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Applying the Analytical Hierarchy Process (AHP) into the effects assessment of river training works

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Abstract

The aim of the following study was to compare a few methods of river regulations and indicate the one which fully meets technical regulative standard and concurrently ensures protection of the watercourse ecosystem. According to the sustainable development rules it is of the most importance in every human activity to compromise between developmental and environmental needs of current and future generations. Therefore, both technical criteria related to flood safety and environmental ones were taken into consideration in the analysis. Field study was conducted in vegetation stage between 2008 and 2014 in small and medium lowland watercourses in Lower Silesia. The research comprised of measurements and descriptions of selected technical and environmental elements of a complex system of the watercourse river bed. Basing on obtained results a multicriterial assessment of the effects of the works was conducted. In order to assess the results an Analytic Hierarchy Process (AHP) was used in the study. It facilitated the creation of linear ranking of river beds and indicate the most optimal solution in terms of sustainable development. Such methods have not been applied in solving problems connected with river regulation. That's why this study aims also at checking the utility of this method in decision making in both planning and regulation works realization. Results of the study indicate high usefulness of AHP method in the decision-making process.

Key words: *Analytic Hierarchy Process (AHP), multicriterial analysis, river training works, sustainable development*

INTRODUCTION

River and stream training works comprise of a range of technical activities and creating hydraulic structures that aim at preventing the damage caused by flowing waters. The aim of the river training works is rising watercourses utility for common usage of water and ensuring flood control [WOŁOSZYN *et al.* 1994]. According to the article 67 of the Water Law [Ustawa… 2001], regulation of natural watercourses exceeds activities relating to water maintenance especially modelling longitudinal profile, cross-sections and the flow system of the river. These procedures attribute to the improvement of conditions of water usage and flood control [Ustawa… 2001].

With accordance to the sustainable development concept each interference in the watercourse should attribute to the improvement of habitat conditions and people safety with possibly the broadest environmental protection [DUSZYŃSKI 2007]. However, during the river regulation it often proves necessary to do the works that interfere with the watercourse ecosystem

[BYLAK *et al.* 2009; JERMACZEK *et al.* 2014; KÖHLER *et al.* 2010; WYŻGA *et al.* 2009]. Due to that it is suggested to adopt solutions that may maximally balance technical and environmental requirements.

The aim of the following study is to compare five alternative river training works patterns and indicate the one which fully meets technical regulative standard and concurrently ensures protection of the watercourse ecosystem.

The analysis was conducted basing on the field research. To compile the results AHP method was used. It is an expert method. Such methods have not been applied in solving problems connected with river training works. That's why this study aims also at checking the utility of this method in decision making in both planning and regulation works realization.

METHODS

RESEARCH SUBJECTS

The research was conducted in vegetation periods between 2010 and 2014 in regulated 100 m long sections of five lowland watercourses in Lower Silesia located in the south-east of Poland (Tab. 1).

Table 1. Study objects

Watercourse name	Study section name	Tributary to	Length of the watercourse km	Catchment area km^2
Dobra	O1	Widawa	36.1	284.0
Sąsiecznica	O2	Barycz	43.8	545.2
Ślęza	O3	Odra	84.1	971.7
Tarnawka	O4	Strzegomka	no data	40.3
Żurawka	O5	Ślęza	27.5	173.6

Source: own elaboration based on data provided by Lower Silesian Board of Land Reclamation and Water Equipment in Wrocław (Pol. Dolnośląski Zarząd Melioracji i Urządzeń Wodnych we Wrocławiu).

All were located in areas with similar climate (moderate, transition zone between maritime and continental), geology (Foresudetic Monocline, Permian Rocks and Trias) and soil (Luvisols formed from loess and brown soil) conditions. These features are typical for the lowland part of the ecoregion that constitutes central European highlands and plains [PETERSEN, GISLASON 1995]. All examined objects were uncontaminated and free of industrial wastewater.

River training works were performed 3–5 years prior to the beginning of the research. They mainly referred to: deepening the river bed, alternating banks inclination, strengthening river banks using fascine, block gabions and concrete elements if necessary. The range of works conducted in particular sections was presented in Table 2. Study sections are presented in Photo 1.

Both technical and environmental criteria were incorporated in the assessment. Each of them is defined with elements which will qualify the choice of optimal solution.

Table 2. The range of river training works in study sections

The range of the river training works	Study sections				
	Dobra O1	Sąsiecznica O2	Ślęza O3	Tarnawka O4	Żurawka O5
Mowing the plants in the littoral and on scarps	x	x	x	x	x
Slit and water plants removal		x		x	x
Deepening the watercourse	x		x		
Conformation of the cross-section with scarps of 1:2 slope		x		x	x
Conformation of the cross-section with vertical scarps	x		x		
Scarps' strengthening with sod		x			
Strengthening scarps' feet with fascine					x
Scarps' strengthening with block gabions	x				
Scarps' and bed strengthening with openwork concrete slabs				x	
Scarps' strengthening with concrete walls, bed strengthening with concrete elements			x		

Explanation: x – done treatments.
Source: own elaboration.

TECHNICAL CRITERION

By way of the technical criterion the elements influencing the degree of the valley protection against the flood were considered. They were as follows:
- slope gradient,
- the width of the river bed,
- the depth of the river bed,
- bank strengthening,
- the bottom substrate.

Slope gradient has an impact on the velocity of the water flow. Increasing slope causes increase of the flow velocity because of the lower flow resistance due to the decreased internal distortion resistance caused by the reduced sinuosity [ERSKINE 1990]. The width, depth and banks' inclination define the river bed capacity [RADECKI-PAWLIK, SKALSKI 2008]. The following parameters were measured in cross-sections located every 10 m along the study sections. Basing on that mean value was calculated for the whole section. In the same cross-sections the kind of bank strengthening and the bottom substrate were assessed.

Table 3. Scale of the assessment of the banks strengthening and bottom substrate

The number of points	The sort of scarps' strengthening	The number of points	The sort of the river bed substrate
1	lack	1	organic
2	biological cover	2	sand
3	fascine	3	gravel
4	rip rap	4	stones
5	gabions	5	concrete
6	retaining wall, concrete cladding, sheet piling		

Source: own elaboration.

Photo 1. Study sections located in: Dobra – O1, Sąsiecznica – O2, Ślęza – O3, Tarnawka – O4, Żurawka – O5 (phot. *J. Hachoł*)

These elements influence slope stability, durability and both banks and bottom endurance. They were all evaluated using the point scales displayed in Table 3.

ENVIRONMENTAL CRITERION

The following elements were considered in terms of the environmental criterion:

- the number of aquatic vascular species,
- Shannon-Wiener biodiversity index,
- the structure of aquatic plant communities on banks,
- watercourse overshadowing.

In each and every study section the number of aquatic vascular plants species and the degree of its bottom coverage was identified. The research concerns vascular plants rooted in water for at least 90% of their vegetation period and free-flowing higher plants floating on the surface or beneath it. Aquatic plants' species were identified directly on the study spot. In order to define the level of plant density 5-grade rating system was used [KOHLER 1978].

Shannon–Wiener index facilitates biodiversity assessment in analysed community considering both the number of species and evenness of their coverage of the river bed. The index was determined using the formula depicted by SCHAUMBURG *et al.* [2006].

Aquatic plant structure occurring on banks and related level of the river bed overshadow determine aquatic and animalistic communities [CORTES *et al.* 2008]. Plant structure assessment was performed basing on five different types of plants such as: bryophytes and lichens, low, trailing herbs or grasses, high herbs and grasses, bushes and brush as well as trees. Plant structure was assessed in four different categories such as: the lack of plants (B), homogenous structure (J), simple (P) and complex structure (Z) [SZOSZKIEWICZ *et al.* 2008]. The river bed overshadowing was assessed in 5-grade rating system where 0 – indicates the lack of overshadowing, 1 – little overshadowing (up to 25% of the water surface), 2 – medium overshadowing (26–50%), 3 – considerable overshadowing (51–75%), 4 – total one (above 76%) [SCHAUMBURG *et al.* 2006].

OBJECTS COMPARISON

To compare investigated objects in terms of applied technical solutions and their ecological effects, the Analytic Hierarchy Process (AHP), developed by SAATY [1980], was used. The basis of the analysis in this method constitutes a hierarchical tree. The tree depicting considered problem was portrayed in Figure 1. Its highest level incorporates the aim of the problem i.e. the selection of optimal alternative in a watercourse regulation considering both technical and environmental criteria. Starting material for the analysis is constituted by alternative watercourse regulations applied in research objects. They were placed on the lowest tree level. Intermediate level is constituted by assessment criteria. They comprise of the elements of watercourses modified in river training works. They influence technical and ecological effects of engineering intervention to the river.

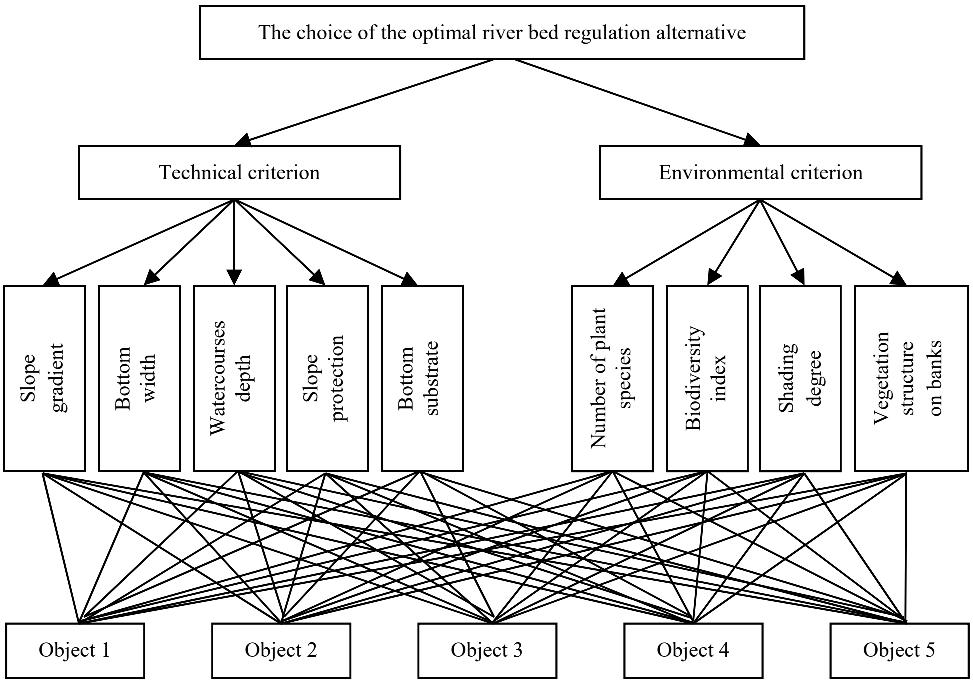

Fig. 1. Hierarchical tree for the investigated problem; source: own elaboration

In subsequent research stage comparison in pairs constituting the same level of the event tree in contrast to the elements from its higher level was done. This stage required attributing certain weights to investigated criteria. Such weights, so called preferences (local vectors) indicate the influence of particular elements on the main target realization by modifying the elements of the watercourse in given conditions in a way that is beneficial both in technical and environmental aspects. Determination of the importance of these elements with accordance to investigated criteria rested upon comparison in pairs by four experts using Saaty's scale (Tab. 4).

Obtaining requisite consistency among the experts' assessments is required in the research conducted using Saaty's method. It is conveyed by the consistency rate (*CR*) which should not exceed 0.1. It was determined in the study using the consistency index (*CI*) [KARANIK *et al.* 2016]:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{1}$$

where: $\lambda_{\max}$ = maximal self-value of the comparison matrix of rank-n; n = the number of compared characteristics.

Consistency rate (*CR*) is a quotient between a consistency index (*CI*) and a random index (RI) [KARANIK *et al.* 2016]:

$$CR = \frac{CI}{RI} \tag{2}$$

where: RI = random index, dependent on the matrix degree. Calculated basing on Table 5.

Table 4. Assessment weights according to Saaty

Numerical assessment	Verbal assessment
1	compared criteria are equivalent
2	a decision maker hesitates between minor prevalence of the first criterion over the second
3	minor prevalence of the first criterion over the second
4	a decision maker hesitates between minor and considerable prevalence of the first criterion over the second
5	high prevalence of the first criterion over the second
6	a decision maker hesitates between considerable and significant prevalence of the first criterion over the second
7	significantly high prevalence of the first criterion over the second
8	a decision maker hesitates between significantly higher and enormous prevalence of the first criterion over the second
9	enormous prevalence of the first criterion over the second

Source: own elaboration based on SAATY [1980].

Table 5. Value of random index

n	2	3	4	5	6	7	8
RI	0	0.58	0.90	1.12	1.24	1.32	1.41

Source: own elaboration based on DOWNAROWICZ *et al.* [2000].

On the next research stage an assessment of investigated river training works alternatives was conducted by pair comparisons taking into account elements considered in technical and environmental criteria. For this purpose matrixes including values of these elements obtained in the field study were developed. For comparisons of other elements of matrixes the scales depicted in Tables 6 and 7 were applied. When developing scales the method of equal ranges was used. Obtained results of comparisons were normalized and conse-

Table 6. Assessment weights used to the pair comparison of study sections – technical criterion

Numerical assessment	Verbal assessment				
	slope gradient	bottom width	watercourses depth	slope protection	bottom substrate
1	equal in both compared objects	equal in both compared objects	equal in both compared objects	equal in both compared objects	equal in both compared objects
2	larger in first object by 0.01–0.39‰	larger in first object by 0.1–1.0 m	larger in first object by 0.01–0.08 m	–	–
3	larger in first object by 0.40–0.79‰	larger in first object by 1.1–2.0 m	larger in first object by 0.09–0.17 m	larger in first object by 1 or 2 points[1)]	larger in first object by 1 point[1)]
4	larger in first object by 0.80–1.19‰	larger in first object by 2.1–3.0 m	larger in first object by 0.18–0.26 m	–	–
5	larger in first object by 1.20–1.59‰	larger in first object by 3.1–4.0 m	larger in first object by 0.27–0.35 m	larger in first object by 3 points	larger in first object by 2 points
6	larger in first object by 1.60–1.99‰	larger in first object by 4.1–5.0 m	larger in first object by 0.36–0.44 m	–	–
7	larger in first object by 2.00–2.39‰	larger in first object by 5.1–6.0 m	larger in first object by 0.45–0.53 m	larger in first object by 4 points	larger in first object by 3 points
8	larger in first object by 2.40–2.79‰	larger in first object by 6.1–7.0 m	larger in first object by 0.54–0.62 m	–	–
9	larger in first object by ≥2,80‰	larger in first object by 7.1–8.2 m	larger in first object by 0.63–0.70 m	larger in first object by 5 points	larger in first object by 4 points

1) According to the Table 3.
Source: own elaboration based on SAATY [1980].

Table 7. Assessment weights used to the pair comparison of study sections – environmental criterion

Numerical assessment	Verbal assessment			
	number of aquatic plant species	biodiversity index	shading degree	vegetation structure on banks
1	equal in both compared objects	equal in both compared objects	equal in both compared objects	equal in both compared objects
2	larger in first object by 1 species	larger in first object by 0.1–0.28	–	–
3	larger in first object by 2 species	larger in first object by 0.29–0.57	larger in first object by 1 grad	more complex in first object by 1 grad
4	larger in first object by 3 species	larger in first object by 0.58–0.85	–	–
5	larger in first object by 4 species	larger in first object by 0.86–1.13	larger in first object by 2 grads	more complex in first object by 2 grads
6	larger in first object by 5 species	larger in first object by 1.14–1.42	–	–
7	larger in first object by 6 species	larger in first object by 1.43–1.70	larger in first object by 3 grads	more complex in first object by 3 grads
8	larger in first object by 7 species	larger in first object by 1.71–1.99	–	–
9	larger in first object by 8 species	larger in first object by 2.00–2.28	larger in first object by 4 grads	–

Source: own elaboration based on SAATY [1980].

quently summed up in matrix lines resulting in organizing vector of considered decision making variants (local priority vector) [SAATY 1990]. Vector components represent weights of consequent elements on each hierarchy level.

In order to select optimal method of river regulation both in terms of technical and environmental aspect further analysis was conducted using three variants:
- variant I – in multicriterial assessment higher rank importance was attributed to technical criterion (local vector for the group of environmental criteria amounted to 0.2);
- variant II – in the assessment equivalent rank was attributed to technical and environmental criterion (local vector for both criteria amounted to 0.5);
- variant III – in the assessment higher rank was attributed to ecological criterion (local vector for the group of environmental criteria amounted to 0.8).

RESULTS AND DISCUSSION

TECHNICAL CRITERION

Table 8 shows values of assessed technical variables, measured or evaluated during the field study. The bottom slope gradient in study sections ranged between 0.39–3.5‰. The width of the watercourses' bottoms ranged from 1.8 to 10.0 m, the depth ranged from 1.5 to 2.2 m. There were sections with scarps of 1:2 slope strengthened with sod or fascine and also vertical slopes strengthened with gabions, openwork concrete slabs and concrete walls (Tab. 2). In study sections five

Table 8. Values of technical variables considered in the ranking

Research object (decision making variant)	Technical criterion				
	slope gradient ‰	bottom width m	watercourses depth m	slope protection	bottom substrate
Dobra (O1)	3.50	5.6	1.8	gabions	gravel and stones
Sąsiecznica (O2)	0.39	10.0	1.5	fascine	sand
Ślęza (O3)	1.00	5.0	2.2	retaining wall	concrete slabs
Tarnawka (O4)	1	1.8	2.0	openwork concrete slabs	openwork concrete slabs
Żurawka (O5)	0.40	3.0	2.0	fascine	sand

Source: own elaboration.

different bottom substrates were observed with organic substrate, sand, gravel, stones and concrete elements.

Depicted data indicates that the highest modification degree was found in the study section located in Ślęza watercourse. In order to strengthen the banks concrete elements were applied. The lowest interference degree was found in Sąsiecznica watercourse. Banks and bottom strengthening was abandoned here. The lack of strengthening is balanced by vast cross-sections ensuring considerable watercourse capacity in case of higher water levels.

ENVIRONMENTAL CRITERION

Table 9 shows values of assessed environmental variables evaluated during the field study. The research indicated that the number of aquatic plants taxa observed in the particular study sites was quite diversified, with values ranging from 0 to 8. Biodiversity index ranged from 0 to 2.28. Three shading stages were registered in the study sections: from the complete lack to the medium shading. On the scarps three plant structure categories were observed: the lack of plants, homogenous structure and complex structure.

In the study section located in Ślęza (O3) there was no vegetation. In so strongly modified watercourses characterizing with simple bottom geometry, impermeable bedrock and banks (Tab. 8, Photo 1) they are habitable only for elements of benthos biofilm, invertebrates crawling on flat surfaces, rarely – fish [BYLAK *et al.* 2009; LENAR-MATYAS, WOLAK 2009]. Such watercourses are habitable only for embryophytes that free float on the water surface e.g. members of *Lemnaceae* (duckweed) family.

The highest number of species was found in Sasiecznica (O2). Similar number of species was inventoried in Żurawka (O5) watercourse where bank feet were strengthened with fascine. This section was characterised with the highest biodiversity index of aquatic plants (Tab. 9).

Table 9. Values of environmental variables considered in the ranking

Research object (Decision making variant)	Environmental criterion			
	number of aquatic plant species	biodiversity index	shading degree	vegetation structure on banks
Dobra (O1)	3	1.10	1	B
Sąsiecznica (O2)	8	1.80	1	J
Ślęza (O3)	0	0.00	0	B
Tarnawka (O4)	5	1.19	0	J
Żurawka (O5)	8	2.28	2	Z

Source: own elaboration.

OBJECTS COMPARISON

In Figure 2 values of local vectors for particular elements considered by way of technical criterion (a) were depicted and for the environmental one (b), resulting from experts' assessments. They determine their weight in particular groups.

Experts' opinions conclude that among factors attributed to technical criterion the most meaningful factor in river regulation is the bottom slope (local vector = 0.53). A bit less significant proved the bottom width and the watercourse depth (local vector = 0.19). The relationship of those elements with the flood risk was demonstrated in numerous studies [ALCÁNTARA-AYALA 2002; BOJARSKI *et al.* 2005; NEUHOLD *et al.* 2009; TOCKNER *et al.* 1998]. With an increasing of bottom slope the energy of the water flow increases. Narrowing of the rivers bottom reduces its cross-section, thus also increasing the flow velocity. This may result in a significant increase in flood risk, as acceleration of water discharge always results in increased intensity of maximum flood flows [BOJARSKI *et al.* 2005]. Therefore the treatment increasingly used on European rivers is a local widening of the river channel [SIMONS *et al.* 2001; TOCKNER *et al.* 1998].

In the group of factors belonging to environmental criterion the most significant is the number of aquatic plant species (local vector = 0.60) while the second most significant factor is the biodiversity index (local vector = 0.27). This is confirmed in the literature. Aquatic plants play important role in the aquatic systems. They supply organic matter to the watercourse, create environment diversity and shape environmental conditions [O'HARE *et al.* 2011; RIIS *et al.* 2008]. They improve the watercourses self-cleaning abilities, and reduce water erosion processes intensity [GRINBERGA 2010; LORENZ *et al.* 2012].

Basing on the results of the research considering both ranks of two criteria groups (variant I–III) and ranks attached by the experts in each group (global vectors) three object rankings were developed (Fig. 3).

In the ranking developed for variant I, where higher weight was attributed to technical criterion the first place took the section located in Dobra watercourse (O1). The section was characterized with considerable watercourse modification especially banks.

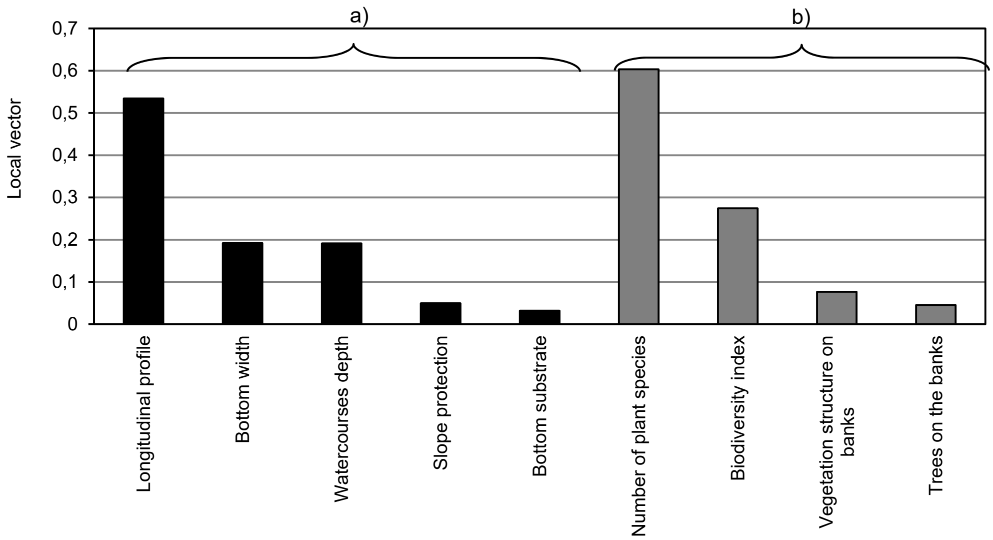

Fig. 2. Ranks attached to technical (a) and environmental (b) criteria by experts; source: own elaboration

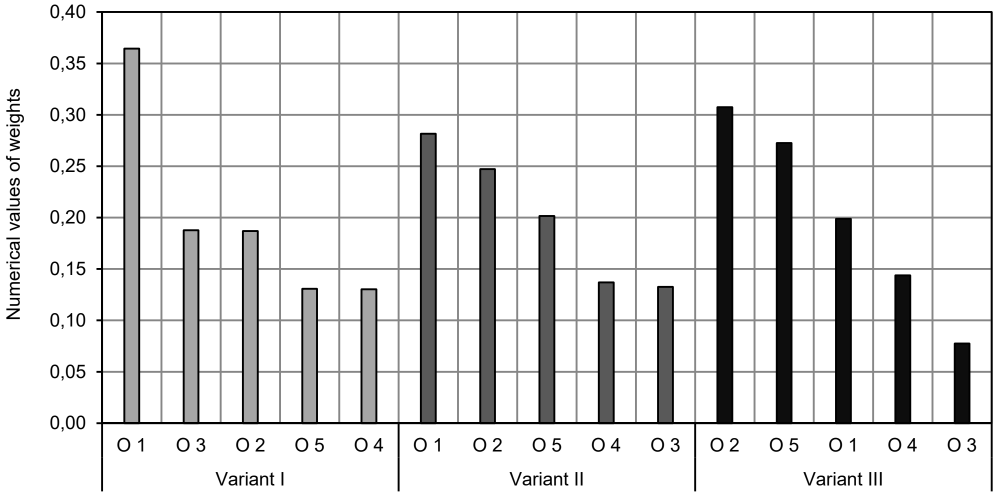

Fig. 3. Rankings of the objects with critical share of technical criterion in the assessment (variant I), equivalent importance of both criteria (variant II) and critical share of environmental criterion in the assessment (variant III); source: own elaboration

Vertical banks, strengthened with gabions characterize with higher staidness, durability and resistance to water erosion than natural biological watercourse protection meeting criteria of environmentally friendly regulation [SZOSZKIEWICZ *et al.* 2008; ŻELAZO, POPEK 2002]. That is why many authors believed such solution increases flood control safety [GILVEAR, WINTERBOTTOM 1992]. Other places in this ranking were taken by Ślęza (O3) and Sąsiecznica (O3). Numerical value of weight of these two objects are similar despite applying different technical solutions in each of them. Their common feature is vast cross-section ensuring high watercourse capacity. Last places in the ranking were taken by Żurawka (O5) and Tarnawka (O4) sections.

Figure 3 depicts that the best method of river regulation ensuring both flood control and ecological safety (variant II) is, alike in variant I, the solution applied in Dobra watercourse (O1). A bit lower weight values were found in Sąsiecznica (O2) and Żurawka (O5) watercourses. Fascine and sod strengthened banks with 1:2 slope were applied in both variants. Last places in this ranking were taken by sections where banks were strengthened with concrete elements.

The ranking considering mostly environmental criterion (variant III) shows utterly different results. First places in this ranking were granted to sections without technically strengthened banks and with natural bottom substrate facilitating aquatic plants development. On the other hand banks strengthened only with plants with strengthened feet only are more susceptible to damage resulting from water erosion or anthropologic and animal activities. It is indicated by inventory results obtained by HACHOŁ and BONDAR-NOWAKOWSKA [2016], during which banks' damage was observed in watercourses strengthened with sod or fascine. Moreover, such banks are quickly overgrown by plants what results in worsened hydraulic conditions of the watercourse [TYMIŃSKI 2008] and therefore more frequent need for maintenance works. The last place in investigated ranking was taken by Ślęza section (O3) with the highest modification degree.

The research shows that the best variant of river training works scheme, ensuring both flood control and ecological safety, is the solution applied in Dobra (O1). Banks strengthened with gabions are resistant to water erosion, the large width and no bottom strengthening create conditions for development of water plants, which grow despite the strongly modified slopes. It is due to the fact that species occurred in the Dobra River (*Berula erecta* (Huds.) Coville, *Callitriche* sp., *Elodea canadensis* L.) are very common in lowland watercourses and have a high tolerance to habitat conditions. Aquatic plants have a very effective mechanism of vegetative reproduction and proliferation. Therefore any disturbance to the environment caused by watercourse modification is in any case quickly repaired by the regeneration of the ecosystem [Bondar-Nowakowska, Hachoł 2010; Gabrey *et al.* 2006; Wiegleb *et al.* 2014]. However, due to the strong profiling and strengthening of the slopes with gabions such a variant would be difficult to accept for ecologists. Due to less resistance this increases the flow velocity and it is widely known that current velocity is a decisive factor determining the vegetation structures in running waters [Janauer *et al.* 2010; Grinberga 2011; Rambaud *et al.* 2009]. Only three aquatic plant species were found in the study section, the biodiversity index was 1.10. In addition, this study section looks more like a channel than a natural river (Photo 1).

River training works have been frequently criticised for causing increased velocities, bank erosion, channel straightening, upstream degradation and downstream deposition [Erskine 1990]. Therefore it is very important to find the solutions that may be compromise between technical and environmental requirements. Multicriteria methods are valuable tools for making decisions and evaluating different solutions. AHP method has not been applied in solving problems connected with river regulation. But it is widely used in the field of environmental engineering, e.g. for selection of localization wind farm [Wątróbski, Garnysz 2009], to support municipal landfill site selection [Kolendo, Kolendo 2013], for searching an optimal solution of an urban sewerage system modernization [Zawilski, Sakson 2013], to evaluate investment projects in a hard coal mine [Sojda, Wolny 2012] and for assessment of management technologies of waste from mining industry [Kozioł *et al.* 2011]. The results does indicate usefulness of AHP method in research and analyses aiming at defining the interference between river training works and alternations in the watercourse ecosystem. However, AHP has disadvantages such as the difficulty with the choice of the assessment criteria and when the criteria assessment obtained from the experts are divergent.

CONCLUSIONS

The river training works are executed mainly for the purpose of eliminating or reducing the flood risk. It is always necessary to study and predict the behaviour of the river and its reaction on the intervention to the river. The study investigated three variants characterizing different attitude to regulatory works. In variant I, the priority was given to technical aims, in variant II the equal importance was granted to both technical goals and environmental protection of a watercourse, in variant I the priority was given to environmental aims. Each attitude requires different model of regulatory works in the watercourse. In the first case the regulation should be technical while in variant II and III it is difficult to unambiguously indicate the right model for further research and analyses.

Conducted research indicated it is impossible to meticulously depict changes in the watercourse being the consequence of regulatory works. However, it possible to foresee them. It was confirmed by experts' observations whose opinions generally corresponded to alternations observed in watercourses after 3–5 years since regulatory works completion. Therefore, planning regulatory works to assess changes in environmental elements of the watercourse requires expert methods. Results of the study indicate high usefulness of AHP method.

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Zastosowanie metody AHP (Analytical Hierarchy Process) do oceny skutków regulacji rzek

STRESZCZENIE

Celem pracy było porównanie kilku metod regulacji rzek oraz wskazanie tej, która w maksymalnym stopniu spełnia wymagania techniczne regulacji i równocześnie zapewnia ochronę ekosystemu koryta cieku. Zgodnie z zasadami zrównoważonego rozwoju w każdej działalności człowieka bardzo ważne jest znalezienie kompromisu między rozwojowymi i środowiskowymi potrzebami obecnych i przyszłych pokoleń. Dlatego w analizie uwzględniono zarówno kryteria techniczne, związane z bezpieczeństwem powodziowym, jak i przyrodnicze. Badania terenowe wykonano w okresach wegetacyjnych w latach 2008–2014 w małych i średnich ciekach nizinnych na Dolnym Śląsku. Badania obejmowały pomiar i opis wybranych technicznych i przyrodniczych elementów złożonego systemu koryta cieku. Na podstawie wyników badań dokonano wielokryterialnej oceny skutków robót. W tym celu zastosowano metodę analizy hierarchicznej problemu (Analytic Hierarchy Process, AHP). Umożliwiło to utworzenie liniowego rankingu koryt rzecznych oraz wskazanie najbardziej optymalnego rozwiązania w aspekcie zrównoważonego rozwoju. Metody tego typu nie były dotychczas stosowane w rozwiązywaniu problemów związanych z regulacją rzek. W związku z tym praca ma również na celu sprawdzenie przydatności tej metody do podejmowania decyzji na etapie planowania i realizacji robót regulacyjnych. Wyniki badań wskazały na dużą przydatność metody AHP w procesie decyzyjnym.

Słowa kluczowe: *analiza wielokryterialna, Analytic Hierarchy Process (AHP), regulacja rzek, zrównoważony rozwój*