layer to a new file in which QGIS will automatically store virtual attributes as permanent.

As with the calculation of watercourse lengths, the numerical value of the Sovytsia Kitsmanska basin area was obtained via the attribute table: we created an area field of the Decimal (double) type and, using the “Field Calculator”, wrote the polygon area into it. Since the $\$area$ function in a UTM project returns area in m^2 , the conversion to km^2 was performed using $\$area / 1000000$. The correctness of the result was checked via the “Statistics” panel for the area field: with a single polygon, the minimum, maximum, mean, and sum coincide. In our case, the table records a value of 271.395072804532, i.e., ≈ 271.40 km^2 .

Drainage density (drainage density) for the Sovytsia Kitsmanska River basin was calculated by us as the ratio of the total length of watercourses to the catchment area, using the formula $D_d = \sum L / A$, where $\sum L$ is the total length of the linear elements of the river network and A is the basin area. Based on the QGIS-derived values $\sum L = 245.183$ km (perennial watercourses 137.274 km + temporary 45.338 km + the length of the watercourse axis within ponds 62.571 km) and $A = 271.395072804532$ km^2 , drainage density equals $D_d = 245.183 / 271.3951 = 0.903$ km/km^2 (≈ 0.90 km/km^2). At the same time, to ensure comparability with traditional approaches, where the total length typically includes channel lines without “pond axes”, it is reasonable to report an alternative value as well: if only the perennial and temporary hydro-network is considered (182.612 km), then $D_d = 182.612 / 271.3951 = 0.673$ km/km^2 . The obtained estimates indicate a moderately high dissection of the catchment by linear runoff elements and, accordingly, a potential sensitivity of the basin to the spatial organization of overland flow and to transformations of the channel network under anthropogenic impacts. The structural contribution of individual components to the total length is uneven: the share of perennial watercourses is about 56.0%, temporary watercourses about 18.5%, and the axes of watercourses within ponds about 25.5%, which additionally emphasizes the significance of the pond complex as an element that “extends” the linear structure of the water network and should be accounted for separately when interpreting drainage-density indicators and in subsequent calculations of flow regulation and hydromorphological characteristics of the basin.

Conclusion. Overall, the study confirmed that, for small agricultural catchments with a high share of artificial water bodies and transformed channels, the decisive factor for obtaining correct morphometric estimates is the development of an internally consistent, high-detail digital hydrographic baseline. The stated objective was achieved through a reproducible two-stage approach: DEM-oriented extraction of the runoff structure in SAGA GIS (DEM preprocessing, derivation of flow directions and flow accumulation, and delineation of the catchment boundary), followed by desktop refinement and verification of the river network in QGIS using Sentinel-2 satellite imagery and open cartographic sources. Based on the geocomputational results, a structured database of watercourses was compiled, distinguishing perennial (137.274 km) and temporary (45.338 km) line features and separately accounting for “hidden” channel reaches within ponds through flow-axis lines (62.571 km). This eliminates systematic underestimation of channel lengths in pond-transformed valleys and increases the comparability of derived indicators in basin-scale analyses. The refined catchment outline obtained through digital delineation

yielded an area of 271.40 km², which is 1.65% larger than the passport value of 267 km² (Derzhkomvodhosp Ukrainy, Instytut “Ukrvodproekt”, & Chernivetska filia instytutu “Lvivhiprovodhosp”, 1993), and therefore requires cautious comparison of drainage-density values only under identical definitions of length and area. If our “extended” total river-network length (245.183 km, including pond reaches) is normalized by the passport area of 267 km², the resulting value is 0.918 km/km², which differs from the passport value of 0.94 km/km² by only ≈2.3%; when normalized by our delineated area of 271.40 km², drainage density equals 0.903 km/km². Such a level of discrepancy is methodologically expected and, in essence, confirms the adequacy of the constructed GIS model: the main part of the difference relative to the passport data corresponds to a magnitude of about 5–6 km of the smallest network links, which are sensitive to cartographic scale, the rules used to classify disputed tributaries as temporary, and the evolution of the drainage-and-pond complex. Consequently, the resulting digital hydrographic baseline is suitable both for reliable morphometric calculations (including drainage density and indicators of runoff transformation) and for further interpretation in the context of basin management and assessment of pond impacts on the functioning of the river system.

References

1. *Bespalko R.I., Hutsul T.V.* Tekhnolohichni osoblyvosti vydilennia mezh vodozbirnykh basiniv zasobamy HIS-tekhnolohii (na prykladi r.Brusnytsia) [Technological features of the allocation of watershed boundaries using GIS technologies (on the example of the Brusnytsia River)]. Visnyk Kharkivskoho natsionalnoho universytetuimeni V.N. Karazina, Serii «Heolohiia. Heohrafiia. Ekolohiia», 2021, vypusk 55, S. 117–127. URL: <https://doi.org/10.26565/2410-7360-2021-55-09>
2. *Buzei, O.V., Pasichnyk, M. D.* Porivnialna otsinka spektralnykh indeksiv dlia napivavtomatychnoho vydilennia poverkhni richky [Comparative assessment of spectral indices for semi-automatic allocation of the river surface]. Pryrodnycha osvita ta nauka, 2025. Vyp. 3. S. 120-133. URL: <https://doi.org/10.32782/NSER/2025-3.17>
3. Comparison of Sentinel-2 and Landsat Data for Surface Water Mapping. URL: <https://www.usgs.gov/centers/eros/science/usgs-eros-archive-sentinel-2-comparison-sentinel-2-and-landsat> (data zvernennia 9.02.2025).
4. Copernicus Land Monitoring Service. Products including DEM. URL: <https://land.copernicus.eu/> (data zvernennia 10.02.2025)
5. Derzhvodkomvodhosp Ukrainy, Instytut «Ukrvodproekt», Chernivetska filia instytutu «Lvivhiprovodhosp». Pasporyzatsiia malykh richok Ukrainy. Chernivetska oblast: Pasport r. Sovytsia [State Water Resources and Water Management Commission of Ukraine, Ukrvodproekt Institute, Chernivtsi branch of the Lvivhiprovodhosp Institute. Passportization of small rivers of Ukraine. Chernivtsi region: Passport of the Sovytsia Rive], 1993.
6. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000. Establishing a framework for Community action in the field of water policy. Official Journal of the European Communities. URL: <https://eur-lex.europa.eu/eli/dir/2000/60/oj/eng>
7. Exploring Hydrological Analyses using SAGA GIS. URL: https://dges.carleton.ca/CUOSGwiki/index.php/Exploring_Hydrological_Analyses_using_SAGA_GIS
8. Vodnyi fond Ukrainy: Shtuchni vodoimy — vodoshkovyshcha i stavky [Water Fund of Ukraine: Artificial reservoirs - reservoirs and ponds] : Dovidnyk / Za red. V.K. Khilchevskoho, V.V. Hrebenia. Kyiv : «Inter-pres LTD», 2014. 164 s.
9. *Kozmuk P.F., Kulish V.I., Cherniavska O.A.* Zemelni resursy Bukovyny: stan, monitorynh, vykorystannia [Land resources of Bukovina: condition, monitoring, use] :buklet. 2007
10. Ministerstvo zakhystu dovkillia ta pryrodnykh resursiv Ukrainy. Plan upravlinnia richkovymi basinamy 2025-2030 roky [Ministry of Environmental Protection and Natural Resources of Ukraine. River Basin Management Plan 2025-2030]. URL: <https://mepr.gov.ua/diyalnist/plany/plany-upravlinnyarichkovymi-baseinamy-2025-2030-roky/> (data zvernennia 20.11.2025)
11. *Palamarchuk M.M., Zakorchevna N.B.* Vodnyi fond Ukrainy [Water Fund of Ukraine]: dovidnykovyi posibnyk. Kyiv : Nika-Tsentr, 2001. 320 s.
12. *Pasichnyk M.D.* HIS-Modeliuvannia vodozbirnoho basynu ta richkovoii merezhi: analiz hidrolohichnykh protsesiv na prykladi basynu richky Brusnytsia [GIS-Modeling of the catchment area and river network: analysis of hydrological processes using the example of the Brusnytsia River Basin]. Hidrolohiia, hidrokimiia i hidroekolohiia, 2024. № 4(74). C. 30-44. URL: <https://doi.org/10.17721/2306-5680.2024.4.3>
13. *Pasichnyk M., Buzei O.* Inventaryzatsiia ta funktsionalna klasyfikatsiia stavkiv za danymy Sentinel-2 NDWI v basyni richky Sovytsia Kitsmanska (Ukraina) [Inventory and functional classification of ponds according to Sentinel-2 NDWI data in the Sovytsia Kitsmanska River Basin (Ukraine)]. Naukovyi visnyk

Chernivetskoho universytetu: Heohrafiia № 854. 2025. S.150–169. URL: <https://doi.org/10.31861/geo.2025.854.150-169>

14. *Pasichnyk, M., Yushchenko, Y., Palanychko, O., Melnyk, A., & Darchuk, K.* Remote sensing and GIS in the research of young river landscape. *Grassroots Journal of Natural Resources*, 8(1), 2025. R. 163–189. URL: <https://doi.org/10.33002/nr2581.6853.080106>

15. *Pasichnyk M.D.* Heohidroheomorfologichnyi analiz terytorialnoi struktury dolyn osnovnykh richok Chernivetskoï oblasti [Geohydrogeomorphological analysis of the territorial structure of the valleys of the main rivers of Chernivtsi region]: avtoreferat, Chernivetskyi natsionalnyi universytet imeni Yurii Fedkovycha, Chernivtsi, 2012.

16. QGIS Tutorials. Calculating raster area (QGIS3). URL: https://www.qgistutorials.com/en/docs/3/calculating_raster_area.html

17. *Rapinel, S., Fabre, E., Dufour, S., Arvor, D., Garbey, C., & Hubert-Moy, L. ()*. Mapping potential, existing and efficient wetlands using free remote sensing data. *Journal of Environmental Management*, 247, 2019. S. 829–839. <https://doi.org/10.1016/j.jenvman.2019.06.098>

18. U.S. Geological Survey. Water basics glossary. Retrieved December 20, 2025, URL: https://water.usgs.gov/water-basics_glossary.html

19. Vseukrainska ekolohichna hromadska orhanizatsiia “MAMA-86”. Plan upravlinnia pilotnym richkovym basinom richky Prut [All-Ukrainian Ecological Public Organization “MAMA-86”. Management Plan for the Pilot River Basin of the Prut River]. (data publikatsii traven, 2015). URL: <https://mama-86.org.ua/index.php/en/ecologization/ecointegration-news.html>

20. *Vudvud M, Pasichnyk M., Yushchenko Yu.* Analiz stanu pryberezhnykh smuh vzdovzh richok Sovytsia Stavchanska i Sovytsia Kitsmanska ta yikh roli u zberezheni yakosti vodnykh ob'ektiv [Analysis of the state of the coastal strips along the Sovytsia Stavchanska and Sovytsia Kitsmanska rivers and their role in preserving the quality of water bodies]. *Naukovyi visnyk Chernivetskoho universytetu : Heohrafiia № 847*, 2024. S. 135-143. URL: <https://doi.org/10.31861/geo.2024.847.135-143>

21. *Yushchenko, Yu.S., Pasichnyk, M.D., Darchuk, K.V., Kostashchuk, I.I., & Zakrevskyi, O.V.* Contemporary geoinformation technologies in postmodern education of geographers, hydrometeorologists, land surveyors. *Postmodern Openings*, 13(2), 2022. R. 409-429. Retrieved from: URL: <https://doi.org/10.18662/po/13.2/462>

Список літератури

1. *Беспалько Р.І., Гуцул Т.В.* Технологічні особливості виділення меж водозбірних басейнів засобами ГІС-технологій (на прикладі р.Брусниця). Вісник Харківського національного університету імені В.Н. Каразіна, Серія «Геологія. Географія. Екологія», 2021, випуск 55, С. 117–127. URL: <https://doi.org/10.26565/2410-7360-2021-55-09>

2. *Бузей, О.В., Пасічник, М. Д.* Порівняльна оцінка спектральних індексів для напівавтоматичного виділення поверхні річки. *Природнича освіта та наука*, 2025. Вип. 3. С. 120-133. URL: <https://doi.org/10.32782/NSER/2025-3.17>

3. Comparison of Sentinel-2 and Landsat Data for Surface Water Mapping. URL: <https://www.usgs.gov/centers/eros/science/usgs-eros-archive-sentinel-2-comparison-sentinel-2-and-landsat> (дата звернення 9.02.2025).

4. Copernicus Land Monitoring Service. Products including DEM. URL: <https://land.copernicus.eu/> (дата звернення 10.02.2025)

5. Держводкомводгосп України, Інститут «Укрводпроект», Чернівецька філія інституту «Львівгіпродгосп». Паспортизація малих річок України. Чернівецька область: Паспорт р. Совиця, 1993.

6. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000. Establishing a framework for Community action in the field of water policy. *Official Journal of the European Communities*. URL: <https://eur-lex.europa.eu/eli/dir/2000/60/oj/eng>

7. Exploring Hydrological Analyses using SAGA GIS. URL: https://dges.carleton.ca/CUOSGwiki/index.php/Exploring_Hydrological_Analyses_using_SAGA_GIS

8. Водний фонд України: Штучні водойми — водосховища і ставки: Довідник / За ред. В.К. Хільчевського, В.В. Гребеня. Київ : «Інтер-прес ЛТД», 2014. 164 с.

9. *Козмук П.Ф., Куліш В.І., Чернявська О.А.* Земельні ресурси Буковини: стан, моніторинг, використання : буклет. 2007

10. Міністерство захисту довкілля та природних ресурсів України. План управління річковими басейнами 2025-2030 роки. URL: <https://mep.gov.ua/diyalnist/plany/plany-upravlinnya-richkovymu-basejnayu-2025-2030-roku/> (дата звернення 20.11.2025)

11. *Паламарчук М.М., Загорчевна Н.Б.* Водний фонд України : довідниковий посібник. Київ : Ніка-Центр, 2001. 320 с.

12. Пасічник М.Д. ГІС-Моделювання водозбірних басейнів та річкової мережі: аналіз гідрологічних процесів на прикладі басейну річки Брусниця. Гідрологія, гідрохімія і гідроекологія, 2024. № 4(74). С. 30-44. URL: <https://doi.org/10.17721/2306-5680.2024.4.3>

13. Пасічник М., Бузей О. Інвентаризація та функціональна класифікація ставків за даними Sentinel-2 NDWI в басейні річки Совиця Кіцманська (Україна). Науковий вісник Чернівецького університету: Географія № 854. 2025. С.150–169. URL: <https://doi.org/10.31861/geo.2025.854.150-169>

14. Pasichnyk, M., Yushchenko, Y., Palanychko, O., Melnyk, A., & Darchuk, K. Remote sensing and GIS in the research of young river landscape. Grassroots Journal of Natural Resources, 8(1), 2025. P. 163–189. URL: <https://doi.org/10.33002/nr2581.6853.080106>

15. Пасічник М.Д. Геогідрогеоморфологічний аналіз територіальної структури долин основних річок Чернівецької області : автореферат, Чернівецький національний університет імені Юрія Федьковича, Чернівці, 2012.

16. QGIS Tutorials. Calculating raster area (QGIS3). URL: https://www.qgistutorials.com/en/docs/3/calculating_raster_area.html

17. Rapinel, S., Fabre, E., Dufour, S., Arvor, D., Garbey, C., & Hubert-Moy, L. Mapping potential, existing and efficient wetlands using free remote sensing data. Journal of Environmental Management, 247, 2019, 829–839. <https://doi.org/10.1016/j.jenvman.2019.06.098>

18. U.S. Geological Survey. Water basics glossary. Retrieved December 20, 2025, URL: https://water.usgs.gov/water-basics_glossary.html

19. Всеукраїнська екологічна громадська організація “МАМА-86”. План управління пілотним річковим басейном річки Прут (дата публікації травень, 2015). URL: <https://mama-86.org.ua/index.php/en/ecologization/ecointegration-news.html>

20. Вудвуд М, Пасічник М., Ющенко Ю. Аналіз стану прибережних смуг вздовж річок Совиця Ставчанська і Совиця Кіцманська та їх ролі у збереженні якості водних об'єктів. Науковий вісник Чернівецького університету : Географія № 847, 2024. С. 135-143. URL: <https://doi.org/10.31861/geo.2024.847.135-143>

21. Yushchenko, Yu.S., Pasichnyk, M.D., Darchuk, K.V., Kostashchuk, I.I., & Zakrevskiy, O.V. Contemporary geoinformation technologies in postmodern education of geographers, hydrometeorologists, land surveyors. *Postmodern Openings*, 13(2), 2022. P. 409-429. Retrieved from: URL: <https://doi.org/10.18662/po/13.2/462>

Високороздільна цифрова гідрографічна модель малого аграрного водозбору: ГІС-інвентаризація на основі програмного забезпечення з відкритим кодом для басейну річки Совиця Кіцманська (Україна)

Пасічник М.Д., Григорійчук В.В.

У статті представлено відтворений ГІС-підхід до формування високороздільної цифрової гідрографії малого лісостепового водозбору з істотною антропогенною трансформацією, продемонстрований на прикладі басейну річки Совиця Кіцманська (Україна) у басейні Пруту. Метою роботи було отримання узгодженої векторної гідромережі та похідних морфометричних показників, придатних для подальших гідрологічних і гідроморфологічних оцінок. Як вихідну модель рельєфу використано Copernicus DEM (30 м) із подальшою обробкою в SAGA GIS 9.8 (гідрологічний блок Terrain Analysis – Hydrology) для одержання Flow Accumulation, автоматизованого формування первинної гідромережі та уточнення меж водозбору (Watershed Basins). Подальшу камеральну верифікацію й редагування виконано у QGIS 3.34.10 із залученням космічних знімків Sentinel-2 L2A (True Color) та онлайн-підкладок (зокрема OpenStreetMap і Visicom) як незалежних джерел просторового контролю. Для методичної однозначності запроваджено правило консервативної класифікації тимчасових водотоків і наведено робоче визначення тимчасового водотоку як непостійного (non-perennial) із сезонною або епізодичною переривчастістю стоку, узгоджене з сучасною термінологією (intermittent/ephemeral). Усі елементи мережі організовані в уніфіковані векторні шари: постійні водотоки (hydro_in_streams_perennial), тимчасові водотоки (hydro_in_streams_temporary) та технічний шар осей проточних ділянок русла в межах ставків (hydro_in_perennial_axis_ponds), що забезпечило топологічну зв'язність і коректний підрахунок довжин. За результатами вимірювань у QGIS площа басейну становить $\approx 271,40$ км²; сумарна довжина постійної гідромережі дорівнює 137,274 км, тимчасової — 45,338 км, а додатково враховані осі русел у межах ставків — 62,571 км. Відповідно, густина річкової мережі становить близько 0,90 км/км² із урахуванням «ставкових осей» і близько 0,67 км/км² за традиційного підходу (без них). Показано, що внесок складників у сумарну довжину є нерівномірним: постійні водотоки формують близько 56,0%, тимчасові — 18,5%, а імпондовані ділянки русел, подані «осями», — 25,5%, що принципово впливає на інтерпретацію морфометричних індикаторів у басейнах зі значною кількістю зарегульованих відтинків. Отримана гідрографічна база даних розглядається як надійна основа для подальших оцінок просторової організації стоку, аналізу антропогенних впливів і підтримки водогосподарських рішень на рівні малого басейну.

Ключові слова: високороздільна гідрографія; малий аграрний водозбір; QGIS; SAGA GIS; Copernicus DEM; Sentinel-2; густина річкової мережі.

Надійшла до редколегії 03.12.2025