HYDROMORPHOLOGICAL AND LANDSCAPE ASSESSMENT OF THE BIAŁKA RIVER VALLEY

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ABSTRACT

This paper presents a hydromorphological and landscape assessment of the Białka river valley. The study follows the Landscape and Hydromorphological Assessment of River Valleys Method (LSHM Method), which is intended for assessing and identifying areas in river valleys and there to determine their development potential. The LSHM Method distinguishes three main groups of factors: hydromorphological (H), landscape (L), and integrated (I). All these factors are assessed using a 10-point scale. In past practice, hydromorphological and landscape elements have been assessed separately. Hydromorphological methods have focused solely on the channel; while landscape methods have only assessed the area up to the watercourse boundary. Application of the LSHM Method offers more "holistic", integrated knowledge of the river valley showing what should be improved and where. The Białka river is a mountain river and, as an effect, changes in its whole valley occur very quickly. Based on the results of the present study, the Białka river valley is characterized by a landscape of regional importance, with a very high tourism potential. It is moreover a braided river, which should be protected.

Keywords: Białka river valley, landscape, hydromorphology, assessment

INTRODUCTION

Water is a fundamental element in the environment and without it people could not exist [Neruda et al.2012]. The channel of a river, which leads the water is constantly subject to outer pressure. With the development of civilization not only river channels, but also the valleys of the rivers have been subject to large transformations. These transformations are consequences of both direct and indirect human pressure [Nowacka-Rejzner 2009]. River valleys often include valuable and unique aquatic and terrestrial ecosystems. The high natural values of these areas are connected to their significant biodiversity. River valleys are therefore often protected areas, such as National Parks, landscape parks or Natura 2000 sites, and thereby they provide ecological corridors for the migration of plants and animals [Keith et al. 2002, Czoch et al. 2013]. Moreover, the water is an important component of the natural landscape [Yamashita 2002, Vogt et al. 2004, Dufour et al. 2015].

Polish region Podhale in the Pleistocene was an area where material transported from the Tatra Mountains by proglacial and nival proglacial rivers was deposited. The transfer of water and clastic material was a complex process [Klimaszewski 1972] because of the diverse landscape of the area. The material was moved through three narrow valleys of the Czarny Dunajec, Biały Dunajec and Białka rivers, down to the large Orava-Nowy Targ Basin. For a long time, these rivers themselves formed their channels to become typical braided river channels. Later on, human river training changed the river channels. River training was driven by the economic development of the river valleys

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[Gorczyca et al. 2011]. Of the three valleys mentioned above, the Białka river valley is the one least affected by human intervention. The Białka river is one of the few mountain rivers in the Carpathians which has preserved its natural, braided character. Located in the area of the valley is the Białka River Gorge at Krempachy Nature Reserve, where most of the relict vegetation and landscape are protected. Here also is the Białka River Valley Natural Area, which is included in the Nature 2000 protection program [Project "Natura 2000 w Karpatach" 2007–2011]. In mountainous areas in general, there is often a dynamic appropriation of the landscape for the purposes of acting on different investments, especially for tourism. These investments, beyond their direct impact on the natural environment, are the main cause of changes in the traditional aesthetics of the mountains area [Myga-Piątek and Jankowski 2009]. The landscapes should therefore receive sufficient protection, management and planning. This is regardless of whether it is a natural, cultural, urban, degraded, particularly beautiful, or a 'mundane' landscape [Gulinck and Wagendorp 2002, Stoeglehner and Schmid 2007]. Despite this, there are at present many areas with valuable landscapes and insufficient protection and management. The presence of valuable cultural landscapes should moreover not limit, prevent, or hinder the economic use of the area [Hernik 2008, Kühne et al. 2015]. The landscape can however not be subject to uncontrolled appropriation. Until recently, activities that affected the landscape, especially in Polish rural municipalities, were often uncoordinated [Hernik at al. 2013, Sankowski et al. 2016]. According to the European Landscape Convention [ELC 2000] the landscape should be considered as a basis for the quality of life, shaping of the regional and local awareness and of futhering natural and cultural diversity. Likewise, river channels should be acknowledged for their importance. The Water Framework Directive (WFD) [Directive 2000/60/EC] was ratified to improve the quality of river ecosystems. Good status of surface waters is measured by biological and physicochemical quality elements, supported by hydromorphological elements.

The aim of this study is to utilize the LandScape & HydroMorphological Assessment of River Valleys Method (LSHM Method) developed by Nawieśniak et al. [2016] in order to make a hydromorphological and landscape assessment of the Białka river valley.

Extended hydromorphological and landscape evaluation of the research area is intended to further identify valuable landscape areas. During the hydromorphological assessment, within the river channel and the areas adjacent to the channel, anthropogenically transformed areas and areas without such transformations were determined. This is in turn necessary for a landscape assessment [Nawieśniak et al. 2015]. Morphological transformations of river channels are affected by natural and anthropogenic factors [Ward at al. 2002, Naiman et al. 2005, Whited et al. 2007]. The LSHM Method includes anthropogenic factors under integrated elements. They influence the value of assessed hydromorphological elements as well.

MATERIAL AND METHOD

The study was conducted on the valley of the Białka river, which is located in southern Poland, in Małopolska Region (fig. 1). The Białka river is an approximately 40 km long mountain river. The beginning of the river is located at 1075 m a.s.l. as a combination of two streams: Rybi Potok – which flows from the Polish part of the Tatra Mountains and Biała Woda – that flows from the Slovak part of the Tatra Mountains. The river flows into the Czorsztyn Lake as a right-bank tributary of the Dunajec river. The Białka river catchment surface area is 232 km^2. Over 60 percent of the catchment area lies in the High Tatra and the Belanske Tatra Mountains. This part is primarily built of granitoids, limestones, dolomites, sandstones and shales. The remaining part of the catchment area is built of flysch formations with a small share of limestone and dolomite outcroppings, which are part of the Pieniny Klippen Belt. The channels of the Białka river and its tributaries, within the part of the catchment located in the Tatra Mountains down to the moraine ridges in the vicinity of Łysa Polana, are armoured with moraine boulders. Therefore, they are relatively stable [Baumgart-Kotarba 1983].

The river channels cut through the moraine ridges and there the rivers flow through gorges. However, the stretches of the river channels in the areas between moraine ridges are typical for braided rivers. The Białka river channel is rocky before it is joined by the Jaworowy Potok. The rocky part of the river channel includes a system of erosional channel forms, such as rock steps and pot-holes. The following sequence of
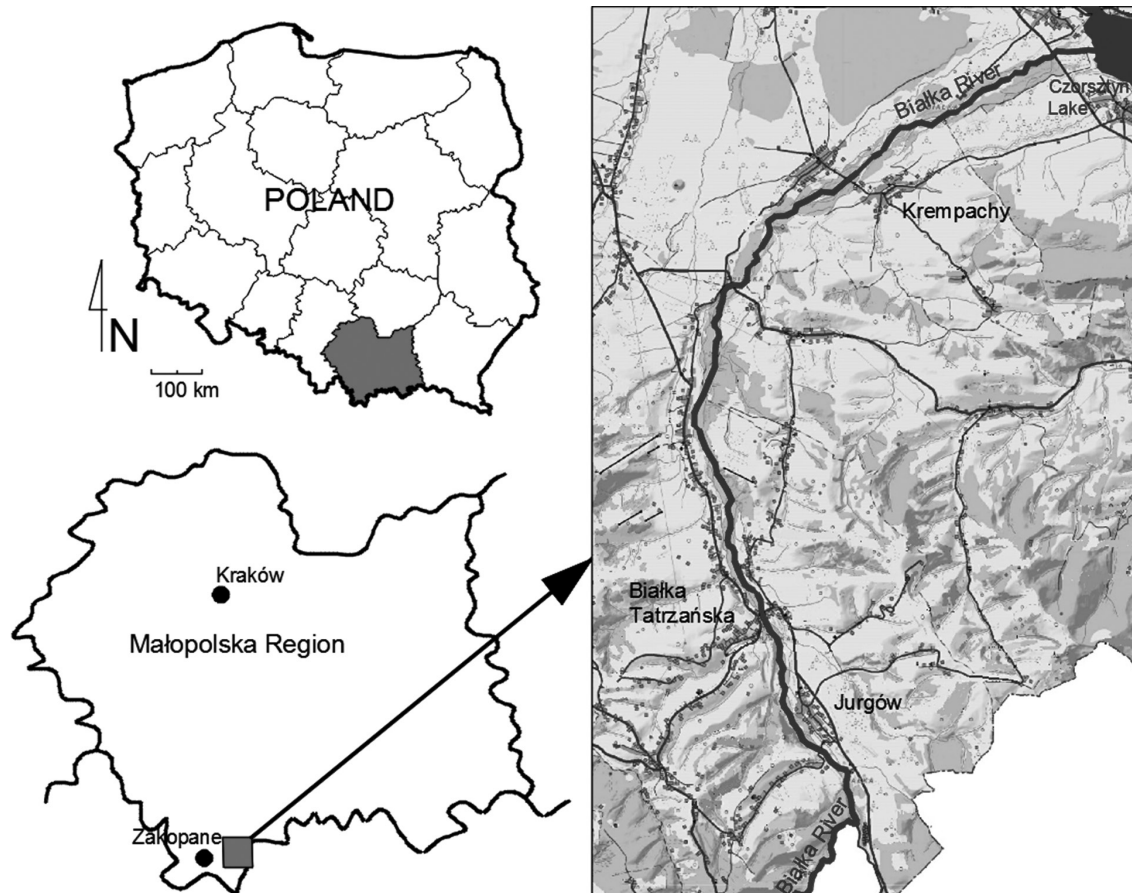
Fig. 1. Location of the Białka river valley

erosional forms often occurs: a rocky or debris step, then a trough or a pot-hole cut in rocks or in debris, and mid-channel bars or side bars [Baumgart-Kotarba 1983]. The part of the Białka river channel located within the Podhale region and in the lower-lying basins is a channel that was mostly cut in a gravel layer. There are numerous mid-channel and side bars in the river channel. This form of river channel was developed because of transport of rock debris, resistant to abrasion, from the Tatra Mountains over a long period of time. The present-day hydrological regime of the Białka river is determined by the hydrology of the highest mountain part of its catchment. Flood stages occur in the Białka river catchment in April and May. They are caused by a rapid snowmelt in the upper part of the catchment located in the Tatra Mountains. Another such period is in the summer months of June and July – flood stages are then a result of extreme precip-

itation (lasting 2–3 days) and prolonged precipitation [Gorczyca et al. 2011].

As mentioned previously in the paper, the study involves the use of the LSHM Method [Nawieśniak et al. 2016]. The LSHM Method was developed by merging and modifying two other methods: the ECO-VAST landscape identification and assessment method and the hydromorphological river quality assessment method. This combining method distinguishes three main groups of factors: hydromorphological (H), landscape (L), and integrated (I). All the factors are assessed using a 10-point scale and assigned to one of five classes (0; 1–2; 3–5; 6–8; 9–10). The first group of elements, the hydromorphological factors, pertains solely to the river channel. This group includes the following parameters: the geometry of the watercourse (H-1), river bed material (H-2), vegetation assessment in the channel (H-3), and erosion/deposition (H-4). Pa-

rameters assessed in the second group, the landscape elements, are: land cover and topography (L-1), open landscape (L-2), settlement areas (L-3), and historical features/structures (L-4). The elements in the third group are integrated elements (I), which could not be assigned solely to either of the previous groups. These last set of parameters integrate hydromorphological and landscape elements: flow characteristics (I-1), anthropogenic elements/modifications (I-2), use and vegetation in areas adjacent to the watercourse channel (I-3), and mobility and connection of the channel to a floodplain and/or adjacent open area (I-4).

The values assigned to individual elements following the assessment indicate the attractiveness (or unattractiveness) for relevant development purposes of the area studied. River valley landscape was divided into three groups according to the economic and tourist attractiveness in order to apply the LSHM Method. The first group (mean values for assessed elements as per the LSHM Method vary from 7 to 10) designates a very attractive area. The second group (mean values for assessed elements as per the LSHM Method vary from 3 to 7) designates a moderately attractive area. The third group designates an unappealing area (mean values for assessed elements as per the LSHM Method vary from 0 to 3). The hydromorphological and landscape assessment using the LSHM Method was performed in summer 2016. The research covered about 21.5 km distance in the Białka river valley, which was divided into fifteen cross-sections (fig. 2).
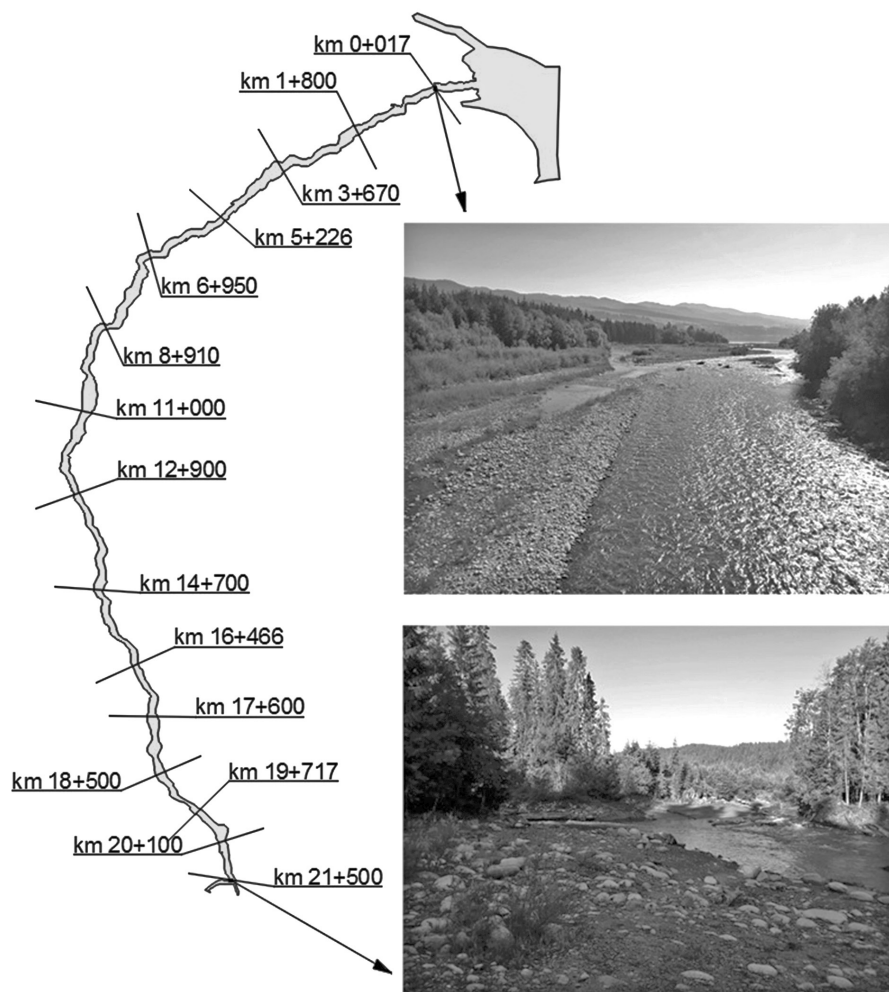
Fig. 2. Evaluated cross-section in the Białka river valley with the photos of the first and the last cross-section

The first cross-section is located where stream Jaworowy Potok flows into the Białka river at km 21+500. Both watercourses, the Białka river and Jaworowy Potok, create a boundary between Poland and Slovakia. The last cross-section is located on the bridge at km 0+017 of the Białka river, before the point where the river flows into the Czorsztyn Lake.

RESULTS AND DISCUSSION

The hydromorphological and landscape assessment in the Białka river valley was performed as mentioned previously using the LSHM Method. Each parameter in each group of elements was assigned a value. The results are presented (fig. 3) as the value of dispersion, which is the range, or the difference between the highest and the lowest value assigned to parameters in any given group of elements. The intervals obtained facilitated assessment of the area in terms of economic and tourist attractiveness. Additionally, a line of the average value of the parameters was plotted.

The highest average value of hydromorphological elements (H), measured 9, was in km 21+500 and km 17+600 of the Białka river valley. There was no hu-

man impact (or minimal interference) in the course of the river channel. The river bed was natural, a large diversity of the material forming the river bed, included oversized grains. The river channel was unregulated with various species of plant life on bars and the banks of the river. There were natural riffle-pool sequences and bars in the river channel (fig. 4). In the rest of the evaluated cross-section, the average value of hydromorphological elements (H) ranged from 6 to 7.5. The human impact in this course of the river channel was more visible. The river bed was in some places regulated using natural materials, in the other places a large diversity of the materials was forming the river bed, which materials included oversized grains. The river channel was unregulated, the vegetation on the sandbanks and on the banks of the river were noticeable. There were natural riffle-pool sequences and the bars in the river channel.

Average value of landscape elements (L) in all the investigated cross-sections was ranged from 7 to 8, which is indicative of diversified topography: hills and valleys. Variability of land cover and spatial order were both visible. Other apparent elements were: boundary between cultivated fields and forests,
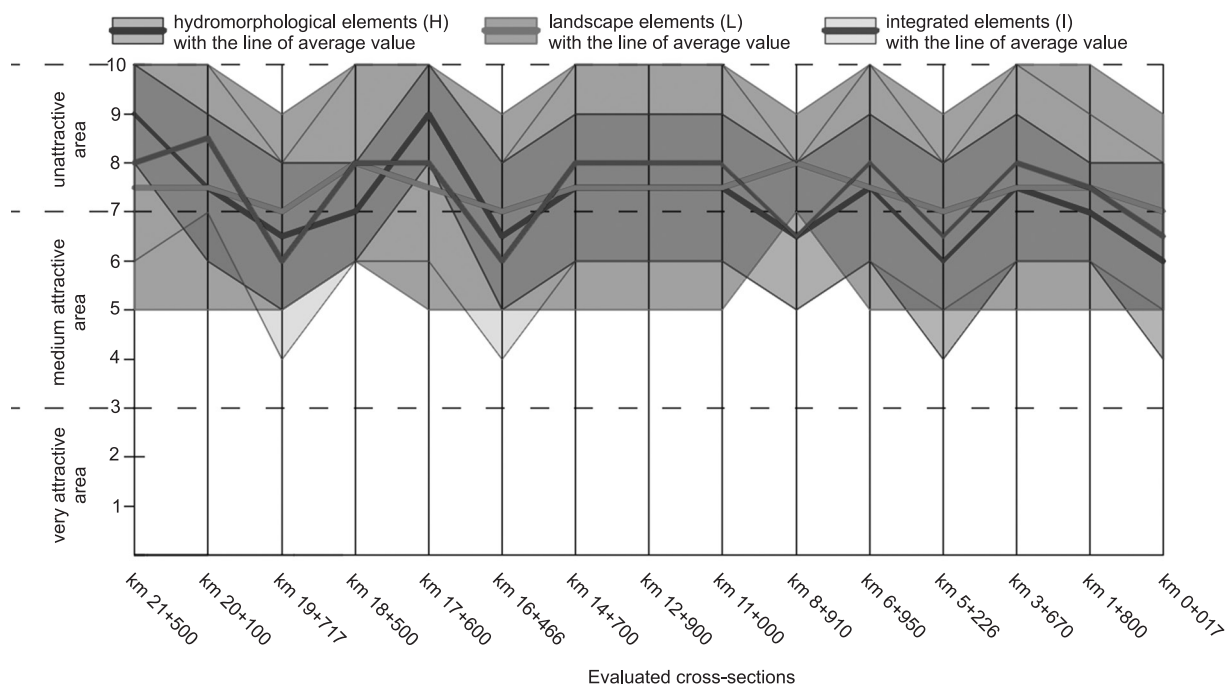
Fig. 3. The results for the evaluation in the Białka River valley using LSHM Method

Fig. 4. Natural riffle-pool sequences and the bars in the river channel at km 17+600

distinguishing agricultural and forestry features and patterns, and preservation of traditional arrangement of farmland. Regional features of development were preserved: they were noticeable both on houses and in settlements; most buildings were in good condition.

Average value of integrated elements (I) varied from 6 to 8 (km 20+100: 8.5). In the evaluated cross-sections there were obtained different hydromorphological units in the river channel. Sound of flowing water was partly disturbed by human activity but the unique landscape accompaniment of the sound was still noticeable. All modifications in the river channel were made by natural materials and they were limited to the edges and the bottoms of the river channel. The area directly adjacent to the river channel was a wide belt, which was used for agriculture and forestry (fig. 5). The river channel had an ability to move (creating structures with many riverbeds). There was good channel communication with the area of the floodplain and the adjacent open areas.

The values of the all parameters in the hydromorphological and landscape assessment of the Białka river valley showed that this area in general is very attractive. It is characterized by very high landscape and cultural landscape values. Cultural landscapes will have a potential for local and regional development if they are properly considered in the broad sense of the environment and spatial planning [Linke and Hernik 2010]. Inadequate spatial management may pose a substantial risk for the landscape and cause underestimating and losing landscape potential. The areas which are characterized by valuable landscape values should be remained unchanged and properly included in local land use plans. Very often it is not realized that even the simplest strengthening or technical treatments in the channel of the river affect the whole landscape of the valley. Especially in this case, when this river is a very good example of a braided river channel and as the last river channel of this type in the Polish Western Carpathians it should be protected from objectionable hydro-technical regulation [Chełmicki and Krzemień 1999]. As a key element of the landscape, the entire valley should be protected as a natural areas [Kałamucka 2007].

Nowadays more and more of the agricultural land in the area studied is dedicated for sports and recreation. Over the years there has been an increase

Fig. 5. Wide belt of area directly adjacent to the river channel (km 3+670) which was used for agriculture and forestry

in the intensity of tourism development of this area [Hełdak and Szczepański 2011]. Tourism in the protected areas is becoming more and more common. Benefits from the location of the towns within the boundaries or zones of the protected areas are noticed by residents and municipal authorities [Zaręba 2006]. Too intensive use of nature in protected areas may lead to its gradual deterioration and, as a consequence, a decrease in the tourist attractiveness of the area [Kistowski and Kowalczyk 2013]. On the one hand, investments for tourism infrastructure, including the construction of hotels, roads, shelters, restaurants and ski lifts facilitate access to natural values. On the other hand these investments may counter the protection and enhancement of natural values [Sobaś et al. 2017].

Until now, hydromorphological and landscape elements have been assessed separately. Hydromorphological assessment methods focused solely on watercourse channel; whereas landscape methods have been concerned, with the area up to the watercourse boundary. River valleys are, however separate natural systems and particular socio-economic systems. An analysis of transformation of river valley land-

scape must not be limited to the geomorphological unit (river valley with the channel and terrace system), hydromorphological unit (with natural riffle-pool sequences), but should adopt a broader perspective, and focus on entire zones and the key function of valleys: corridors for nature and people (meaning of wildlife, social, and cultural corridors). When embarking on a study of transformation of river valley landscape, one must be aware of the influence the river and the valley have on their hinterlands [Bernat 2005] as well as on the quality of the life for the people who lives in zones with direct river impact.

CONCLUSIONS

Mountain river valleys undergo constant changes in time and space. The completed hydromorphological and landscape valorization of the Białka river valley using the LSHM Method enabled the identification of areas valuable in terms of hydromorphology and landscape. The Białka river valley is characterized by a landscape of regional importance, with a very high tourism potential. It is also a special place with a braided river, which should be protected.

Hydromorphological and landscape assessment with the LSHM Method will facilitate discerning social, landscape, hydromorphological benefits of the area for tourism, leisure, and economic use of river valleys. This will facilitate identification transformations of both the river channel and valley in terms of the function of wildlife corridor together with areas interrelated with the river and assessment of integrated river valley landscape as an element determining attractiveness of the area or a space with a significant development potential.

Acknowledgments

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HYDROMORFOLOGICZNO-KRAJOBRAZOWA OCENA DOLINY RZEKI BIAŁKI

STRESZCZENIE

W pracy przedstawiono ocenę hydromorfologiczno-krajobrazową doliny rzeki Białki. Badania przeprowadzono zgodnie z metodą oceny hydromorfologiczno-krajobrazowej dolin rzecznych (metoda LSHM), która służy do oceny i identyfikacji cennych obszarów w dolinach rzecznych, ze wskazaniem możliwości rozwoju tych obszarów. Metoda LSHM rozróżnia trzy główne grupy czynników: hydromorfologiczne (H), krajobrazowe (L) i zintegrowane (I). Wszystkie czynniki są oceniane przy użyciu 10-punktowej skali. Do tej pory elementy hydromorfologiczne i elementy krajobrazowe były oceniane osobno. Metody oceny hydromorfologicznej skupiały się jedynie na korycie cieku, a metody krajobrazowe oceniały obszar do granicy z ciekiem. Zastosowanie metody LSHM oferuje bardziej „holistyczne", zintegrowane podejście przy ocenie dolin rzecznych, pokazujące, co i gdzie należy poprawić. Rzeka Białka jest rzeką górską, a co za tym idzie, zmiany w całej dolinie następują bardzo szybko. Na podstawie wyników stwierdzono, że dolina rzeki Białki charakteryzuje się krajobrazem o znaczeniu regionalnym, o bardzo wysokim potencjale turystycznym. Ponadto rzeka Białka jest rzeką roztokową, którą należy chronić.

Słowa kluczowe: dolina rzeki Białki, krajobraz, hydromorfologia, ocena