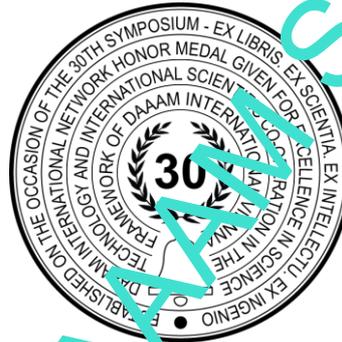


# SUSTAINABILITY ASSESSMENT OF SMALL HYDROPOWER PLANTS

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## Abstract

The paper presents a set of criteria for assessing the sustainability of Small Hydropower Plants in Bosnia and Herzegovina developed on the basis of the catalogue of criteria for the use of hydropower in the Austrian province of Tyrol as well as the application of the criteria in a case study. Bearing in mind that the criteria used in the Tyrolean catalogue refer to all types of hydropower plants without capacity limitations, and the catalogue for SHP applies to plants with a capacity of less than 10 MW, it was necessary to choose a methodology for adapting the Tyrolean catalogue. The SHP catalogue includes five interdisciplinary areas as well as the Tyrolean catalogue, namely: Energy, Water Management, Spatial Planning, Water Ecology, Nature Protection. The evaluation of the project by all criteria is done on the basis of a point scale from 0 to 5, and weighting factors are taken into account for the final evaluation by area. Ultimately, the values obtained according to the criteria are classified into ranges of values marked with red, yellow and green colours. Criteria whose values fall into the red range are not acceptable, while the yellow colour suggests the possibility of improving the project.

**Keywords:** Small hydropower plant; Multicriteria analyses; Sustainability assessment; Scoring intervals.

## 1. Introduction

Small Hydropower Plants (SHPs) are highly represented in Bosnia and Herzegovina (BiH). By 2020, 113 have been built, and another 340 are planned. Out of total 2373 MW of renewable energy installed in BiH in 2020 (2,42% below the targeted 40% of renewables share for 2020), 172 MW are produced in SHPs [1]. Decision-making on the construction of hydropower plants and feasibility assessment were mainly based on the criterion of maximum utilization of water potential, in fact there are no procedures for mitigating the conflicting goals between energy, water and the environment. Investors often plan the construction of SHP in protected natural areas, and the competent authorities issue a concession regardless of the protection objectives. Several problems related to the development of hydropower has been identified

in the country: over-ambitious assessment of usable hydro potential, subsequent planning without involvement and communication between different sectors in charge of managing and protecting water resources, while corruption is especially emphasized mainly due to lack of bureaucratic transparency.[2] This leads to conflicts between local communities and different interest groups. The SHP projects are often considered as an alternative to large hydroelectric power plants due to the assumed lower environmental impact [3]. Although studies of the impact of SHP on the biological communities show different levels of impact, from very small [4] to significant [5], impacts related to SHP cannot be neglected, so there is a need for a comprehensive set of indicators allowing complete and transparent assessment of the sustainability of SHP projects, from various perspectives. With the growing interest in maintaining and improving the quality of the environment, companies and investors turning with increased rate their attention to the potential impacts of their activities on the environment. Interest in achieving and proving good environmental performance through managing the impacts of one's activities is a necessary direction for environmental protection and achieving the goals of sustainable development. [6] In the context of the development of hydropower projects, the environmental protection policy should be based on the Application of criteria for sustainability assessment of hydropower projects in the early stage of the project development, i.e. on the level of the project design.

Number of authors contributed to development of a sustainability criteria for hydropower assessment and multicriteria evaluation methods. Following the results of the CHOICE project [7], the authors [8] developed a concise criteria matrix that was used to evaluate impacts of the project and its alternatives during the construction phase and during the operational phase of hydro power plants (HPPs). They included quality elements of the river ecosystem into consideration, such are: phytobenthos, macrophytes, fish fauna, benthic, invertebrates, morphological, conditions, water quality, terrestrial and habitat. For selection within a set of alternative HPPs, i.e. for ranking they took construction costs, installed capacity (in MW) and production capacity (GW h/y) using Vikor method as multicriteria decision aid. However, the tested method did not take social criteria into account. A chronological list of research studies along with the reported technical, ecological, economic and social parameters has been provided and analysed by [9]. Authors pointed on the complexity in quantifying social impacts, as one of the most challenging aspects of hydropower development. Under the reported parameters, only few authors consider limited number of technical criteria such are: installed capacity, development period, transmission, etc. Further development of environmental criteria has been presented by [10], who developed a comprehensive checklist of river function indicators for hydropower ecological assessment has been developed, but no social or economic criteria has been included. Authors [11], tested innovative multicriteria assessment model, i.e. Mesohabitat Simulation Model, on hydropower projects in Aosta Valley, as a good representative of Alpine region. They replaced the EU Water Framework Directive (EU WFD)[12], biological indicators with the MesoHABSIM based river Habitat Integrity Index, amending the list of indicators with "energy index", that quantifies the production losses due to the flow releases; and to economy related indicators: "producer income" and "local community income". this method also includes the indicator of "landscape protection level", assessing to which extent the landscape changes due to the changes in the natural flow. The analysed research papers show that the challenge of defining an appropriate set of sustainability indicators that covers social, economic, technical and environmental indicators is still present and that most of the papers refer to hydropower plants in general. Some authors have investigated the criteria for SHP analysis, but the research has mostly focused on aquatic ecology perspective [13], [14].

The transposition and implementation of the EU WFD (2000/60/EC) in BiH imposed a new imperative and the need to define criteria more precisely, bearing in mind that the directive requires the achievement of a good qualitative and quantitative state of waters, assuming the "principle of non-deterioration" of the existing ecological status. On the other hand, the national goals of increasing the share of renewable energy and the interest of investors in the construction of new renewable capacities as SHP, represent additional pressure on water bodies, which required the urgent development of a set of evaluation criteria that will enable the assessment of the sustainability of SHP, taking into account the efficiency in energy production, efficiency in the use of water potential, impact on water ecology, biological and landscape diversity, population and space, enabling decision makers to make an informed decision. The paper presents a set of criteria for assessing the sustainability of SHPs in Bosnia and Herzegovina as well as the application of the criteria in a case study.

## 2. Method and adaptation results

A set of criteria for assessing the sustainability of Small Hydropower Plants (SHP) in BiH is developed on the basis of the catalogue of criteria for the use of hydropower in the Austrian province of Tyrol [15]. The Tyrolean Catalogue has been prepared as a basis for regional planning in the field of hydropower supply, and it includes an assessment of hydropower projects in the early stages of planning. The Tyrolean Catalogue contains five thematic areas as follows: energy management, water management, spatial planning, water ecology and nature protection. The criteria used in the Tyrolean Catalogue refer to all types of hydropower plants without capacity restrictions. The catalogue of criteria for BiH refers only to small hydropower plants the capacity of which is less than 10 MW. Therefore, a first step in adaptation approach was to eliminate criteria not applicable on SHP with capacity less than 10 MW. A second step was elimination of criteria for which BiH lack of data and information. Third step was to adapt the names of the adopted criteria to the

professional terminology used in the territory of BiH. This resulted in adoption of 33 out of total 55 criteria (6 for Energy management, 9 for Water management, 10 for Spatial planning, 22 for Water ecology 8 for Nature protection) from Tyrolean catalogue (Table1). In addition to the 33 criteria we introduced category of 5 eliminatory criteria that would suspend a project in case of a negative evaluation (Table 2). 4 of them are introduced due to the legally prescribed restrictions while existence of valid hydrological study is introduced with the aim to improve the quality of the studies accompanying the project documentation, i.e. the reliability of the input data based on which the hydropower facility is planned and designed.

Energy management	Water management	Spatial planning	Water ecology	Nature protection
Specific investment	Degree of utilization of hydropower potential	Spatial planning documents	Ecological status	Protection of species
Contribution to climate protection	Water management related characteristics of the SHP, using the following indicators: <ul style="list-style-type: none"> <li>Degree of Utilization</li> <li>Ratio of Head and Length of Diversion</li> <li>Duration of spillover</li> </ul>	Direct use at watercourses	Hydromorphology	Protection of natural habitat
Connection to the distribution network	Efficiency of Utilization of the River Stretch	Infrastructure	Catchment area	Ecosystem
Additional Effects / Synergies.	Change of Hazard Potential	Agriculture	Presence of natural fish spawning site	Landscape-recreational values
	Effects on Immission Situation	Forestry	Special types of water bodies	Natural values of water courses
	Effects on Groundwater	Tourism	Thermal pollution	Sensitive water bodies
		Local Economy	Free flow pathways	Sensitive/ unique water bodies
			Reservoir size	Protected areas

Table 1. List of selected criteria for BiH Catalogue

No	Subject area	Criterion	Reason for introduction
1	Water Management	Existence of valid hydrological study	Ensuring reliability of the input data
2	Spatial Planning	Cultural property	Legal
3	Water Ecology	Ecological Flow	Legal
4	Water Ecology	Reference sites	Legal
5.	Nature protection	Protected areas	Legal

Table 2. Eliminatory criteria for BiH Catalogue

For most of the criteria the Tyrolean Catalogue adopts a unique scoring method with a scale of 0-5 and is established in a way that score 0 corresponds to the lowest and score 5 to the highest score. For quantified type of indicators (energy management and water management) specific scoring intervals are associated to each score. Since the criteria in the field of Energy and Water management depend primarily on the technical and economic parameters of the hydropower plant, and the Tyrolean Catalogue covers all types and sizes of power plants, there was a need to adjust the range of values used in scoring. We used data from 2019, when 83 SHPs with an installed capacity of up to 10 MW were built. The following information was collected and analysed necessary to adjust scaling in scoring system for selected energy management and water management set of criteria:

- Mean annual flow rate of river stretch

2. Length of pipeline
3. Installed flow rate of HPP
4. Installed rated capacity
5. Average annual electricity production
6. Gross head
7. Length of water course section under the influence of HPP
8. Full load hours - calculated based on input data
9. Length of connection to the distribution network (km)
10. Total investment costs –calculated based on input data,
11. Type of SHP

After classifying the collected data, we completed quantitative data for 30 SHPs. Hence, analyses per criterion were made by using all available data. The approach to adjusting the scoring system is illustrated on the example of the indicator “Energy related efficiency” for which the scoring intervals are not changed after analyses and the indicator “Aspects of the grid economy” for which the scoring intervals are changed after analyses. “Energy related efficiency” is an indicator of the ratio of the length of the waterbody (m) section affected by the plant and average annual production in a normal year (GWh/year). This shows the extent to which the hydropower plant uses the watercourse in relation to the production. The length of the waterbody under the influence of the power plant should be minimized, and annual production maximized. This criterion for BiH SHPs ranges from a very good 114 m / GWh to a very unfavourable 8344 m / GWh (Fig1).

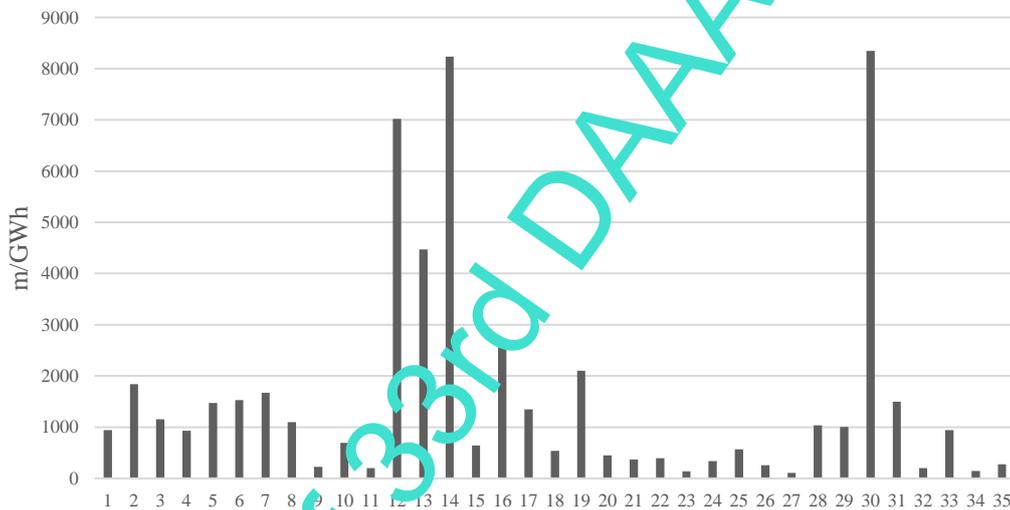


Fig. 1. Values of the criterion "Efficiency of Utilization of the River Stretch - energy efficiency" for existing SHP in BiH

Applying the Tyrolean Criteria to the SHPs in BiH shows that only in 2 SHPs, the waterbody is efficiently used (4 or 5 points), 11 show medium scoring (2 and 3 points) while 19 have 0 points, since the amount of the produced energy is small in relation to the length of the waterbody under the influence of a power plant (Table 3).

Score	Length of waterbody section/yearly production (m/GWh)	Number of existing SHP
0	$800 < EE$	19
1	$500 < EE \leq 800$	4
2	$250 < EE \leq 500$	6
3	$125 < EE \leq 250$	5
4	$80 < EE \leq 125$	2
5	$EE \leq 80$	0

Table 3. Number of SHP built in BiH falling into the scoring intervals of the “Energy related efficiency” as set in the Tyrolean Catalogue

Small power plants built in BiH have values from almost all intervals foreseen by the Tyrolean Catalogue, and as the criterion in terms of scope and purpose should be minimized, the scoring scale from the Tyrolean Catalogue is adopted for BiH without changes.

Connection to electrical power transmission grid of new hydropower plants can require lower or higher cost, depending on the distance from a suitable network hub as well as the way it connects to the network (cables or transmission lines). On the other hand, new hydropower plants may have positive or negative impact on the electricity grid which is needed to transfer the electricity that can be produced. With a decentralized method of production, it could be possible to avoid the need for further network development measures and support weaker areas of the network. However, additional production may make it necessary for the network to be further developed, in cases where there are no consumers in the immediate vicinity or when the existing network is too weak. The grid related aspects are determined based on the distance of the power plant from the point of connection to the public grid and the average annual electricity production. Additionally, for the assessment in the Tyrolean catalogue, the voltage level at the grid connection point is relevant. The result is expressed in km / GWh/per year. In the Criteria Catalogue for BiH, this criterion will be applied under the name "Connection to the Distribution network" (Fig. 2).

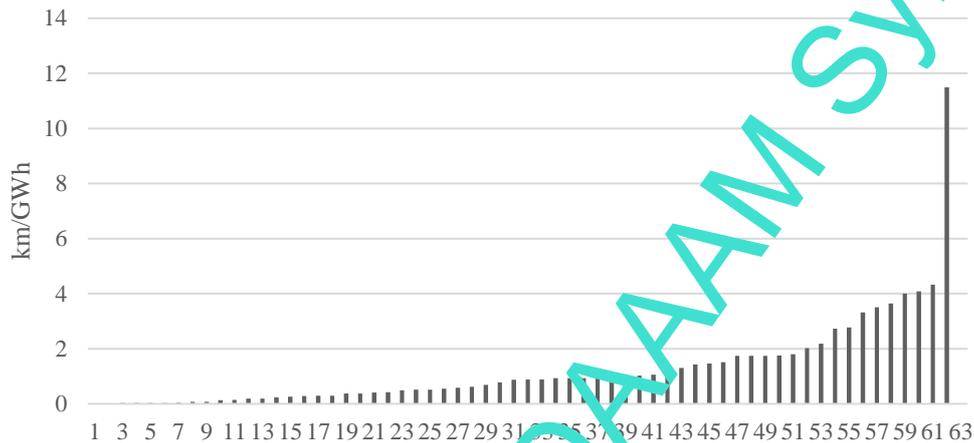


Fig. 2. Value of Criterion "Connection to the distribution network for SHPs built in BiH"

When applying the Tyrolean Catalogue scoring intervals on the selected BiH SHPs, out of 63 SHPs 41 have values of the criterion "Connection to distribution network" above 0.45, thus scored with 0. Bearing in mind that the electricity distribution network is quite underdeveloped, and that better scoring is not realistically possible to achieve in Bosnia and Herzegovina, the scoring intervals have been adjusted. (Table 4)

Score	Scoring intervals Aspects of Grid Economy - Tyrolean Catalogue $e_{Net}[km / GWh/ann.]$	Number of SHP built in BiH falling into the Tyrolean catalogue range	Adopted scoring intervals and criterion Connection to distribution network- BiH $e_{Net}[km / GWh/ann.]$	Number of SHP built in BiH falling into the BiH catalogue range
0	$e_{Net} \geq 0.45$	41	$e_{Net} \geq 1.50$	18
1	$0.35 \leq e_{Net} < 0.45$	4	$1.00 \leq e_{Net} < 1.50$	6
2	$0.25 \leq e_{Net} < 0.35$	3	$0.75 \leq e_{Net} < 1.00$	10
3	$0.15 \leq e_{Net} < 0.25$	5	$0.50 \leq e_{Net} < 0.75$	6
4	$0.05 \leq e_{Net} < 0.15$	3	$0.10 \leq e_{Net} < 0.50$	15
5	$e_{Ne} \leq 0.05$	7	$e_{Net} < 0.10$	9

Table 4. Analysis of the criterion "Connection to distribution network" for selected hydropower plants through Tyrolian Catalogue scoring

For the criterion "Additional Effects / Synergies", under the Energy management thematic area the following country specific additional effects /synergies are selected as subcriteria: i) Impact on the operation of other hydropower plants, ii) Synergy with parts of existing plants; iii) Additional use as reversible plant, iv) Output regulation, v) Security of supply, vi) Contributions to local / regional energy programs. If the criteria are positively evaluated it will gain 1 or 2 points. In case of decrease in production in other hydropower plants the criterion "Impact on the operation of other hydropower plants" will receive negative points:

- (1) in case of 5 - 10% decreased production in other hydropower plants
- (-2) in case of  $\geq 10\%$  decreased production in other hydropower plants

For the overall assessment of the "Additional Effects / Synergy" criterion, the points of individual subcriteria are added up, where the sum cannot exceed 5 and be less than 0.

The criteria for the area of spatial planning have been adapted taking into account the availability of spatial planning documentation and the criteria and provisions of national legislation for the protection of natural resources included in the set of spatial planning area. The criterion "spatial planning at the local level" in the Tyrolean catalogue is impact analyses type of criterion based on two elements of planning: i) effects on the Local Concept of Spatial Planning, in compatibility with the categories of land use from the Land Use Local Development Plan. Data were collected on the existence of spatial planning documentation, which showed that out of 135 local self-government units in BiH that are obliged to draw up spatial plans, 29 do not have a plan, while in 21 plans are under preparation. These 50 units of local self-government make up 41.66% of the total territory with 26.75% of the population of BiH. Among them are those with significant hydropower potential, such as Foča, Kalinovik, Višegrad, Srebrenica, Knežev, Šipovo and Drvar. In the past period, due to the lack of detailed spatial planning documents for the majority of realized SHPs, the institutions responsible for spatial planning prepared expert opinions on the suitability of the location for the construction of SHP, which created the basis for issuing location permits. When preparing expert opinions, criteria from the fields of Water management, Water ecology, and Nature protection were not taken into account. Therefore, instead of assessing the impact on spatial planning concept or land use, the criterion is based on the assessment of the existence of spatial planning documentation. Thus, a project whose spatial assessment is based on expert opinion gets 1 point, and a project that is specified in a detailed spatial planning document gets 5 points.

For the selected 8 criteria from the field of Water ecology, the scoring approach remained the same as in the Tyrol Catalogue, but the scoring criterion were adapted. A first step is the sensitivity analyses of water bodies, which are classified as "very sensitive" and "sensitive". The baseline data for the sensitivity analyses could be found in water management plans [16], [17], [18], [19] in which the status of surface bodies of water in the River Sava and Adriatic Sea basin districts is determined in accordance with the EU WFD [12] and regulations in field of water management in BiH [20], [21], [22], [23]. As example, for the sensitivity analyses for Hydromorphology criterion we used data on assessments of the general hydromorphological status of the water bodies. High sensitivity classification requires a minimum length of 1 km (except for water bodies shorter than 1 km, in which case the entire length is used), as prescribed in the hydromorphology standard defined in the water district management plans in BiH. [24] Sensitivity assessment of a body of water under this criterion is based on the total length of a type-specific body of water in BiH, which is subject to changes in morphology. Types of bodies of water deemed sensitive are those where <20% of the length of sections of water body of a specific type in the territory of BiH is subject to morphological changes.

Assessment	Hydromorphological status
Very sensitive	Quality of the hydromorphological structure of the body of water Class 1 in the length of at least 1 km (or total length for water bodies < 1 km)
Sensitive	Quality of the hydromorphological structure Class 1 - natural state, in the length of only 500 m; Quality of the hydromorphological structure Class 2 - slightly modified state, in the length >500 m
Low to moderately sensitive	Quality of the hydromorphological structure Class 3-5 (moderately modified to highly modified) in the length >0.5 km

Table 5. Sensitivity assessment for the Hydromorphology criterion (BiH Catalogue)

For all of 8 criteria under the Water ecology, the project is scored by combining two parameters: sensitivity and weight, whereby the highest score (5 points) is awarded to projects where none of the criteria were evaluated as highly sensitive and the lowest score (0 points) to projects with three or more "highly sensitive" criteria or where the ecological status of the water body is high. For the Hydromorphology criterion assessment weights are determined as follows:

- \*\*\* High status sections of the water body cover <20% of the total length of a type-specific body of water in the territory of BiH
- \*\* High status sections of the water body cover >20% of the total length of a type-specific body of water in the territory of BiH

For the criteria from the field of Nature Protection, adjustment of the internal scoring within each individual criterion was done on the basis of the BiH laws on nature protection and the laws on freshwater fisheries, which regulate protection issues. Laws prescribe measures for the preservation of biological diversity through the preservation of habitats, ecological networks and ecologically significant areas. As example, evaluation of the criterion "Protection of species" is based on the assessment of the impact of a certain SHP project on the species listed on the BiH Red lists [25], [26] and species protected by laws on nature protection [27], [28]. The assessment is based on scoring from 0 to 5. The project receives 0 points when directly impacts vulnerable, critically endangered and endangered species from the Red Lists while 5 is awarded to projects having neither impact on endangered and/or protected species, nor on population/subpopulation, even at the level of individual specimens. (Table 6).

Score	Estimation - Range Definition
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0	Threatens individuals, parts of the population or populations of critically endangered wild species (CR, RE) or endangered (EN) or vulnerable (VU)
1	Threatens population or part of populations of endangered (EN) or vulnerable (VU) species
2	Threatens population or parts of the populations of nearly threatened (NT) or data deficient (DD) species
3	Negative impact to individuals of least concern (LC) species and/or those that receive 2 points in the case of negative impact on population or parts of populations
4	Negative impact to individuals of non-threatened species
5	No impact on endangered and/or protected species, nor on any population/ subpopulation, even on the individual specimens

Table 6. Scoring for the Protection of species criterion (BiH Catalogue)

For the overall evaluation of the criteria under the Nature protection thematic area, a dominantly quantitative approach is used in the evaluation, with a scale from 0 to 5. If none of the criteria receives points, the Nature Protection score is calculated as mean value of individual criterion scoring. The criterion "Sensitive Water Types" and "Sensitive / Unique Water Bodies" will be awarded 0 points if the project is planned on watercourses that belong to this category (sensitive types and sensitive and unique water bodies). (Table 7) Depending on the number of criteria evaluated with 0 points, the Nature Protection overall score will receive 0 (more than 2 criteria), 0.5 (2 criteria) or 1 point (1 criteria).

Criterion	Score
Species Protection	0 to 5
Habitat Protection	0 to 5
Natural Value of Watercourses	0 to 5
Ecosystem	1 to 5
Landscape/Recreational Values	1 to 5
Sensitive Water Types	0
Sensitive / Unique Water Bodies	0
Protected Areas	0 to 5

Table 7. Scoring of the Nature Protection criteria (BiH Catalogue)

The consolidated scoring of the criteria within the thematic areas is carried out in such a way that the results of the evaluation of individual criterion within the thematic area are assigned with their shares (weights) according to their importance in the overall evaluation. Determination of weight shares, as well as the entire process of analysis, selection and adaptation of criteria was done through consultation with a stakeholder working group composed of staff members of the ministries of environment, water management and energy management, regulatory renewable energy agency, agencies for granting concession, water management agencies, as well as non-governmental organizations, and other representatives of hydropower industry. Finally scoring results are summarised in spider graphic form. To facilitate the interpretation of scores, we followed the Tybjean Catalogue approach and divide scores into three ranges (Fig. 2.):

- "Red" range - the score is between zero and the yellow-red boundary: If the thematic area score is in the red range, it has to be significantly improved or the project will be abandoned,
- "Yellow" range - the score is between the red-yellow and yellow-green boundary: If the thematic area score is in the yellow range, this indicates that the project can be approved only on the ground of favourable assessment of public interests unrelated to thematic area. Alternatively, assessment score in the yellow range can be interpreted as a recommendation to improve the project to bring the project score as close as possible to the green area,
- "Green" range - the score exceeds the yellow-green boundary: This indicates that the project is eligible for approval with respect to considered thematic area.

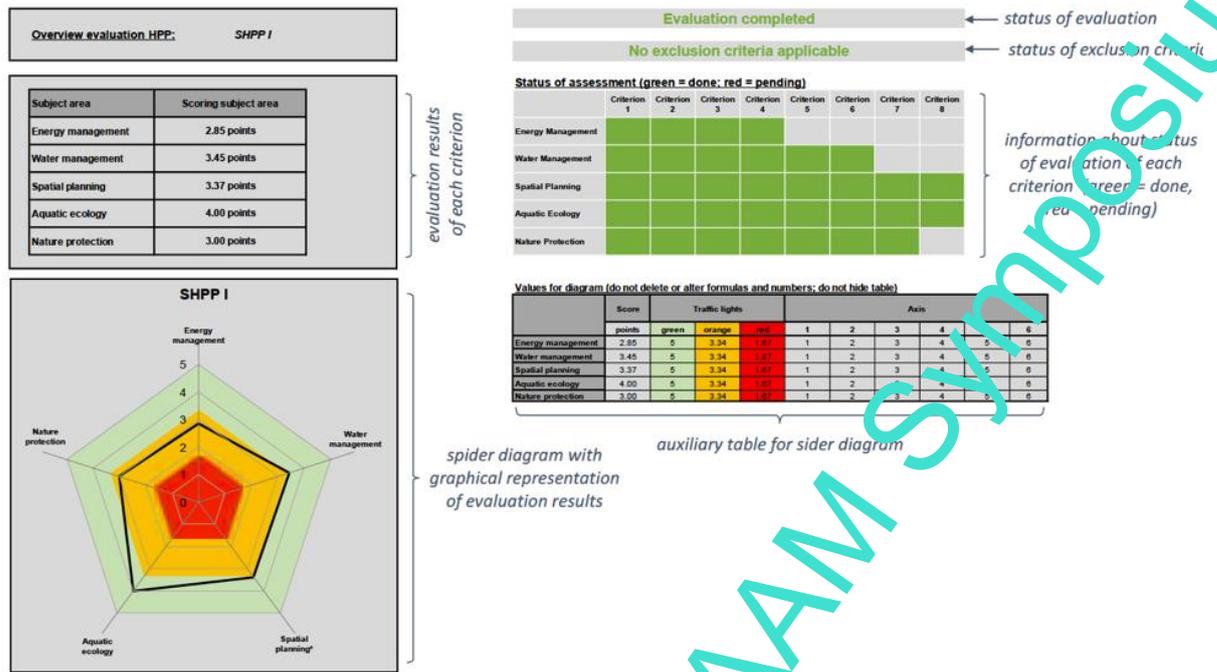


Fig. 2. Example of consolidated scoring for the SHP project presented in the spider diagram form

### 3. Results and discussion

To illustrate the applicability of the selected criteria to the assessment of the sustainability of the SHP, a diversion power plant with the installed capacity of 249 kW, annual production 965 MWh/a, total investment 0.924 mill. BAM, Head 66.9 m, Grid connection 0.7 km, mean annual flow 0,26 m3/s, installed flow 0,48 m3/s, length of pipeline 1,6 km. The project does not meet any of the eliminatory criteria, so an evaluation for all groups of criteria followed. With these technical characteristics, the project in the field of energy management has a favourable rating only for a specific investment. (Table 9).

Criterion	Score	Weight	Weighting score
1. Specific investment	4	30%	1.2
2. Climate protection	1	30%	0.3
3. Grid connection	2	20%	0.4
4. Additional aspects/synergies	1	20%	0.2
Total score			2.1

Table 9. Scoring for the thematic area Energy management

The location of the SHP is unfavourable as the available potential is utilised to a minor degree and poses major obstacles to future utilisation of the remaining hydropower potential. The characteristics of the hydropower plant are also unfavourable due to the fact that the degree of utilization of SHPP is 1,85 m3/s (1 point), duration of spillover during one-year period is 37 days (1 point) and head to length ratio is 4,2% (1 point). When applying weighting factors for this subcriterion as 40%, 40%, 20% we get total score of 1 point for the criterion "Characteristics of the hydropower plant" (Table 10). The aspect of impact on society is incorporated into the "Change of hazard potential" criterion, and for this pilot SHP was rated with a favourable score of 4 because the SHP is located in an unpopulated area without the presence of other users of the water body, there are no other buildings in the risk area. Efficiency of utilization of river stretch is lowest as possible as it is 1.337 m/GWh what gives 0 points on the scoring scale for this criterion ( $w_{Eff} > 800$ ), while the 5 points gets  $80 \geq w_{Eff} > 0$ .

Criterion	Score	Weighting factor	Weighting score
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1. Degree of utilization of hydropower potentials	1	20%	0,20
2. Characteristics of the hydropower plant	1	25%	0,25
3. Efficiency of utilization of river stretch	0	20%	0,00
4. Change of hazard potential	4	10%	0,40
5. Effects on emission situation	0	10%	0,00
6. Impact on groundwater	1	15%	0,15
Total score		100%	0,20

Table 10. Scoring for the thematic area Water management

There is no agricultural land around the location of SHP while the forest land is solely of lowest category class V – VIII. Since the location is outside urbanised area it is expected that the construction of the SHP will contribute to infrastructure development. There are also no other water users along the water course, thus the awarded score for the subcriterion “Direct use at watercourses” is 5 points. (Table 11). The only unfavourable scoring is given to the subcriterion “local economy” as the level of the annual concession fee is below 5,000 BAM/a. The best score (5) is given when the concession fee is over 20,000 BAM/a. Since two criteria are not applied the weighting is adjusted to give the total score of 100%. The total scoring is converted from a scoring range 1-5 to the scoring range 0-5 points that is used in all other thematic areas.

	Score	Adjusted weighting factor	Weighting score	Weighting factor
1. Spatial planning documentation	4	25%	1,00	20%
2. Direct use at watercourses	5	25%	1,25	20%
3. Infrastructure	5	13%	0,63	10%
4. Agriculture	5	13%	0,63	10%
5. Forestry	4	13%	0,50	10%
6. Cultural property	n/a			10%
7. Tourism	n/a			10%
8. Local economy	1	13%	0,13	10%
Total score (scope 1-5 )		100%	4,13	100%
Total score (Score 0-5 )			3,91	

Table 11. Scoring for the thematic area Spatial planning

The water course (w.c) is of 1290 m length with where 20% of the total length of the water has a “High status” and has preserved natural features in length of 1000 m, i.e. the quality of hydromorphological structure is Class 1. Due to this fact the Hydromorphology criterion is assessed as “Very sensitive”. Given that the ecological status is very high, the total score for the Water Ecology criterion will be 0, regardless of the scores of other criteria.

Hydro-morphology	Ecological status	Basin size	Special types of w.c.	Special features by w.c type	Presence of spawning sites	Free flow pathways	Thermal pollution	Reservoir size
Very sensitive	Very sensitive	Sensitive	Low to moderately sensitive	Low to moderately sensitive	Low to moderately sensitive	Sensitive	Low to moderately sensitive	Low to moderately sensitive
**	***	*	**	*	***	***	*	***

Table 12. Scoring for the thematic area Water ecology

Protection of species	4
Protection of natural habitat	5
Ecosystem	3
Landscape and recreational values	n/a
Natural value of the water course	4
Sensitive water types	0
Sensitive and unique water bodies	0
Table 13. Scoring of the subject area Nature protection	

The SHP is planned to be built on sensitive water type and that the water body is sensitive and unique those two criteria are scored with 0. Since the number of criteria scored with 0 is 2 the Nature protection thematic area is granted with 0 points.

Bearing in mind that the three key criteria for the protection of natural assets, Water management, Water ecology and Nature protection, fall into the "red range" (Fig. 3.), this project would not be able to obtain construction permits.

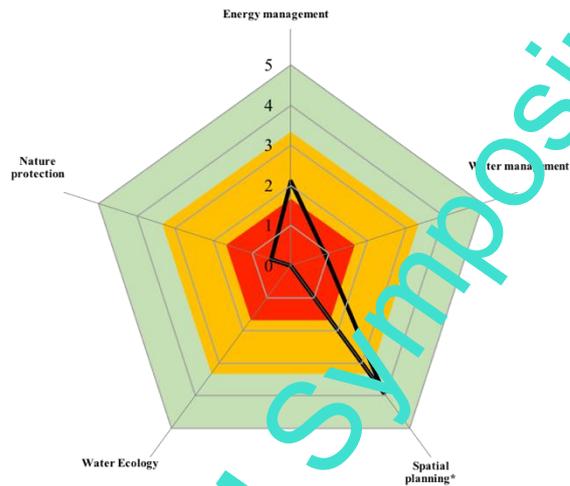


Fig. 3. Consolidated scoring for the SHP pilot project presented in a spider diagram form

The fact that the project has favourable spatial planning characteristics, even that the location in the detailed local spatial plan is reserved for the SHP, indicates that these criteria were not taken into account during spatial planning.

#### 4. Conclusion

Due to the increase in interest in the construction of SHP, the introduction of criteria for evaluating their sustainability deemed necessary. The criteria must cover all five areas (energy management, water management, spatial planning, water ecology and protection of natural resources), and issues of social protection should be mainstreamed in all the mentioned areas. The adaptation of the Tyrolean Catalogue to the context of Bosnia and Herzegovina proved to be a good choice, especially because the interested parties involved, who are at the same time future users of the criteria for decision-making, showed a high level of understanding regarding the purpose of criteria, calculation and scoring method. The adaptation methodology, which was based on the principles of applicability to the SHP context and national context, compliance with national laws and data availability, was a legitim choice, as it resulted in a comprehensive set of indicators was chosen in all five areas that decision makers can evaluate by themselves. Progress made in implementation of European directives in Bosnia and Herzegovina in particular: The Water Directive (status assessment and risk assessment for surface water bodies) and the Habitat Directive (red list of habitats and species) was a key for the data availability for thematic areas of Water Ecology and Nature Protection. The need to engage an external expert arises only in the field of Nature Protection, because it is the only field for which there is not enough data and an expert opinion based on field investigation is needed. Testing of the BiH catalogue on the pilot SHP showed the need to apply the criteria at the earliest stage, already during the creation of spatial planning documentation. The fact is that the SHP pilot was planned in the spatial planning documentation, but the evaluation of the criteria showed that the project could not be approved. Consideration of the sustainability of waterpower utilization at the spatial plan level should be preceded by an extensive study on water potential to which the above criteria would be applied. That study would serve as a background study for the spatial plan.

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