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Research Article

Spatial Patterns and Functioning of Water Springs in the Sacred Landscape Structure: The Case of Lviv and Volyn Oblasts of Ukraine

 Olena Mishchenko¹  Valerii Petlin¹ &  Serhii Puhach²

¹ Department of Physical Geography, Lesya Ukrainka Volyn National University, Ukraine

² Department of Economic and Social Geography, Lesya Ukrainka Volyn National University, Ukraine

✉ Correspondence: mischenko.olena@vnu.edu.ua

Abstract: Sacred springs are significant among water sources, as they serve not only natural functions but also social ones, fulfilling the spiritual needs of residents and pilgrims. This article aims to determine the spatial distribution and role of consecrated/sacred springs in the formation of sacred landscapes. Sanctified springs act as key components and markers of sacred landscapes. The hydrogeological and climatic conditions of Western Ukraine, particularly in Lviv and Volyn oblasts, contribute to the formation of water springs. These regions' national, ethnological, religious, and cultural characteristics have influenced the development of a network of consecrated/sacred springs. The physiographic zoning scheme of Ukraine served as the cartographic basis for this study. During 2018-2023, field research was conducted on 112 sacred springs in Lviv oblast and 61 in Volyn oblast. Also, a survey of residents was carried out to gather information about the history and medicinal properties of the investigated springs. The identified spatial patterns of sacred spring distribution within Lviv and Volyn oblasts indicate that their location, concentration, and functioning depend on the characteristics of the surrounding natural environment. Various types of sacred spring groupings have been recorded, including ribbon, double, dispersed, isolated, compact, and blocked. Sacred/consecrated springs play a central role in forming sacred landscapes. The adequate functioning of such a landscape requires the development of special organisational, landscape-planning, and protective mechanisms for nature use.

Keywords: sacred spring; sacred landscape; Volyn oblast; Lviv oblast; Ukraine.

Highlights:

- Sanctified springs are not individual formations but form a sacred landscape with the natural and cultural environment.
- Sacred/sanctified springs serve as focal points for the formation of certain social groups around them, sometimes far beyond the geographical location of these springs.
- Sacred springs should have the status of protected objects.

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1. Introduction

Studies on sacred landscapes are underrepresented in geographical science. To explore this issue, it is necessary to consider the scientific contributions of physical and cultural geography and religious studies, cultural studies, and sociology.

The analysis of interpretations of the term "sacred landscape" has made it possible to identify stable characteristics inherent in its various definitions across different disciplines. In particular, a sacred landscape is a part of geographical space and a socio-cultural phenomenon characterised by a specific set of value-based attributes. It has clearly defined, non-imaginary boundaries and a spatial structure that exhibits systematicity and orderliness. Such landscapes contain natural, anthropogenic, and cultural components, with a sacred object (e.g., a church, monastery, chapel, water spring, cave, or rock) serving as the central element and marker of the sacred landscape. This study demonstrates the regularities in the spatial organisation of water springs within the structure of sacred landscapes.

Water is one of the fundamental components of landscapes, historically determining the feasibility of settlement formation. Despite advancements in modern technologies, it remains essential to human life and activity. In Ukraine, consecrated or sacred springs are protected at local and regional levels. These springs have spiritual, medicinal, aesthetic and cognitive significance for residents and pilgrims. Their sacred value is linked to their history, local stories and legends about the healing properties of their waters, and their role in ritual practices.

As stated by old-timers in the village of Novosilka (Lviv oblast, Ukraine), an image of the Mother of God appeared near the spring in ancient times. According to legend, the water of this spring healed a blind man who regained his sight. Since then, pilgrims from all over Ukraine have been coming to the spring. The description of all healings with spring water is recorded and stored in the archive of the Spiritual Centre of Novosilka

village. Throughout the year, this water has the same temperature (+5°C ... +6°C). The tradition is that whoever walks twelve times in a circle in the pool with spring water will be healed of their illness.

Sacred springs not only contribute to the natural hydrological balance but also possess profound spiritual significance. During the Soviet era in Ukraine, a lot of such springs were destroyed, as atheism was a core element of the Soviet Union's state ideology (Luehrmann, Smolkin & Ruse, 2021). However, since Ukraine's independence in 1991, restoring sacred springs has become part of state policy.

Sacred landscapes delineate both the spiritual and material spaces in which the Ukrainian nation was shaped, encompassing cultural and natural monuments that reflect the national characteristics of Ukrainian identity. These territorial systems, including sanctified springs as their components, belong to the cultural and natural heritage, imbued by society with religious, supernatural, and symbolic meanings. Since approximately 90% of Ukraine's believers adhere to Christianity, this study examines sacred landscape traditions and planning according to Christian canons (Religious and Church Affiliation of Citizens of Ukraine, 2020).

In 1935, the English archaeologist Boothby, in his article "Religion of the Stone Age", pointed out that underground springs were found beneath every sanctuary he studied (Boothby, 1935). Ancient religious structures were commonly built in locations where groundwater accumulated. As a result, both pagan and later Christian buildings were often situated near sacred springs. In Europe, there are numerous springs and wells named after Christian saints. A common feature of many of these sacred waters is their reputation for healing ailments (Misstear & Gill, 2024). The historical and cultural significance of sacred springs is reinforced by their association with important historical events that took place nearby and notable figures who visited them. For instance, near the Zymne Monastery (Volyn oblast, Ukraine), there is a spring which, according to legend, was consecrated in 1065 by the Monk Varlaam of Pechersk, the first abbot of the Kyiv-Pechersk Monastery.

The purpose of this article is to determine the spatial distribution and role of consecrated/sacred springs in the formation of sacred landscapes. The main objectives of this study include spatial analysis and identifying distribution patterns of sacred springs, with a focus on Lviv and Volyn oblasts in Ukraine. The scientific novelty of this study lies in its integration of geographical methodology with the authors' interpretations of the sacred landscape concept and the application of physiographic zoning as a research method. Through the case studies of two regions in Western Ukraine, this study reveals the structural organisation, contemporary functions, and societal significance of landscapes containing sacred springs. Today, against the backdrop of the Russian-Ukrainian war, the study of sacred springs is particularly relevant, as historical, cultural, and spiritual sites of great importance to Ukraine continue to be destroyed by hostilities and missile attacks.

2. Literature Review

2.1. The state of the art and the importance of water springs

Water springs serve as important landscape components ensuring its integrity and contributing to species diversity within biocenoses. Scientists characterise water springs as significant yet rare ecosystems on the verge of extinction (Chelmicki et al., 2011). The ecological conditions of water springs depend on environmental changes and local land use patterns (Bonacci, 1987; Zuber et al., 2008). They act as indicators of changes in the natural environment, reflecting the increasing anthropogenic impact (Bascik & Chelmicki, 2004).

Water springs are elements of geodiversity and geological heritage (Dingwall et al., 2005). They give rise to many rivers (NITI Aayog, 2018), belong to biocultural diversity sites that require protection (Ray, 2020), and serve as factors in the development of tourism and recreation (Bascik & Chelmicki, 2004). These systems are the subject of scientific research not only because of their ecological function but also due to their cognitive and cultural significance (Bascik et al., 2008). The provision of ecosystem services in aquatic ecosystems should be carried out with consideration of their ecological state (Grizzetti et al., 2016).

An analysis of scientific publications on natural water springs reveals their underrepresentation in geographical research. In particular, there is a lack of studies examining the hydrological and hydrogeological characteristics of water springs and their cultural, especially sacral, value.

Kravchynskiy et al. (2019) conducted one of the few studies to monitor natural water springs in Ukraine. Human influence on the environment in the ancient Greek world, as well as the importance of karstic springs for the functioning of ancient Greek cities, was highlighted in Krauch's (1996) work. Sacred springs are considered part of religious practice, symbolising the washing away of sins promoting health and well-being (Bikse & Gavinolla, 2023). Adams (1938) contributed to developing scientific ideas regarding the formation of springs and related hydrogeological processes. Haland (2009) studied modern Greek rituals related to springs and their connection with pre-Christian traditions. Research on the impact of urbanisation on karstic water resources, as well as the hydrogeological and hydrochemical properties of the Gihon sacred spring in Jerusalem, is scientifically comprehensive (Amiel et al., 2010). Based on aquifer mapping and analysis, Klempe (2015) investigated the hydrogeological basis of two sacred springs in Bø, Telemark County, Norway. The history and hydrogeology of the water springs in one of England's oldest towns were examined by Mather (2009). The formation of cult structures (nuraghi) in Sardinia, built near water springs, was studied by Fadda and Lo Schiavo (1992). Based on a study of religious rituals at the sacred spring of the "En Four" area (Africa), the influence of spring water on human mental and physical health is substantiated (Meiring, 2024). In Ukraine, vodovsyatni are a specific type of water springs used for ritual purposes, particularly to end droughts and invoke rainfall (Mishchenko, 2018b).

2.2. The interpretation of the notion of a water spring

When studying the issue of water springs, particularly sacred ones, it is essential to analyse the variety of interpretations of this concept. A spring is defined as a natural outlet of groundwater to the surface or underwater (submarine spring) (Khilchevskiy & Romas, 2007); a point of leakage from a surrounding wet area; a component of the infiltration surface (Bear, 2012); an element of the landscape formed through the interaction of various environmental components: hydrological, geomorphological, geological, climatic, and, in some cases, anthropogenic (Jokiel & Michalczyk, 2021); a unique feature of the geological environment that emerges due to the continuous dynamic processes of the global water cycle, influenced by Earth's gravity or hydrostatic pressure in various landscape and geomorphological settings, such as the bottoms of gullies and arroyos, hillsides, steep riverbanks, etc. (Kravchynskiy et al., 2019).

Natural water springs differ from other water systems in that their temperature remains relatively constant, especially near the discharge point (Sada & Pohlmann, 2002). Therefore, a water spring is a key landscape component that influences the state of surface waters and is closely connected to the hydrogeological environment.

The analysis of scientific literature and regulatory documents on water bodies reveals no universally accepted classification of water springs as either surface or underground water bodies. The EU Water Framework Directive (European Commission, 2000) does not define “water spring” nor explicitly classify it as either a surface or an underground water body. There is no legally defined interpretation of the notion “of water spring” in Ukraine. According to Art. 3 of the Water Code of Ukraine (Verkhovna Rada of Ukraine, 2017), springs are not classified as surface water but rather as “underground water and springs”. The normative document of the Republic of Poland (Sejm of the Republic of Poland, 2017) categorises springs as internal surface water bodies. According to the Water Code of Kazakhstan, Art. 13 (Gazette of the Parliament of the Republic of Kazakhstan, 2003), natural water springs refer to underground water body. In contrast, the Art. 5 of the Water Code of the Russian Federation (Legislation of Russian Federation, 2006) states that natural underground water outlets (springs, geysers) belong to surface water bodies.

Although regulatory frameworks in different countries vary in their classification of water springs as either surface or underground water bodies, the methods used to determine their water quality and discharge are often the same as for surface water bodies.

3. Study area and background

Lviv and Volyn oblasts, selected for this study, are valuable areas for this type of comparative geographical analysis: according to the physiographic zoning of Ukraine (Marynych et al., 2003), they are located within two major physiographic countries (the East European Plain – a lowland region, and the Ukrainian Carpathians – a mountainous region) and six physiographic regions. To determine the patterns of spatial distribution of sacred springs, the hydrogeological and climatic prerequisites for their formation have been analysed (Fig. 1).

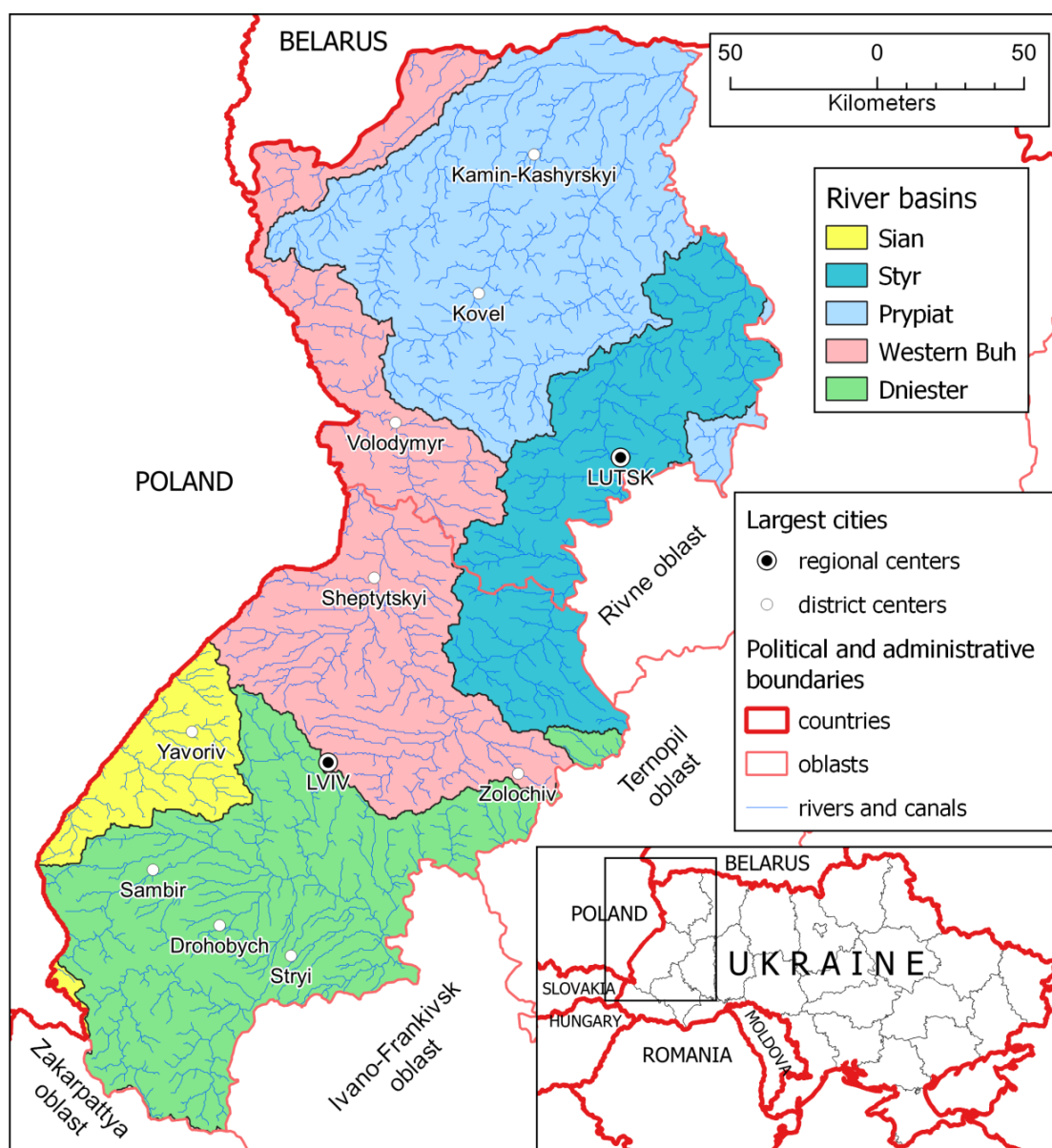


Figure 1. Study area: River basins of Lviv and Volyn oblasts, Ukraine. Note: The Styr River is a right tributary of the Prypiat River and within the Volyn oblast is studied as one river basin (Prypiat).

Lviv oblast is located within three main hydrogeological structural units: the Volyn-Podolia artesian basin, the Precarpathian artesian basin, and the hydrogeological region of the folded Carpathians (Matolych, 2007). The following types of underground water are present in this area: fresh, mineralised, mineral, and thermal. The most significant potential for fresh groundwater is recorded in the Volyn-Podolia artesian basin, where water-bearing complexes are confined to Neogene, Upper Cretaceous, and, in the eastern part, Devonian deposits.

In the Precarpathian artesian basin, the aquifer complex is formed mainly by alluvial deposits in floodplains and river terraces. Freshwater resources in the mountainous-folded region of Lviv oblast are relatively limited and are associated with the weathering zone of flysch rocks (Nazaruk, 2018).

Lviv oblast also has significant reserves of mineral water with various chemical compositions and therapeutic properties, including bromine, boron, carbon dioxide, sulphide, iron, iodine, and siliceous waters, as well as water with an increased content of organic substances such as Naftusya, as well as other waters without specific mineral components.

The studied area is characterised by low geothermal gradients, averaging 2–3°C per 100 meters of depth (Nazaruk, 2018). In general, thermal waters in natural reservoirs have high mineralisation (30 g/dm³ or more) and an increased hydrogen sulphide content. Therefore, purification from impurities and reverse injection into deep collectors are recommended for their use.

The formation of springs is significantly influenced by the amount of precipitation and the density of the river network in the region. Lviv oblast lies within a zone of excessive moisture, with an average annual precipitation of 650 mm in the lowland areas and 750–1000 mm in the foothills. In the mountainous part of the region, precipitation reaches up to 1400 mm, mainly in April and September (Matolych, 2007). There are 2.522 rivers with a total length of 11 574.55 km in Lviv oblast. The densest river networks are found within the Dniester basin (52%) and the Western Bug basin (28%), with smaller shares belonging to the Sian (12%) and Stry (8%) basins. The total river network density in the oblast reaches 0.75 km/km², indicating high moisture levels and favourable conditions for surface runoff formation (Nazaruk, 2018).

Volyn oblast is located within the Volyn-Podolia artesian basin, where fresh and mineralised underground water is common (Herenchuk, 1975). It is also part of the Western Polesia karstic region, characterised by a mixed type of karst: surface and deep. The hydrogeological conditions of this territory are influenced by geological structure together with climatic and geomorphological factors. The aquifers of Neopleistocene and Holocene deposits, as well as the Upper Cretaceous, play a crucial role in shaping the modern hydrogeological situation.

On the oblast territory, there are springs associated with fissure-type waters, which are confined to karstic massifs with underground voids connected by a system of fissures. There are no continuous water-resistant layers between all the aquifers of quaternary sediments. Therefore, quaternary sediments form a single aquifer complex within the entire studied territory.

The first aquifer, located within swamp and lake-swamp sediments, has an average thickness of 1–5 meters and occurs in river floodplains. The thickness of the Holocene alluvial aquifer reaches 5–6 meters and is also associated with river valleys (Zuzuk, 2012). The alluvial aquifer of the first supra-flood terraces belongs to the Upper Neopleistocene, while the moraine and lacustrine-glacial aquifer complex is attributed to the Middle Neopleistocene. The fluvioglacial and moraine deposits of the Lower Neopleistocene have a more fragmented distribution. The aquifer of fluvioglacial and moraine deposits of the Lower Neopleistocene has a fragmentary distribution.

In the Volyn Highland, aquifers are found within Paleogene formations and Oka glaciation deposits, allocated within the sporadically spread Cretaceous relief lowering. In some places, there is a topwater associated with lenticular sand formations within loess deposits. In the river valleys of the Volyn Highland, Holocene deposits in floodplains, streambeds, and swamps serve as water-bearing layers.

The water belongs primarily to the hydrocarbon-calcium type in elevated areas, with mineralisation levels of 0.2–0.5 mg/L (Herenchuk, 1975). In the flat, low-lying areas of Volyn Polesia, where the underground flow slows down and, waterlogging is common, nitrogen oxide compounds and iron of marsh origin appear in higher concentrations.

The underground water of Volyn oblast mainly belongs to the hydrocarbon class, the calcium group of the first or second type (Mishchenko, 2018a).

Volyn oblast is characterised by excessive to sufficient moisture. Over the long-term climatic period, the highest levels of precipitation occur in the central part of the oblast, near the border of Southern Polesia (660 mm at the Manevychi weather station), and in the western outskirts (600 mm at the Volodymyr weather station). The lowest precipitation levels are observed in the suburbs of Lutsk and the northwestern part of the oblast – in the Shatsk Lakes area. A favourable factor for the formation of water springs is a well-developed river network, with an average density of 0.25–0.47 km/km² in the Prypiat River basin and 0.22–0.35 km/km² in the Western Bug River basin.

4. Materials and Methods

The research is based on the concept of cultural landscape, which was developed taking into account the fact that such a landscape has a natural basis and is shaped by a particular group of people (Sauer, 1925; Gong et al., 2022). One of the areas of research in cultural geography is sacred geography, which encompasses the study of sacred landscapes (Mishchenko, 2024).

Some scientists considered landscape as a part of the area that can be seen from a single point of view (Olwig, 1993). Neef (1967) described a landscape as a section of the Earth's surface with "a uniform structure and functional pattern". The information-processing theory of landscape perception explains the patterns of information processing that go from the landscape to the person and determines the person's preference for one or another landscape (Kaplan & Kaplan, 1989). Since geography conceptualises landscape as a spatial unit composed of interconnected components (Schmithüsen, 1976; Mishchenko, 2016), in the context of this study, a sacred landscape is marked by a consecrated spring and exists within both a natural and social environment (Fig. 2).

A water spring, particularly a sacred one, is an integral part of the landscape structure, incorporating abiotic natural components (hydrological, hydrogeological, geomorphological, climatic, soil), as well as plant and animal life. The anthropogenic-technogenic component within the studied landscape includes elements such as wells, pools/baths, chapels, churches, etc. The arrows in Fig. 2 illustrate the mutual interaction between the sacred spring and the surrounding landscape. Arrows extending beyond the figure indicate the sacred landscape's interconnectedness with the surrounding natural and anthropogenic environment.

The perception of a spring's sacredness and that of the entire landscape is inherently human and is shaped by myths, legends, and folk stories about miraculous healing. A sacred spring differs from an "ordinary one" in that religious activities, such as consecration rituals, take place nearby. Thus, a specific social group utilises a sacred spring not only for economic needs but also for spiritual practices, such as worship, honoring, etc.

The concept of a sacred landscape is interdisciplinary, attracting the attention of geographers, ecologists, anthropologists, philosophers, and architects. Consequently, this study employs geographical, general scientific and interdisciplinary research methods.

The research methodology follows a sequence of stages: theoretical, informational, cartographic, analytical, and implementation (Fig. 3). The theoretical stage involved reviewing the scientific literature to define key concepts such as cultural landscape, sacred landscape, and sacred water spring, as well as studying the interpretation of the concept of a “water spring” in regulatory documents of European and Asian countries. A systems analysis approach was employed, treating the sacred spring as a territorial system or landscape component. Using a transdisciplinary approach resulted in integrating methodological and theoretical perspectives from both natural and social sciences.

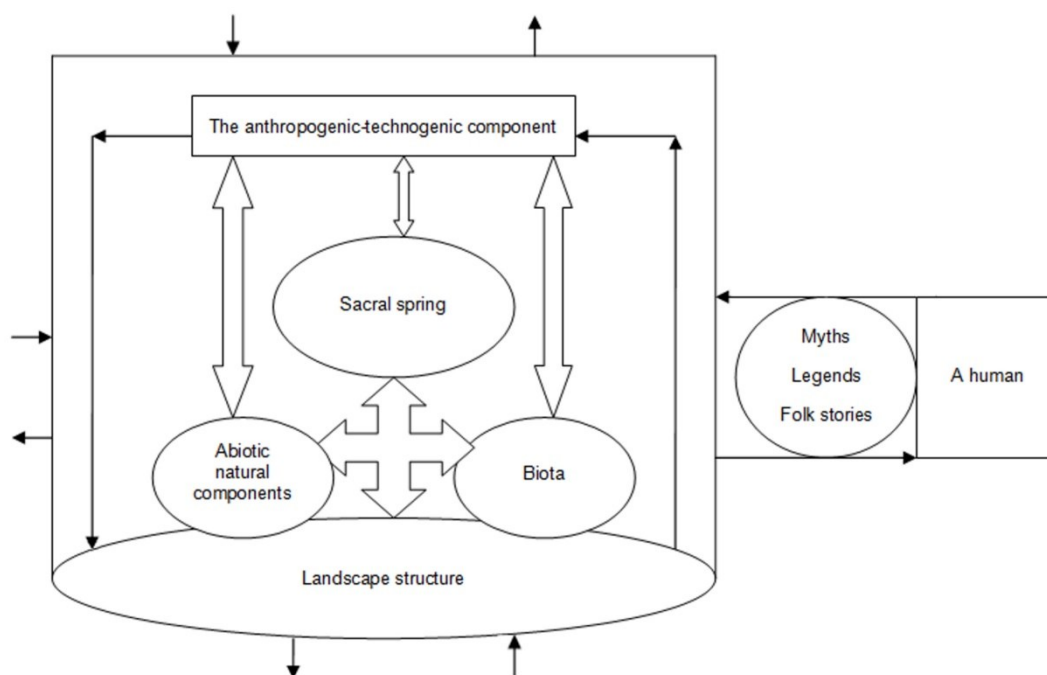


Figure 2. Spatial arrangement of a sacral spring in the structure of a sacred landscape. Source: Mishchenko, 2018a.

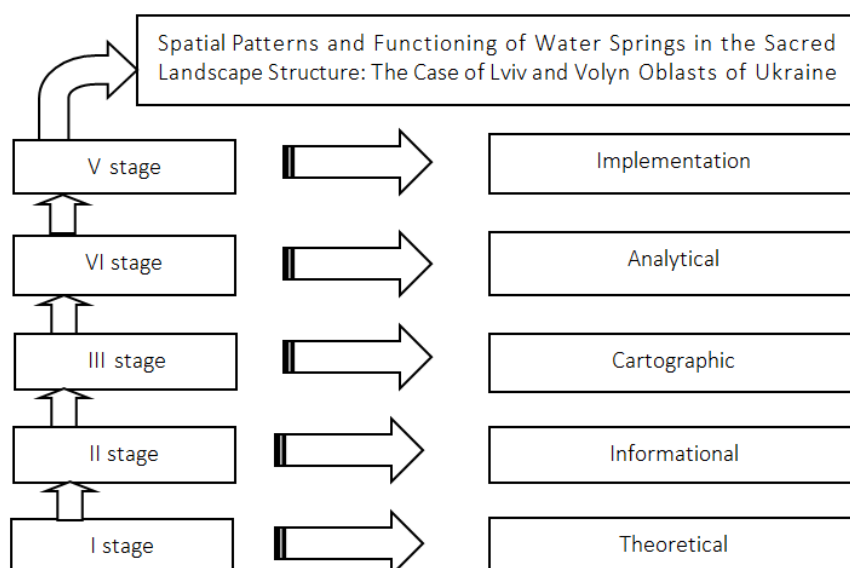


Figure 3. Stages of research into the spatial distribution and role of sanctified/sacred springs in shaping sacred landscapes.

Field surveys and descriptive methods were used to gather data on sacred springs within the studied territories during the informational stage. The study utilised materials from the Basin Management of Water Resources of the Western Bug and Sian Rivers (headquarters in Lviv), the Regional Office of Water Resources in Volyn oblast (headquarters in Lutsk), and scientific works concerning sacred springs in Volyn and Lviv oblasts. A significant proportion of sacred springs were absent in the cadastral records of local organisations that manage water resources in the studied

territories. Between 2018 and 2023, field research was conducted on 112 sacred springs in Lviv oblast and 61 in Volyn oblast. The authors assessed their condition, infrastructure, and potential use for religious purposes. The authors focused on the most renowned and frequently visited sacred springs in Western Ukraine. Their characteristics were based on the authors' field descriptions, analysis of hydrogeological, geomorphological, and landscape maps of the studied territory, and generalisation of scientific data on their physical and chemical parameters. The survey on the medicinal properties of the studied springs was conducted among the residents. This survey was based on the stories of villagers/townpeople who reported instances of healing attributed to sacred spring water.

The cartographic stage mapped the spatial distribution of sacred springs in Lviv and Volyn oblasts. The study employed physiographic zoning as a method used in complex geographic research to identify regions with relatively homogeneous natural conditions and distinct landscape structures. The hierarchic taxonomy of physiographic zoning units in Ukraine includes country, zone, subzone, region, oblast, and district. The research utilised the physiographic zoning scheme of Ukraine by Marynych et al. (2003) to develop the maps and analyse the results. Visualisation was conducted using the software packages MapInfo Professional and QGIS.

At the following analytical stage, of the spatial distribution of sacred springs within the studied regions was examined. The study applied system analysis to assess the place of sacred springs in the structure of landscapes, comparative-geographical methods to evaluate the prerequisites for their formation and spatial distribution, and historical analysis to explore the historical significance of sacred springs in Lviv and Volyn oblasts.

The implementation stage involved presenting the authors' findings through this scientific publication. The study's results were also shared with local authorities responsible for water resource management in Lviv and Volyn oblasts and implemented in their work.

5. Results

5.1. Current state and spatial distribution of sacred springs in Lviv oblast

The springs of Lviv region are located in the basins of the Dniester, Western Bug, Styr, and Sian. According to the materials of the Basin Management of Water Resources of the Western Bug and Sian Rivers, and the authors' research, there are 454 water springs on the territory of Lviv oblast, 112 of which are sanctified, with a total discharge of 65.94 l/s (Table 1).

Table 1. Sacred springs of Lviv oblast. Source: Based on data from Management of Water Resources of the Western Bug and Sian Rivers headquarters in Lviv) (2023), authors' research.

River basin	Number	Discharge l/s	Springs conditions	
			satisfactory/equipped	in need of improvement/clearing
Dniester	71	54,4	57	14
Western Bug	24	5,76	19	5
Styr	15	5,38	15	–
Sian	2	1,2	2	–
Total	112	66,74	93	19

84% of the sacred springs in Lviv oblast are equipped and in satisfactory condition. The most significant number is located in the Dniester River basin, with a total discharge reaching 54.4 l/s. Out of 71 functioning sanctified springs in this basin, 57 are in satisfactory condition and equipped, while 14 require improvement and cleaning. Undoubtedly, the large number of springs in the Dniester basin is due to the fact that it is the main water artery of Lviv oblast, with a catchment area of 11,420 km² and a length of 207 km within the oblast's borders. The Western Bug River, which has a length of 184 km within Lviv oblast and a basin area of 6,586 km², contains 24 sacred springs, 19 of which are in satisfactory condition and equipped. The length of the Styr River in Lviv oblast reaches 66.8 km; its catchment area is 1840 km². Its basin contains 16 sacred springs, all in satisfactory condition. The smallest number of sacred springs is located in the Sian River basin, where the total discharge reaches only 1.2 l/s.

Lviv oblast is located within two physiographic countries: the plain (southwestern part of the East European Plain) and the mountains (Ukrainian Carpathians) (Fig. 4).

The highest concentration of sacred springs is observed in the plain part of the oblast. The most significant number was recorded in the Roztochia-Opillia Highland physiographic Region (45), particularly in the Mykolaiv-Berezhany physiographic district (33). There are 24 sacred springs in the Precarpathian Highland Region, 17 in the Small Polesia Region, 13 in the Outer Carpathian Region, and 13 in the West Podolia Highland Region. The remaining physiographic regions within Lviv oblast (Volyn Highland Region and Watershed-Verkhovyna Region) occupy relatively small areas, where almost no sacred springs have been recorded.

Regarding the general distribution of sacred springs within Lviv oblast, the following patterns are observed:

- The density of sacred springs increases from northwest to southeast due to the increasing complexity of physiographic diversity;
- Almost all the springs are located according to the following spatial patterns: isolated, blocked (grouped), compact, and dispersed;
- Isolated springs are primarily found in the Regions of Small Polesia and Volyn Highland;
- Blocked springs are common in almost all the physiographic Regions of Lviv oblast.

In terms of spatial density, the following features are observed:

- The compact distribution of sacred springs is observed within the combination of two physiographic Regions: Roztochia-Opillia Highland and West Podolia Highland;

- Small Polesia and Precarpathian Highland Regions exhibit a dispersed structure of sacred springs;
- The relatively uniform distribution of sacred springs is observed only within the Precarpathian Highland Region;
- West Podolia Highland Region is characterised by the densest spread of sacred springs;

There are no sacred springs within the Watershed-Verhovyna Region; nevertheless, some of them may be classified as sacred based on the attitudes of the local population.

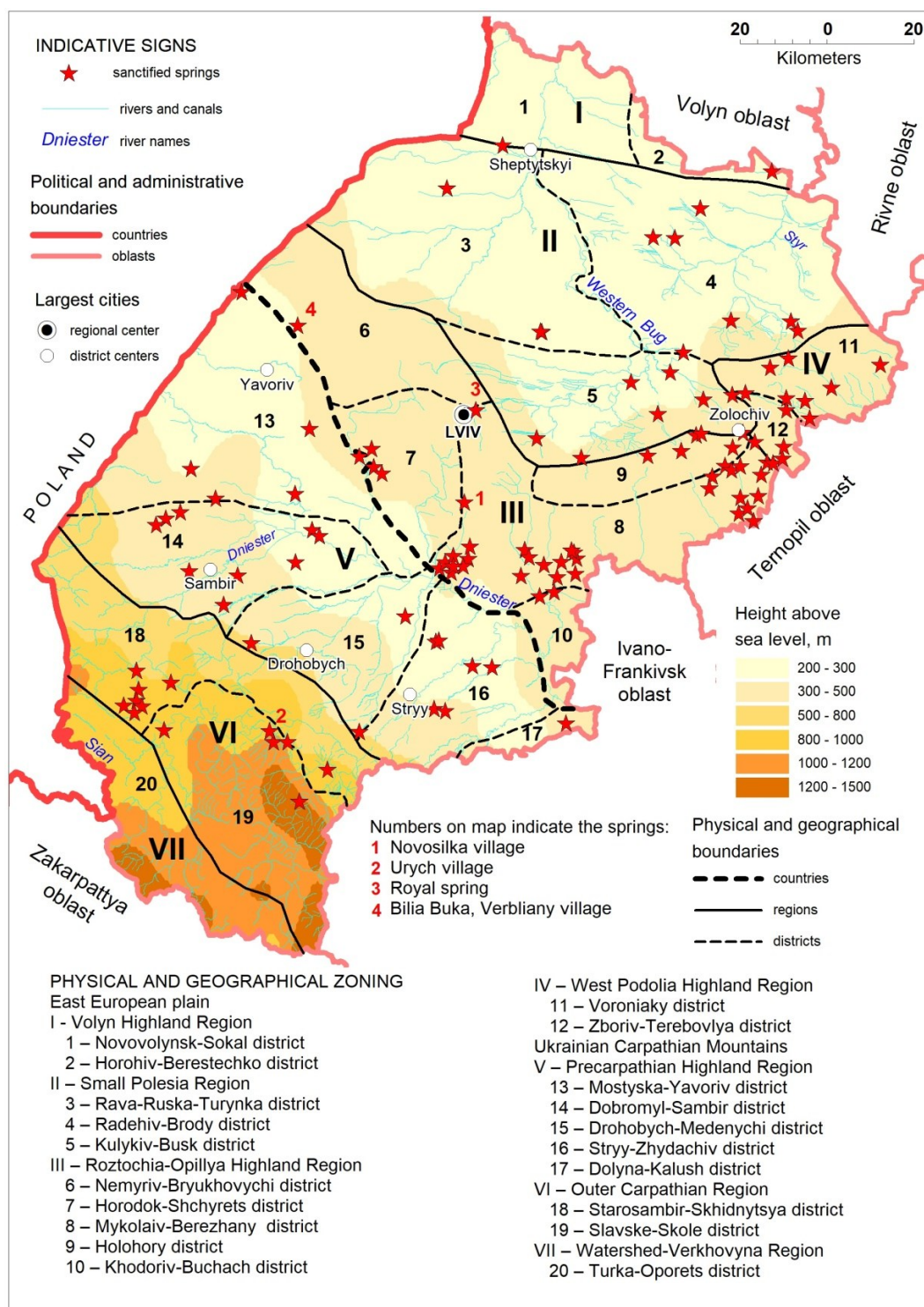


Figure 4. Spatial distribution of sacred springs in Lviv oblast. Sources: Based on data from Management of Water Resources of the Western Bug and Sian Rivers (headquarters in Lviv) (2023); Marynych et al., 2003; processed by authors.

As for the internal distribution of sacred springs within the physiographical regions of Lviv oblast, the following patterns are observed:

- Springs are classified as either internal (located within a region) or limitrophe (spanning multiple regions);
- Internal springs are represented by individual springs and small blocks (groups) of springs;
- Limitrophe springs form significant block formations;
- Blocks consist of four to ten sacred springs located next to each other so that they can be divided into small and large;
- Based on the density of the internal location of springs, the blocks may be divided into compact blocks, dispersed blocks, and mixed blocks (a combination of compact and relatively distant individual springs);
- Compact blocks of sacred springs are typical of the boundary space between the Roztochia-Opillia Highland Region and the Precarpathian Highland Regions;
- Mixed blocks of sacred springs are widespread in the Precarpathian Highland and Outer Carpathian Regions.

Most of sacral springs are located in erosional forms, while a few are confined to the bottom lands of rivers and streams. The oblast's most famous sacred springs attract a large flow of visitors. One of the most famous sacred springs in Lviv oblast and beyond is located 20 km from Lviv, in the village of Novosilka, in the floodplain of the Zubra River (Dniester River basin). The spring flows from under the hill where the church of St. Maccabees is located. The discharge of the spring reaches 2.5-3 l/s. It was formed in the Neogene limestones and sandstones of the Opillia region. Its water is hydrocarbon-calcium in composition with mineralisation up to 0.5 g/dm³. According to general sanitary chemical indicators, water quality belongs to Class 1 ("excellent", very clean water with a bias to a "good" class, clean water of desirable quality) (Didula et al., 2018). In the 1990s, the scientists of the Odesa Institute of Spa Research studied the water of this spring and found a high content of silver in it. The Novosilka sacral spring is well equipped: the area is fenced, the road is paved with cobblestones, a sculpture of the Mother of God has been erected, and a cascade of two basins (for drinking and washing) has been formed for the flow of spring water. According to the legend, the water from this spring cured visitors of various diseases.

In the village of Urych, near the Tustan fortress, a spring brings water from Paleogene flysch formations to the surface. Tectonically, this area belongs to the outer (folding) folded zone of the Carpathians. The discharge of the spring reaches 0.3 l/s. Its water is fresh, has a hydrocarbon-magnesium-calcium composition and mineralisation of 0.28 g/dm³, is characterised by high quality, and meets the requirements of regulatory documents for sanitary and chemical indicators. Water quality, according to general sanitary chemical indicators, belongs to Class 1 ("excellent", spotless water with a bias to a "good" class, clean water of desirable quality) (Didula et al., 2018). The sacred landscape, based on which this spring functions, is well equipped, catering to the visitors' spiritual and cognitive needs. It has been complemented by the Church of the Holy Trinity construction and a chapel with a sculpture of the Mother of God. According to the legend, in ancient times, the defenders of the Tustan fortress used water from the spring. According to the visitors' folk stories, spring water helps to heal diseases.

On the outskirts of Lviv, on the slope of High Castle from the Pidzamche side, the *Royal Spring* is located. Geologically, the spring was formed in the sands and limestones of the Opillia formation of Lower Baden. The fresh spring water has a sulphate-hydrocarbon-calcium chemical composition of sulphate-hydrocarbon-calcium and mineralisation of 0.97 g/dm³. High hardness and nitrate content indicators do not ensure spring water compliance with drinking water requirements (DSanPiN, 2010). In the archival documents of Lviv, this spring is mentioned as early as 1510. The territory is equipped, and a statue of the Mother of God was installed there. The spring is a place of pilgrimage and recreation for Lviv residents and city guests. The *Royal Spring's* water pollution reduces this sacred landscape's functionality making it more suitable for spiritual, educational, and recreational purposes rather than drinking needs.

In the valley of the Volena River (Sian River basin) near the village of Verbliany, the sacred spring *Bilia Buka* (literary "Near the Beech") is located, which draws water from Neopleistocene alluvial deposits. Its water is weakly mineralised, with a hydrocarbon-calcium-sodium composition and 1.15 g/dm³ mineralisation. However, due to its high sodium content, it does not meet drinking water standards (DSanPiN, 2010). Although ammonium, nitrate and nitrite levels do not exceed maximum permissible limits, their relatively high concentrations indicate weak aquifer protection from pollution. The water quality, according to general sanitary chemical indicators, belongs to Class 2 ("good", clean water of acceptable quality) (Didula et al., 2018). The spring is well-equipped. A well was built here, and a statue of the Mother of God was constructed. According to the folk stories of spring visitors, its water was helpful for many illnesses. Around the sacred site are earth ramparts used in the past by the village's inhabitants as a refuge to hide from the enemy during the military events of the 17th century.

Our research shows that most of the sacred landscapes in Lviv oblast, which include sanctified springs, are in satisfactory condition. They have transport accessibility, which is determined by the presence of a road with a hard surface, equipped with a swimming pool, and are surrounded by green spaces. In addition, churches/chapels were built near the springs, and statues of the Mother of God were constructed, enhancing this landscape's sacrality. These landscapes contribute to tourism and recreation, attracting local residents and visitors from other regions.

5.2. Current state and spatial distribution of sacral springs in Volyn oblast

According to the data from the Regional Office of Water Resources in Volyn oblast, there are 90 natural water springs within this territory, 61 of which are sanctified (Fig. 5). The studied area generally belongs to the basins of two rivers – the Prypiat and the Western Bug, which are separated by the European Watershed. The Styr River is a right tributary of the Prypiat River and flows through the Lviv, Volyn, and Rivne oblasts of Ukraine. There are 51 sacred springs in the Prypiat River basin, 43 of which are in satisfactory condition, while 8 require improvement. The Western Bug River basin is located in the western part of the Volyn Polesia and the Volyn Upland. In this basin, 10 sacred springs have been recorded, 8 of which are in satisfactory condition, while 2 require improvement (Table 2).

The analysis of the spatial location of natural springs in the structure of physiographic regions reveals that within the boundaries of the Polesian part of the studied territory (Volyn Polesia) there are 74 springs, 49 of which are sanctified, while in the Volyn Highland physiographic region, there are 16 springs, 12 of which are sanctified. This disproportion is explained primarily by the larger area of the Volyn Polesia (80.2%) compared to the Volyn Highland (19.8%) within the studied territory.

According to the physiographic zoning of Ukraine, Volyn oblast is located within two physiographic regions: Volyn Polesia and Volyn Highland (Marynych et al., 2003). There are 7 physiographic districts within Volyn Polesia. 19 sacred water springs are recorded in the High Prypiat physiographic district and 12 in the Liuboml-Kovel district. These springs are mostly limited to the Turiya River and the Vyzhivka River basins. 5 sacred springs are recorded in the Kolky-Sarny physiographic district, 3 in the Manevychi-Volodymyrets district, four in the Turiysk-Rozhyshche district, 4 in the Kivertsy-Tsuman district, and 2 in the High Prypiat district.

Table 2. Sacred springs of Volyn oblast. Source: Regional Office of Water Resources in Volyn oblast (headquarters in Lutsk) 2023, authors' research.

River basin	Number	Springs conditions	
		satisfactory/equipped	in need of improvement/clearing
Prypiat	51	43	8
Western Bug	10	8	2
Total	112	93	19

The Volyn Highland physiographic Region includes four physiographic districts. The most significant number of sacred water springs is found in the Lokachi-Torchyn physiographic district (5), followed by Novovolynsk-Sokal (5) and Olyka-Rivne (2) districts.

Regarding the general distribution of sacred springs within Volyn oblast, the following patterns are observed:

- Sacred springs form a ring around the central area of the oblast, where non-sacred springs are densely located;
- The spatial distribution of almost all the springs shows the following spatial patterns: isolated, double, blocked (grouped), compact, dispersed, and ribbon;
- The isolated spring pattern mainly belongs to the Turiysk-Rozhyshe district of the Volyn Polesia Region and the Olyka-Rivne district of the Volyn Highland Region;
- The double pattern is inherent in the Lokachi-Torchyn district of the Volyn Highland Region;
- The blocked pattern is common in the High Prypiat district and on the border between it and the Liuboml-Kovel district;
- The ribbon pattern is typical of the Verkhno Prypiat district, where a ribbon cluster of sacred springs extends from the district's centre to the border with the Liuboml-Kovel district. A ribbon cluster of springs stretches from the north to the south. It consists of four springs. A larger ribbon cluster of sacred springs stretches from the northwest to the southeast from the High Prypiat to the Kolky-Sarny district. It consists of at least eight springs;
- 40% of the sacred springs of Volyn oblast are located near inter-district borders; this indicates that a significant amount of underground water is wedged out here.

The distribution density of sacred springs follows these patterns:

- The compact spatial location of sacred springs is observed within the High Prypiat district and the combination of three physiographic districts: Liuboml-Kovel, Manevychi-Volodymyrets and Kolky-Sarny;
- Turiysk-Rozhyshe district of the Volyn Polesia Region and the Olyka-Rivne district of the Volyn Highland Region both have a dispersed pattern of the sacred springs;
- The homogeneity of the distribution of the sacred springs characterises none of the physiographic regions of Volyn oblast;
- The densest distribution of sacred springs is observed in Verkhno Prypiat district of the Volyn Polesia Region;
- No sacred springs exist within the Horokhiv-Berestechko district of the Volyn Highland Region. However, according to the attitudes of the local population to some of them, they can be classified as sacred.

The internal distribution of sacred springs within physiographic regions and districts follows these patterns:

- According to their location, sacred springs are divided into internal and limitrophe springs;
- Internal springs are represented by individual springs and small blocks (groups) of springs;
- Limitrophe springs are large block formations between the High Prypiat and Liuboml-Kovel districts;
- The blocks consist of three to ten sacral springs located next to each other, so they can be categorised as small and large; all of them are observed in the High Prypiat district;
- According to the internal density of the springs in a block, the blocks are divided into compact, dispersed, and mixed (a combination of compact and relatively distant springs);
- Compact blocks of sacred springs are characteristic of the boundary space between the Verkhno Prypiat and Liuboml-Kovel districts of the Volyn Polesia Region;
- Dispersed blocks are typical of the Liuboml-Kovel district on the border with the High Prypiat district;
- Mixed blocks of sacred springs are characteristic of the High Prypiat district.

Regarding the location of sacral springs within the basin systems, as in Lviv oblast, the most springs are confined to the basins of rivers and streams. At the same time, a significant number of them are located within erosive landforms.

The following paragraphs consider Volyn oblast's most famous sacral/sanctified springs. One such spring is located in the interfluvium of the Western Bug River and its right tributary, the Luga River, near Budiatchi village, Volodymyr-Volynskyi district, Volyn oblast. The first aquifer from the surface within the spring is located in Turon-Senone deposits of the Upper Cretaceous, which is fed by the infiltration of atmospheric precipitation and the inflow of waters of tectonic disturbances from the depth. This aquifer is separated from the upper quaternary water complex by a layer of Cretaceous chalk and marl. The spring itself became known for its healing properties as early as 1637 (Tourist Volyn, 2010). According to the folk stories, at that time, an icon of the Mother of God appeared near the spring, which was later brought to the Budiatchi church. According to the testimony of the village's old residents, the water of this spring cured various diseases. In Soviet times, local communists repeatedly tried to destroy the spring. In the 60s of the XX century, the chapel on the spring site was demolished, and the spring was covered with earth. The old-timers of the district say that people from all over the village came together to restore the spring. Secretly, at night and dawn, they came there to worship the holy place. Today, a well has been built at the spring, and a chapel is next to it (Fig. 6).

The next site became an object of pilgrimage not only for Ukrainians but also for tourists from abroad. In the village of Stara Lishnia of Volodymyr district in Volyn oblast, there is a fresh, sanctified spring of the Holy Spirit. The spring was formed in the Upper Cretaceous deposits. Their fissures determine the water-bearing capacity of this layer of rocks. The old-timers of the village claim that the water from the spring was helpful to those with vision problems. During Soviet times, the spring was neglected. In the 1990s, the residents purchased the abandoned estate

where the spring is located. The spring was arranged and cleaned, and the crosses were restored. To further enhance the sacrality of this site, a sculpture of the Mother of God was brought from Zakarpattia. Today, this place serves as a source of drinking water and a sacred site for worship. Regular efforts are made to maintain the sacred landscape and preserve the spring.

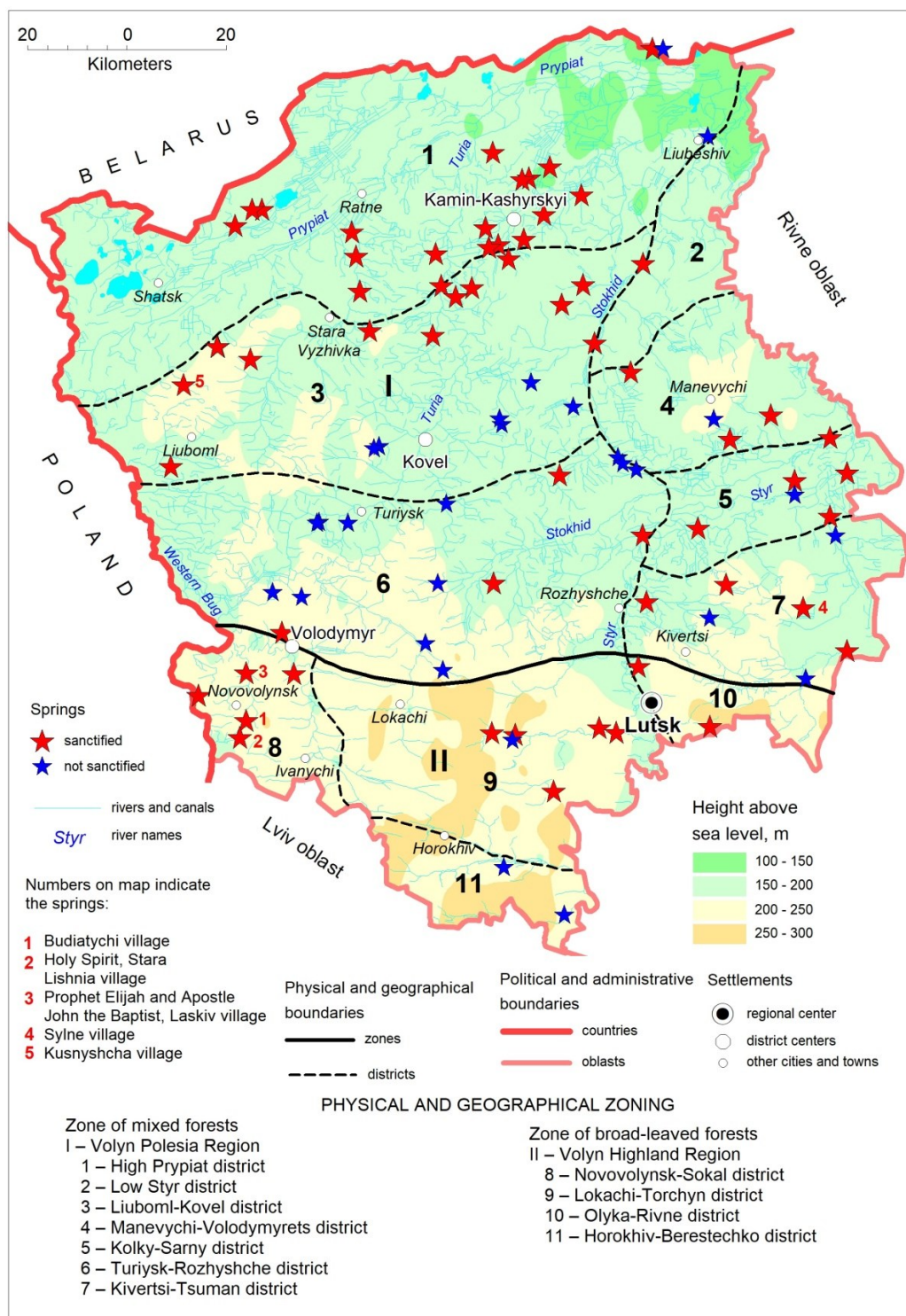


Figure 5. Spatial distribution of sacred springs of Volyn oblast. Sources: Based on data from the Regional Office of Water Resources in Volyn oblast (the town of Lutsk) (2023); Marynych et al., 2003; authors processing.

Near the village of Laskiv (Volodymyr district, Volyn oblast), there is a fresh spring dedicated to the Prophet Elijah and John the Baptist. Hydrogeologically, the spring was formed where the first aquifers from the surface are common in the current marsh alluvial deposits. The average groundwater depth here ranges from 1.25 to 1.50 m. In 1888, the residents of the village of Orany built a church in honour of the Intercession of

the Holy Mother of God, and the spring next to the church was revered as a holy place. Local villagers still consider the water from the holy spring to be healing, as evidenced by numerous cases of healing from diseases. At the end of the 1950s, the church was destroyed, and the village of Orany disappeared. Consequently, the sacred spring also fell into decline. In 2010, on the day of commemoration of the Prophet Elijah, the monks from the Nyzkynytskyi Monastery sanctified this spring. They reinforced the path to it with plans to construct a bathhouse. However, today the path to the spring is overgrown with grassy vegetation, and the spring is silted up (Fig 7).

The saltiness of the spring is explained by the flat terrain of this area and its location within the river floodplain. The spring has a descending character (it is fed by headwater and pressure-free interlayer groundwater). Usually, such springs function only during rainfall and infiltration of atmospheric precipitation, while they dry up during the dry periods of the year.



Figure 6. Sacred spring near the village of Budiatchi (Volodymyr district, Volyn oblast). Source: The Bug, 2016.

Seven kilometres from the village of Sylne, Lutsk District, Volyn Oblast, there is a well in the forest, whose water, according to folk stories, healed the sick. People used to pray here for a long time in case of drought. Geologically, this area is composed of chalk and marl. The first aquifers from the surface are located in the upper and mid-quaternary eolian deluvial deposits. On May 6, 2011, the priests sanctified the chapel, which was built over the well. The well is known for the fact that people used to pray near it in times of drought and on the day of the Great Martyr Saint George. Elderly residents have spoken of several healings that took place at this site.



Figure 7. The spring of the prophet Elijah and John the Baptist (Volodymyr district, Volyn oblast): (a) April 2012; (b) April 2022. Sources: (a) Healing springs of Ukraine, n. d.); (b) own photography.

Not far from the village of Kusnyshcha, Kovel district, Volyn oblast, there is a fresh spring, which, according to the folk stories, helps people with kidney and liver diseases and getting rid of smoking. Here, the first aquifers from the surface are located in the upper and mid-quaternary eolian deluvial deposits. Today, a chapel has been installed at the water spring.

6. Discussion

Sacred landscape studies represent a branch of cultural geography that integrates scientific achievements from various fields, including the humanities, social and behavioural sciences, natural sciences, architecture and construction, as well as the service sector (Mishchenko, 2022). The combination of geospatial analysis and historical approaches enables studying the spatial organisation of sacred landscapes (Vargha & Eichert, 2025). Unlike existing approaches (Park, 1994; Volovyk, 2013), this study examines sacred objects (temples, springs, caves) not as isolated entities but as elements embedded in a specific environmental context that interact with them. After all, studying sacred springs without considering their physiographic characteristics, such as hydrogeology, geomorphology, and climate is impossible. This is especially relevant for the sacred springs of Volyn oblast and the lowland part of Lviv oblast, which are often silted up and overgrown with grass. An analysis of the physiographic conditions for spring formation in Lviv oblast shows that they typically emerge in erosional landforms (Nazaruk, 2018), while in Volyn oblast, their formation is primarily linked to groundwater confined within karst massifs (Mishchenko, 2018a). When studying a sacred landscape, it is essential to consider not only its physiographic characteristics but also the cultural elements associated with sacralisation tools, such as traditions, customs, and spiritual practices (Mishchenko, 2018b). The planning of sacred landscapes, in which sacred springs serve as key markers, differs between Lviv and Volyn oblasts. In Lviv oblast, the improvement of sacred springs typically includes the installation of a statue of the Mother of God, while in Volyn oblast they are usually equipped with a well and a chapel (a small temple).

Sacred springs can be protected as components of various categories within Ukraine's nature reserve fund, including national nature parks, hydrological reserves, landscape art parks, and hydrological monuments, etc. However, most sacred springs in Lviv and Volyn oblasts lack protected status. In Volyn oblast, only three of 61 consecrated springs are officially protected as hydrological natural monuments. However, a significant proportion of these springs are located near territories and objects of the nature reserve fund. Therefore, it is advisable to consider partially expanding protected area boundaries in Lviv and Volyn oblasts to include sacred springs within their conservation frameworks.

7. Conclusions

A water spring is a landscape component, influencing the state of surface waters and maintaining a close connection with the hydrogeological environment. The spatial structure of the sacred landscape, marked by a sacred spring, encompasses a landscape component that integrates abiotic natural elements (hydrological, hydrogeological, geomorphological, climatic, soil), as well as flora and fauna. Additionally, it includes an anthropogenic-technogenic component, represented by elements such as wells, pools/baths, chapels, churches, etc. The interpretation of the sacredness of the spring and the entire landscape is inherently subjective, depending on human interpretation through the lens of myths, legends, and stories of miraculous healing.

There are 454 water springs in the Lviv oblast, 112 of which are consecrated. The highest concentration is found within the Dniester River basin, where 71 consecrated springs have been recorded: 57 are in satisfactory condition and properly maintained, while 14 require improvement and cleaning. At the same time, there are 90 water springs within the Volyn oblast, 61 of which are consecrated. The largest number of them was formed in the Prypiat River basin. In total, 51 sacred springs have been recorded in the region, which are well-maintained and equipped, while 10 require improvement. There are 454 water springs in the Lviv oblast, 112 of which are consecrated. The largest number of them is confined to the Dniester River basin, where 71 consecrated springs have been recorded, 57 of which are in satisfactory condition and equipped, and 14 require improvement and cleaning.

Sacred springs, as markers of sacred landscapes play a crucial role in their formation and serve as significant spiritual landmarks within society. While they fulfil a natural function in maintaining the region's water balance, they also act as focal points for forming of certain social groups, sometimes extending their influence far beyond the immediate boundaries of the sacred landscape itself.

The individuality of the sacred spring formation is determined by the peculiarities of the geological basis in which they are formed and the surrounding landscape environment. It shapes the specific conditions of the spring's existence and influences its long-term development.

The occurrence, spatial distribution, and functioning of consecrated springs, which contribute to the formation of sacred landscapes, represent a scientific challenge in understanding the cultural organisation of sacredly oriented cultural landscapes.

Using a landscape approach has enabled a spatial analysis of the location of sacred springs within various physiographic formations. The revealed patterns of their spatial distribution across Lviv and Volyn oblasts indicate that their placement, concentration, and functioning are closely linked to the characteristics of the surrounding natural environment (Petlin & Mishchenko, 2022).

Various types of groupings of sacred springs have been identified, in particular: ribbon, double, dispersed, isolated, compact, and blocked (Mishchenko, 2024). In our article, these spatial patterns were established through the cartographic data analysis, which provided insights into the overall distribution and density of sacred springs in Lviv and Volyn oblasts (Ukraine). A sacred landscape based on one or multiple springs requires developing specialised organisational, landscape-planning and conservation mechanisms for sustainable natural resource management. The development of such mechanisms at the theoretical, methodological and applied levels will be the focus of our further research.

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