GLL
Geomatics, Landmanagement and Landscape No. 3 • 2025, 147–161

ISSN 2300-1496 https://doi.org/10.15576/GLL/210440

*Research paper*

Received: 4.08.2025
Accepted: 8.09.2025
Published: 30.09.2025

# Environmental valorisation through GIS and photogrammetry: a framework for sustainable land use in southern Poland

Izabela Piech[1] 0000-0002-6710-4387
Aneta Dacko[1]

[1] Department of Agricultural Surveying, Cadastre and Photogrammetry, University of Agriculture in Krakow
✉ Corresponding author: rmpiech@cyf-kr.edu.pl

**Summary**

Environmental valorisation plays a crucial role in comprehensive understanding and effective man agement of the complex interactions between natural and anthropogenic landscape components a. It is particularly relevent in areas characterized by varied topography, rich ecological diversity, and increasing human pressure, such as the Limanowa region in southern Poland. The study presented here utilized Geographic Information System (GIS) tools in combination with high-resolution aerial photogrammetry to conduct a detailed environmental assessment of this mountainous area. By focusing on key environmental parameters, including vegetation cover, hydrological networks, and terrain morphology, the research employed spatial analysis alongside both qualitative and quantitative evaluation methods. The results of the study underscore the central importance of terrain relief, which emerged as the most influential environmental factor shaping local ecological patterns. The diverse landforms not only dictate the distribution and composition of vegetation but also guide the configuration of natural watercourses and valleys. Despite covering only 17% of the total area, forested zones were identified as crucial ecological corridors that support biodiversity, enhance connectivity, and act as natural buffers against erosion and climate extremes. Additionally, the presence of natural streams and valley systems contributes to the functional integrity of the landscape and enriches its aesthetic value, making the region attractive for nature-based tourism and outdoor recreation. However, the analysis also identified significant environmental constraints. The prevalence of steep slopes and areas with low soil fertility poses notable challenges for agriculture and limits the potential for urban expansion. These physical limitations necessitate a cautious and well-informed approach to spatial planning, especially when it comes to balancing conservation goals with the socio-economic aspirations of local communities. To synthesize these findings, the study integrated a set of thematic maps with a 3D numerical terrain model (NTM), providing a multidimensional understanding of environmental interrelations. This integrative approach allowed for the identification of zones with high ecological value, areas susceptible to degradation, and locations suitable for specific forms of land use or protection. Ultimately, the research offers a practical and replicable methodology for regional planners, environmental managers, and policymakers aiming to develop sustainable land-use strategies. It demonstrates how environmental valorisation can support informed decision-making that reconciles ecological integrity with human development, particularly in regions with complex landscapes and environmental sensitivities.

**Keywords**

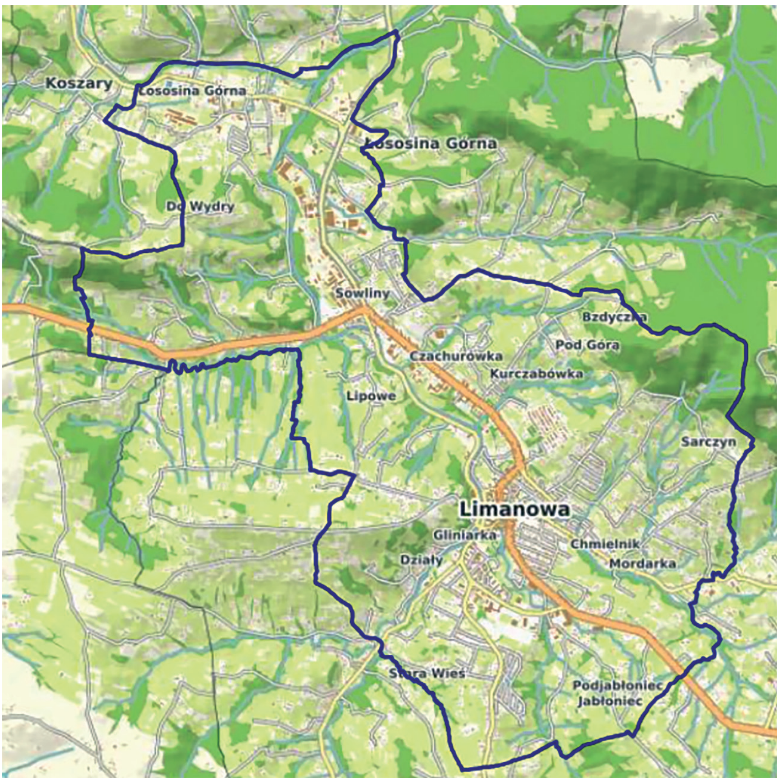
environmental valorisation • aerial photogrammetry • GIS • 3D modelling • landscape assessment • sustainable development

## 1. Introduction

The environment that humans live is is a complex system of interconnected elements and relationships. Understanding and accurately describing these relationships pose significant challenges across natural, economic, and social sciences. Due to its inherent complexity and diversity, there is an ongoing pursuit of robust and reliable methods for environmental assessment. A crucial advancement in this field has been the application of photogrammetric and remote sensing data. These technologies have broadened the analytical scope for evaluating natural and anthropogenic elements, significantly enhancing the precision and objectivity of valorisation processes. Aerial photographs, in particular, have become indispensable in spatial analysis, measurement, and qualitative assessments due to their high resolution and data quality. However, the effective processing of photogrammetric data in environmental studies requires specialised tools capable of conducting advanced analyses of both natural and anthropogenic features. GIS (Geographic Information Systems) tools have emerged as an essential solution to these challenges. By integrating photogrammetric data, GIS facilitates multi-perspective assessments of environmental components and provides an effective platform for their visualisation. Moreover, the advanced analytical functions of GIS support decision-making processes, promoting land-use planning that aligns with the unique characteristics and values of specific areas. The aim of this study is to evaluate the environmental components of the Limanowa region using GIS and aerial photogrammetry. The study focuses on three key elements: vegetation cover, hydrological networks, and terrain relief, aiming to identify their ecological, tourist, and developmental potential. The results are intended to provide insights into sustainable land-use planning and conservation strategies for the region.

## 2. Research area

The study was conducted in southern Poland, within the Małopolskie Voivodeship, specifically in the city of Limanowa and its surrounding areas (Fig. 1). The research area covers 18.64 km$^2$ and exhibits diverse land use patterns, comprising urbanised areas (47%) and agricultural and forest land (53%). A distinctive feature of the region is its varied topography, characterized by the isolated hills of the Beskid Wyspowy range and limited forest cover. The environmental characteristics of Limanowa are intrinsically linked to its physical and geographical setting. The region's diverse topography and elevation significantly influence local climatic conditions, soil properties, and vegetation patterns. The dominant soils in the area are have low agricultural value, with approximately 90% belonging to classes IV and V, while higher-quality soils (classes I and II) are completely absent. The region's soil profile is predominantly composed of a cereal-mountain soil complex, with most soils exhibiting poor permeability. Forest cover in the study area is relatively limited due to the high proportion of land allocated to agriculture and urbanisation. Forested areas are primarily situated on the hills and consist mainly of mixed and beech forests, contributing to the ecological and aesthetic value of the landscape. The hydrological network of the Limanowa region includes numerous mountain streams, which converge into the Sowlinka River.Shaped by the region's topography, these watercourses play a crucial role in maintaining biodiversity, regulating local hydrological processes, and enhancing the scenic value of the area.




Source: Authors' own study

**Fig. 1.** Administrative boundaries of Limanowa

## 3. Methodology

### 3.1. Data acquisition and preparation

The study utilised aerial photographs as the primary data source, captured with a Leica RC20 aerial camera. These high-resolution images formed the basis for spatial analyses and environmental valorisation. A topographic map aligned to the PUWG1992 coordinate system served as the geospatial reference, ensuring precise alignment and metrical accuracy. The initial stage of the methodology involved creating a geodatabase in the ArcGIS environment, which served as a central repository for all spatial data used in the study.

### 3.2. GIS-based analysis

The valorisation process commenced with a preliminary identification of the features of the study area. Environmental elements such as vegetation, hydrology, and topography were represented as thematic layers within the GIS project. Each element was digitised as a shapefile vector layer, enabling detailed analysis and visualisation.

### 3.3. Topographic relief analysis

The topographic relief was analysed to understand the terrain's influence on environmental components. Interpolated points representing elevation above sea level were processed using the 'Spline' method, which provided an accurate and visually coherent representation of the terrain. Based on the elevation raster, additional steps in spatial analyses were conducted:

- Terrain exposure analysis: determining the geographical orientation of slopes.
- Contour line generation: creating precise isolines to represent terrain changes.
- 3D terrain surface creation: producing a realistic three-dimensional model of the relief.
- Slope analysis: evaluating the steepness of slopes to understand their impact on land use and hydrology. These analyses generated various raster data layers, which were further refined for optimal presentation and usability.

### 3.4. Numerical Terrain Model (NMT) creation

The final stage of the relief analysis involved generating a numerical terrain model (NTM) using the ArcScene application. This 3D model received graphical post-processing, including adjustments to shading, contrast, and colour schemes, to improve its clarity and visual appeal. The resulting model was saved in two formats: a 2D graphic for integration into maps and reports, and an ArcScene file for interactive visualisation.

### 3.5. Tools and software

The entire analysis was conducted using the ArcGIS software suite, which provided a comprehensive platform for multi-level data processing and visualisation. The software facilitated data acquisition in various formats and supported advanced 2D and 3D geo-design functionalities. These tools proved instrumental in integrating aerial photogrammetry with GIS, enabling precise spatial analyses and effective visualisation of environmental elements.

## 4. Literature review

### 4.1. Concept of environmental valorisation

Humans interact with a complex and dynamic environment that sustains life and provides essential resources for social and economic development. The Environmental Protection Law defines the environment as 'the totality of natural elements, including those transformed as a result of human activity.' These elements include land surfaces, water bodies, climate, and landscapes. Landscapes, while often overlooked, play a critical role in environmental assessment and management due to their spatial, ecological, and functional importance [Solecka i in. 2019].

Environmental components can be broadly divided into natural and anthropogenic categories. Natural elements, such as geological formations, soil, and water systems, are shaped over millennia by natural processes [Matuszkiewicz i in. 1999]. In contrast, anthropogenic elements reflect human influence and are often linked to social phenomena, such as urbanisation and infrastructure development [Litwin i in. 2017]. The concept of valorisation refers to assigning value to environmental elements and identifying optimal land-use functions based on their characteristics. Valorisation is essential for balancing natural and anthropogenic components to support sustainable development by integrating environmental, social, and economic perspectives [Šiljeg i in. 2021]. In geographical sciences, valorisation specifically focuses on assigning value to environmental features and determining their benefits for social needs [Bródka 2007]. Landscape valorisation, a subset of environmental valorisation, places particular emphasis on spatial, aesthetic, ecological, and functional features of landscapes. It assesses their ability to support human activities, maintain biodiversity, and improve quality of life. This approach is particularly relevant in areas undergoing rapid urbanisation or land-use changes, where sustainable spatial planning is critical [Buława 2024].

### 4.2. Landscape valorisation: methods and phases

Landscape valorisation employs a variety of methods, including GIS-based tools, quantitative indices, and ecological assessments. GIS tools facilitate detailed spatial analyses, enabling data visualisation, land-use evaluation, and hydrological studies [Solecka 2017]. These tools are often integrated with models such as the landscape valorisation method to identify areas of high ecological or socio-economic potential

[Interreg Central Europe 2018]. GIS has proven particularly effective in evaluating landforms, climatic conditions, and biodiversity, supporting ecosystem-based management approaches [Šiljeg 2021]. Quantitative approaches such as site significance indices provide measurable indicators for assessing agricultural, urban, and tourism potential. These indices incorporate natural, demographic, and economic parameters, presenting results in form of numerical data that support evidence-based decision-making [Litwin 2012]. Complementary taxometric techniques, including the Wroclaw dendrite and the Ward method, classify regions based on environmental similarities, increasing precision in land-use recommendations [Litwin 2017]. Ecological valorisation is another critical aspect, focusing on biodiversity and ecological functionality. It evaluates landscape connectivity, species richness, and ecosystem services such as carbon sequestration and flood regulation. These ecological criteria play a pivotal role in supporting biodiversity conservation and climate adaptation strategies [Grêt-Regamey 2014].

The valorisation process typically follows two key phases [Bródka 2005]:

1. Diagnosis and analysis: This phase involves collecting comprehensive data on the environment, including spatial, qualitative, and quantitative information. The scope of analysis may be thematic (focusing on specific elements) or broad, covering multiple environmental aspects.
2. Synthesis and prognosis: The second phase integrates findings to identify optimal land-use strategies that balance environmental, social, and economic factors. It also includes forecasting the impacts of planned activities on the environment to ensure sustainable development.

### 4.3. Role of aerial photography in environmental valorisation

Aerial photographs have become a cornerstone in environmental valorisation, enabling the acquisition of both qualitative and quantitative data on natural and anthropogenic features. Their high resolution, spectral accuracy, and cartometric nature make them indispensable tools for spatial analysis. The integration of aerial photographs with technologies such as LiDAR further increases their utility, allowing for the incorporation of three-dimensional parameters, such as vegetation height and terrain profiles [Kokalj 2011]. Advancements in photogrammetric and remote-sensing techniques have significantly improved the resolution, radiometric quality, and temporal precision of aerial images, generating more accurate environmental interpretations [Lillesand 2020, Mancini 2019, Hejmanowska 2007, Nita 2007]. Studies highlight that photogrammetric images reduce the subjective element in the process of assessing terrain relief and environmental features by providing precise measurements. Moreover, modern machine learning algorithms have further automated the classification and analysis of aerial photographs, increasing efficiency and reducing human error [Ma 2019]. Aerial photogrammetry also plays a key role in creating numerical terrain models (NTM), which provide detailed representations of terrain features and their spatial relationships. These models support both qualitative and quantitative assessments, identifing the most valuable environmental elements [Nita

2005]. The use of aerial photographs extends beyond environmental assessment to applications in tourism planning. For example, features such as relief, vegetation, and surface waters can be evaluated for their aesthetic and functional suitability for recreational activities [Piech 2011]. However, the effectiveness of photogrammetric data varies depending on the environmental component being assessed. Factors such as the structural characteristics of the terrain and the quality of the imagery influence the precision of the analysis. To address these limitations, integrating aerial photographs with other remote-sensing data, such as satellite imagery or LiDAR, is recommended [Cracknell 2018, Dworak 2005].

## 5. Results of valorisation of environmental elements based on aerial photographs

The primary objective of the analyses and their graphical interpretation was to valorise the environmental elements in the Limanowa area and its surroundings. The key components considered in the analysis were vegetation, the hydrological network, and relief. These components were evaluated both qualitatively and quantitatively, with aerial photographs serving as the foundational data source. Based on these photographs, three main environmental elements were identified and assessed in detail.

### 5.1. Vegetation cover

The vegetation cover in the study area predominantly consists of forests and numerous wooded areas. Land cover analysis identified three major, compact forest complexes:

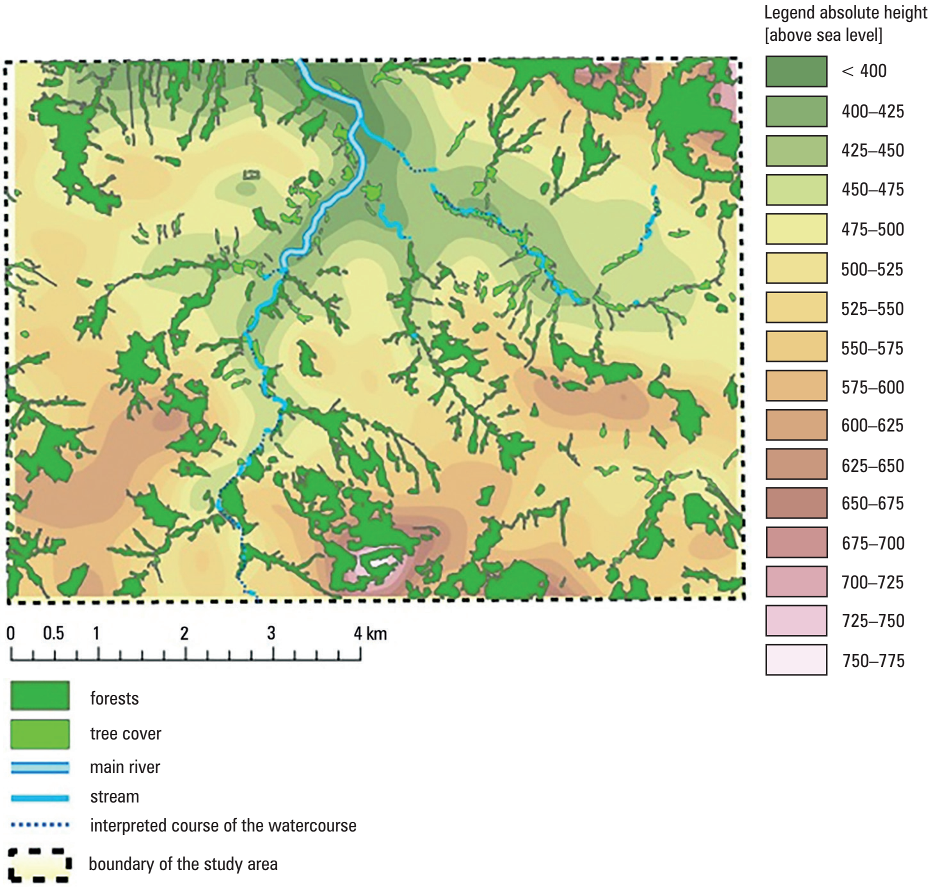
- North-western complex: ~52 ha
- North-eastern complex: ~82 ha
- Southern complex: > 82 ha

In addition to these, 126 smaller forest areas and 137 polygons representing various types of woodland were identified. A summary of vegetation area coverage is presented in Table 1.

**Table 1.** The structure of the plant cover in the analyzed area

| Type flora of | Area [ha] | Share in the total land area [%] |
|---|---|---|
| Forests | 902,0407 | 17,21 |
| Tree cover | 110,1460 | 2,10 |
| **Together** | 1012,1867 | 19,31 |

Based on the aerial photographs, the largest forest communities are concentrated in the north-eastern and southern parts of the study area, in the map of selected environmental elements (Fig. 2).




Source: Authors' own study

**Fig. 2.** Map of selected environmental elements

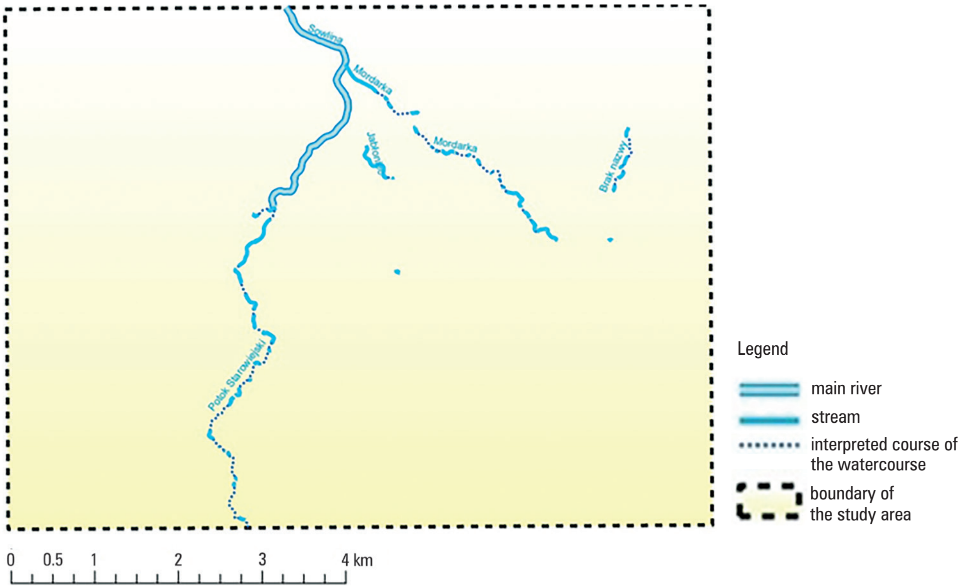
In contrast, the central and northern parts of the area are characterized by sparse forests, primarily due to the urbanized landscape of Limanowa and the associated anthropogenic land use. The spatial distribution of forests and wooded areas, as shown on the map of selected environmental elements, reveals two main patterns: compact forest complexes in elevated areas and irregular, elongated forms following hydrological features such as rivers and streams.

Compact forested areas are primarily located in the elevated north-eastern and southern parts of the study area. These areas, unsuitable for agriculture due to steep slopes, provide valuable ecological and aesthetic resources. In contrast, the elongated and irregularly shaped forest areas along rivers and streams highlight the relationship between vegetation cover and the hydrological network. The study indicates that most forests in the area are deciduous or mixed, with irregular boundaries that blend into adjacent agricultural lands. Although, the irregular and asymmetrical distribution of forests enhances the area's landscape value and contributes positively to tourism, this lack of a clear agro-forestry boundary restrains agricultural development. Forests cover only 17% of the total study area, a proportion significantly lower than the national average. Despite this, the spatial variation in vegetation cover, shaped by natural and anthropogenic factors, represents an important environmental and landscape asset.

### 5.2. Hydrological network

The hydrological network in the study area is well-developed and includes five main watercourses, primarily located in the central and north-eastern parts (Fig. 3). Two dominant watercourses extend from the northern to the southern boundaries of the study area:

1. Sowlina River (length: 3499 m), flowing in the northern part.
2. Starowiejski Stream (length: 5186 m), feeding the Sowlina River from the south.




Source: Authors' own study

**Fig. 3.** Hydrological network map

Additionally, three smaller streams contribute to the hydrological network, which spans nearly 10 km (Table 2). Mountain streams, characterized by their natural flow and role in the preservation of biodiversity, are integral to environment and landscape.

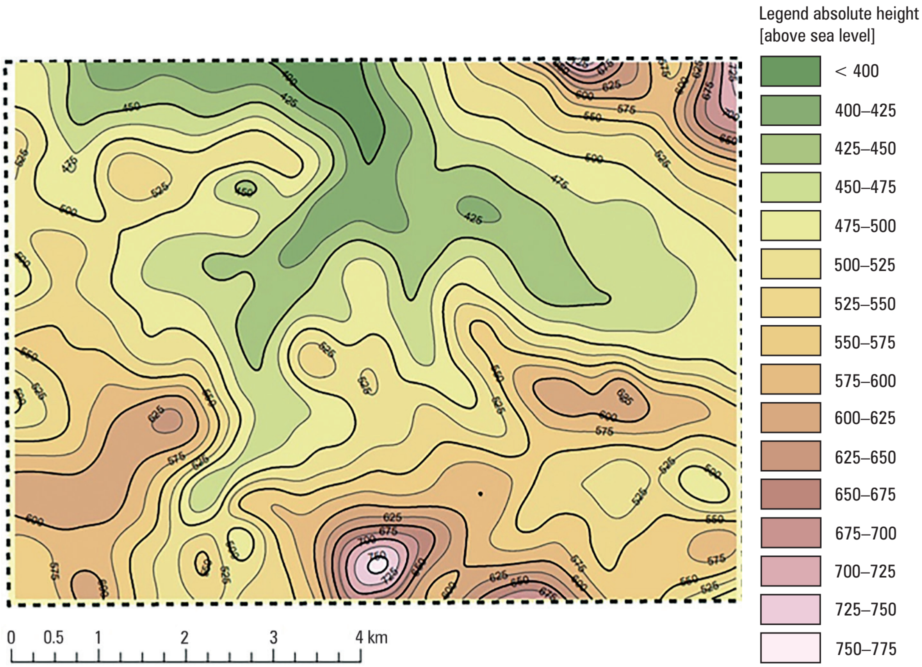
The spatial distribution of rivers and streams is closely linked to the area's relief. The Sowlina River flows through the central valley, and it is fed by tributaries originating from the hills in the north-east and south. In areas where streams are not directly visible in aerial photographs, their courses were inferred from the layout of adjacent environmental features, such as elongated woodlands. The hydrological network is a critical environmental asset, contributing to biodiversity, landscape aesthetics, and tourism. Its relatively high density and natural character add significant ecological and recreational value to the region.

**Table 2.** Structure of the hydrological network in the analyzed area

| Type of watercourse | Length [m] |
|---|---|
| Rivers | 3498,71 |
| Streams | 6189,02 |
| Together | 9687,73 |

### 5.3. Relief

The relief of the study area is a prominent environmental feature, characterized by significant variability and diverse geomorphological forms (Fig. 4). Elevations decrease consistently from south to north, with the lowest points (~376–400 m above sea level) located in the river valleys in the northern part and the highest points exceeding 700 m above sea level in the hills of the south and north-east. The average elevation is 519 m above sea level, with most of the area situated between 475 and 525 m.



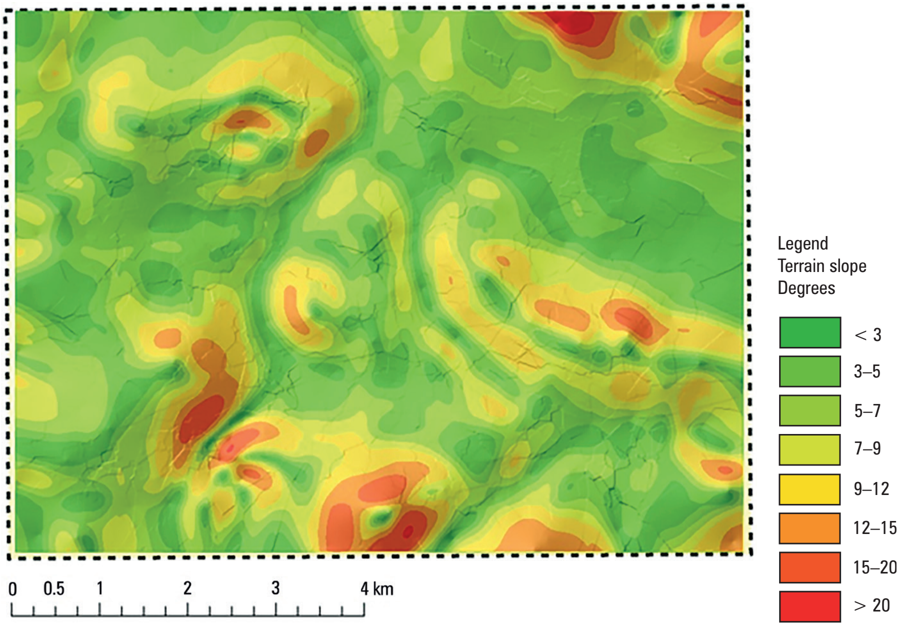

Source: Authors' own study

**Fig. 4.** Contour map of the terrain

Notable geomorphological features include:

- Mount Golców (752 m a.s.l.) in the southern part,
- Góra Miejska (715 m a.s.l.) in the north-east,
- Sowlina River valley, which dominates the central and northern parts of the area.

Slope gradients vary significantly across the area (Fig. 5). The steepest slopes (up to 28°) are located in the north-eastern part, while slopes ranging from 10–20° are common in the southern and central regions.




Source: Authors' own study

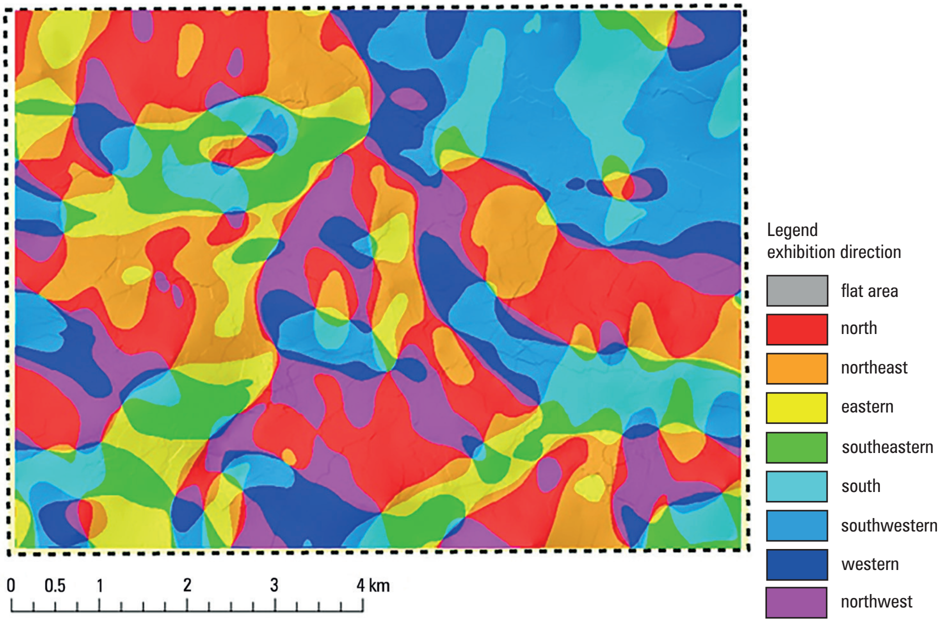
**Fig. 5.** Terrain slope map

Flat or gently sloping areas (2–3°) dominate the northern and eastern parts. The average slope gradient is 6°, with varying exposures depending on the location (Fig. 6).

The relief plays a double role in the area's environmental and socio-economic context. On one hand, its diversity enhances tourism potential, enriching the landscape with valleys, hills, and slopes that are visually appealing and suitable for recreational activities. Key tourist attractions include:

- Mount Miastowa in the north-east, with its favorable southern exposure,
- Mount Gorce in the south, offering scenic views.

On the other hand, the steep slopes and irregular terrain pose challenges for agriculture and settlement development. Slopes exceeding 25° in the southern region hinder mechanized farming and exacerbate soil erosion risks, limiting the area's agricultural value.




Source: Authors' own study

**Fig. 6.** Area exposure map

## 6. Discussion

The results of this study provide valuable insights into the environmental characteristics of the Limanowa area, emphasizing the interplay between vegetation cover, the hydrological network, and terrain relief. These components, individually and collectively, create the region's ecological and landscape values, offering significant potential for tourism, conservation, and sustainable development. The analysis revealed that relief is the dominant feature in the study area, influencing both the distribution of vegetation and the hydrological network. The steep slopes and elevations in the northern and southern parts of the region provide conditions for the formation of compact forest complexes, while valleys and lower areas are dominated by urbanised and agricultural land. This finding supports earlier studies emphasizing the role of topography in shaping land-use patterns and environmental systems [Šiljeg 2021, Grêt-Regamey 2014]. Additionally, the alignment of streams and rivers with the area's geomorphological features highlights the close relationship between hydrology and terrain relief – a pattern commonly observed in mountainous regions [Kokalj 2011]. The study also showed that vegetation cover, although limited in extent (17% of the total area), contributes significantly to the ecological and aesthetic qualities of the landscape. Forests and other wooded areas are concentrated in elevated zones and along riverbanks, affording ecological connectivity and supporting biodiversity. Such spatial patterns are consistent with findings from similar regions, where vegetation plays a key role in stabilizing slopes, regulating hydrological processes, and enhancing ecosystem services [Grêt-Regamey 2014, Sylla 2019]. The integration of GIS tools and aerial photogrammetry proved to be highly effective for conducting spatial, qualitative, and quantitative analyses of environmental elements. The use of the 'Spline' method for elevation interpolation, combined with advanced 3D modeling and thematic mapping, allowed for detailed visualisation and interpretation of environmental data. These methods align with the best practices outlined in the literature, where GIS has been presented as a powerful tool for analyzing terrain, vegetation, and hydrology [Šiljeg 2021, Mancini 2019]. However, certain limitations were noted. For example, the resolution of aerial photographs, while sufficient for large-scale analyses, may not capture fine-scale features, such as small watercourses or microhabitats within forested areas. Additionally, the lack of detailed field surveys limited the ability to verify certain interpretations, particularly in areas where streams were inferred rather than directly observed. These challenges underscore the importance of integrating multiple data sources, such as satellite imagery, LiDAR, and ground-based surveys, to improve the accuracy and reliability of environmental assessments [Lillesand 2020, Cracknell 2018].

From a practical perspective, the findings provide actionable insights for regional planning in the Limanowa area. The aesthetic and ecological value of the area's natural features, particularly its forests and hydrological network, offer significant potential for eco-tourism and landscape conservation. These features could be leveraged to promote sustainable tourism, aligning with broader goals of preserving biodiversity and maintaining ecological integrity. At the same time, the steep slopes and poor soil quality present challenges for agricultural and settlement expansion, in which is typical for mountainous regions [Nita 2005, Solecka 1019]. Land-use policies should prioritize the conservation of forested and hydrologically sensitive areas while limiting intensive agricultural or urban development in regions prone to erosion or other environmental risks. These strategies align with the principles of sustainable development, ensuring that land use supports both ecological and socio-economic objectives [Šiljeg 2021, Willis 1993].

Future research should address the limitations identified in this study by incor-porating higher-resolution datasets and conducting detailed field surveys. For instance, LiDAR technology could enhance the accuracy of terrain models, while hyperspectral imaging might provide additional insights into vegetation composition and health. Additionally, exploring the social and economic dimensions of land use in Limanowa would offer a more holistic understanding of the region's development potential. Expanding the scope of research to include climate adaptation strategies and ecosystem service valuation could further enrich the understanding of environmental dynamics in the region. Such studies would support the integration of biodiversity conservation and climate resilience into regional planning, thereby maintaining the Limanowa area's status as a model of sustainable development in Poland [Grêt-Regamey 2014, Sylla 1993].

## 7. Summary

This study investigated the environmental characteristics of the Limanowa area, focusing on the valorisation of vegetation cover, hydrological networks, and terrain relief. The integration of aerial photogrammetry and GIS tools enabled precise spatial, qualitative, and quantitative analyses, providing detailed insights into the region's ecological and landscape value.

The analyses revealed that the relief of the area plays a dominant role in shaping its environmental components, influencing both vegetation patterns and the alignment of the hydrological network. Forested areas, though limited in extent, contribute significantly to ecological connectivity and biodiversity, while natural streams and valleys boost the aesthetic and functional qualities of the landscape. The findings highlight the region's potential for tourism and conservation but also emphasize limitations for agriculture and settlement development due to steep slopes and poor soil quality. These insights underscore the need for balanced land-use strategies that prioritize environmental protection while addressing socio-economic needs. By demonstrating the utility of GIS and photogrammetry for environmental val-orisation, this study provides a replicable framework for sustainable planning in regions with diverse topographical and ecological characteristics. The results contribute to a deeper understanding of the interactions between natural and anthropogenic elements, supporting efforts to promote resilient and adaptive land use in the Limanowa area and similar regions.

## References

**Bródka S., Macias A.** 2007. Etapy oceny środowiska przyrodniczego oraz ich znaczenie w procesie planistycznym. Waloryzacja środowiska przyrodniczego w planowaniu przestrzennym. M. Kistowski, B. Korwel-Lejkowska (ed.). Fundacja Rozwoju Uniwersytetu Gdańskiego, Gdańsk–Warszawa.

**Buława B., Ahn S.** 2024. Rozumienie krajobrazu i wartości w rozszerzonych konsultacjach publicznych dotyczących planowania przestrzennego w gminach wiejskich w Polsce. Landscape Online, 99, 1124. https://doi.org/10.3097/LO.2024.1124.

**Cracknell A.P.** 2018. Introduction to Remote Sensing, CRC Press.

**Dworak T.Z., Bonikowska M.** 2005. Teledetekcyjny monitoring środowiska. Inżynieria środowiska, 10, 1.

**Grêt-Regamey A., Bebi P., Bishop I.D., Schmid W.A.** 2014. Linking GIS-Based Models to Value Ecosystem Services in an Alpine Region. Journal of Environmental Management, 145, 159–171. https://doi.org/10.1016/j.jenvman

**Hejmanowska B.** 2007. Porównanie wyników klasyfikacji obrazów satelitarnych HYPERION i ALI. Archiwum Fotogrametrii, Kartografii i Teledetekcji, 17a.

Interreg Central Europe. 2018. Landscape Valorisation Method (VM) and GIS Tool for Identifying Potential Locations of Natural Small Water Retention Measures.

**Kokalj Ž., Zakšek K., Oštir K.** 2011. Application of Sky-View Factor for the Visualisation of Historic Landscape Features in LiDAR-Derived Relief Models. Antiquity, 85(327), 327–341.

**Lillesand T., Kiefer R.W., Chipman J.** 2020. Remote Sensing and Image Interpretation, Wiley.

**Litwin U., Bacior S., Piech I.** 2012. Wartościowanie struktur przestrzennych za pomocą wskaźników istotności terenu na przykładzie gminy Klucze w województwie małopolskim. Infrastruktura i Ekologia Terenów Wiejskich, 1/II.

**Litwin U., Bacior S., Piech I.** 2017. The methodology of valorising and assessing landscape. Journal of Ecological Engineering, 18(1), 210–230. https://doi.org/10.12911/22998993/67101.

**Ma L., Liu Y., Zhang X., Ye Y., Yin G., Johnson B.A.** 2019. Deep Learning in Remote Sensing Applications: A Meta-Analysis and Review. ISPRS Journal of Photogrammetry and Remote Sensing, 152, 166–177.

**Mancini F., Riccardo S.** 2019. Applications of Photogrammetry for Environmental Research. ISPRS International Journal of Geo-Information, 8(12), 542. https://doi.org/10.3390/ijgi8120542

**Matuszkiewicz X.** 1999. Geografia Polski: środowisko przyrodnicze. L. Starkel (ed.). Wydawnictwo Naukowe PWN, Warszawa.

**Nita J., Giętkowski T.** 2007. Możliwości wykorzystania Numerycznych Modeli Powierzchni w planowaniu przestrzennym i ochro-nie środowiska przyrodniczego. Waloryzacja środowiska przyrodniczego w planowaniu przestrzennym (red. Kistowski M., Korwel-Lejkowska B.) Fundacja Rozwoju Uniwersytety Gdańskiego, Gdańsk–Warszawa,.

**Nita J., Myga-Piątek U.** 2005. Przykład zastosowania technik komputerowych do waloryzacji i ochrony krajobrazów Wyżyny Częstochowskiej. Przegląd Geograficzny, 77, 3.

**Piech I.** 2011. Waloryzacja turystyczna okolic miasta Krakowa z wykorzystaniem zdjęć lotniczych i obrazów satelitarnych. Infrastruktura i Ekologia Terenów Wiejskich, 3.

**Sadurska U.** 2017. Waloryzacja elementów środowiska w oparciu o zdjęcia lotnicze. Praca magisterska na kierunku Geodezja i Kartografia.

**Solecka I.** 2017. Landscape Valorisation Model as a Tool for Assessing Directions of Socio-Economic Development of the Municipality. Participatory Mapping.

**Solecka I., Bothmer D., Głogowski A.** 2019. Recognizing Landscapes for the Purpose of Sustainable Development – Experiences from Poland. Sustainability, 11(12), 3429. https://doi.org/10.3390/su11123429

**Sylla M., Solecka I.** 2019. Highly Valued Agricultural Landscapes and Their Ecosystem Services in the Urban-Rural Fringe. An Integrated Approach. Journal of Environmental Planning and Management, 63(5), 883–911. https://doi.org/10.1080/09640568.2019.1616982

**Šiljeg A., Mažeika R., Kriaučiūnienė J.** 2021. GIS-Based Landscape Assessment: A Tool for Environmental Planning and Ecosystem Services Evaluation. Sustainability, 13(9), 4590. https://doi.org/10.3390/su13094590

**Willis K.G., Garrod G.D.** 1993. Valuing Landscape: A Contingent Valuation Approach. Journal of Environmental Management, 37(1), 1–22. https://doi.org/10.1006/jema.1993.1001.