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THE USE OF THE FLUVIAL FUNCTIONING INDEX AS DECISION TOOL FOR NEW SMALL HYDROPOWER PLANTS IN THE ALPS

Utilisation de l'Indice de Fonctionnalité Fluviale en tant qu'instrument de décision pour l'approbation de nouvelles installations hydroélectriques de petites dimensions sur les torrents alpins

Siligardi Maurizio, Canepel Raffaella, Fabris Margherita, Negri Paolo

Provincial Agency for Environmental Protection of Trento (Italy)

In recent years and in the foreseeable future, there has been and will be a constant increase in the demand for electricity.

This is leading to the construction of new hydropower plants and, in particular, of smaller plants built on small (and therefore more fragile) alpine streams.

The Provincial Agency for Environmental Protection of Trento has developed a methodology based on the Fluvial Functioning Index (F.F.I.) which allows a quick and effective appraisal of the impact of new small hydropower plants (20-3000 kW) on the river environment and of the problems of ecosystemic stability, ecological functioning ability and self-depuration ability of the aquatic environment.

THE FFI METHOD

The FFI (Siligardi et al., 2000) is a method for the evaluation of the functional state of fluvial environments, based on the morphological, structural and biotic parameters of the fluvial ecosystem. This is a rapid method for the ecological assessment and monitoring of fluvial environments for the purpose of conservation.

The FFI is a development of the RCE-2, the first draft of which was drawn up by Siligardi and Maiolini (Siligardi & Maiolini, 1993) which, in turn, is derived from the Riparian Channel and Environmental Inventory (RCE-I) drawn up by Peterson from the Institute of Limnology of Lund University (Peterson, 1990).

The FFI record was further refined and foresees **14 questions**, with **4 predetermined answers** to each question, concerning almost all the ecological characteristics of a watercourse.

The answers are expressed numerically in classes of numbers with a minimum of 1 and a maximum of 30, expressing the qualitative differences between individual replies.

Below an example of the first and second questions:

	Left bank		**Right bank**
1) Land use pattern within the surrounding area			
a) Undisturbate, covered by forest, woodland and/or natural wetlands	25		25
b) Meadow, pasture, woodland, with little cropland and fallow lands	~~20~~		20
c) Seasonal cropland ore mixed arable and/or permanent cropland	5		~~5~~
d) Urbanised area	1		1
2) Vegetation within the riparian area			
a) Riparian arboreal formation	30		30
b) Riparian shrubby formations (willow thicket and/or cane thicket)	~~25~~		25
c) Non typical riparian arboreal formation	10		~~10~~
d) Non typical riparian shrubby or herbaceous formations or absence of vegetation	1		1

From a mathematical point of view, there is no justification for the attribution of numeric weight to the answers, but only statistical-ecological motivations, which are based on the mutual relations between the concepts contained in the answers, making the method substantially more stochastic and less deterministic.

The FFI record is thus made up of a series of questions which embraces several subjects concerning the functional state of the watercourse.

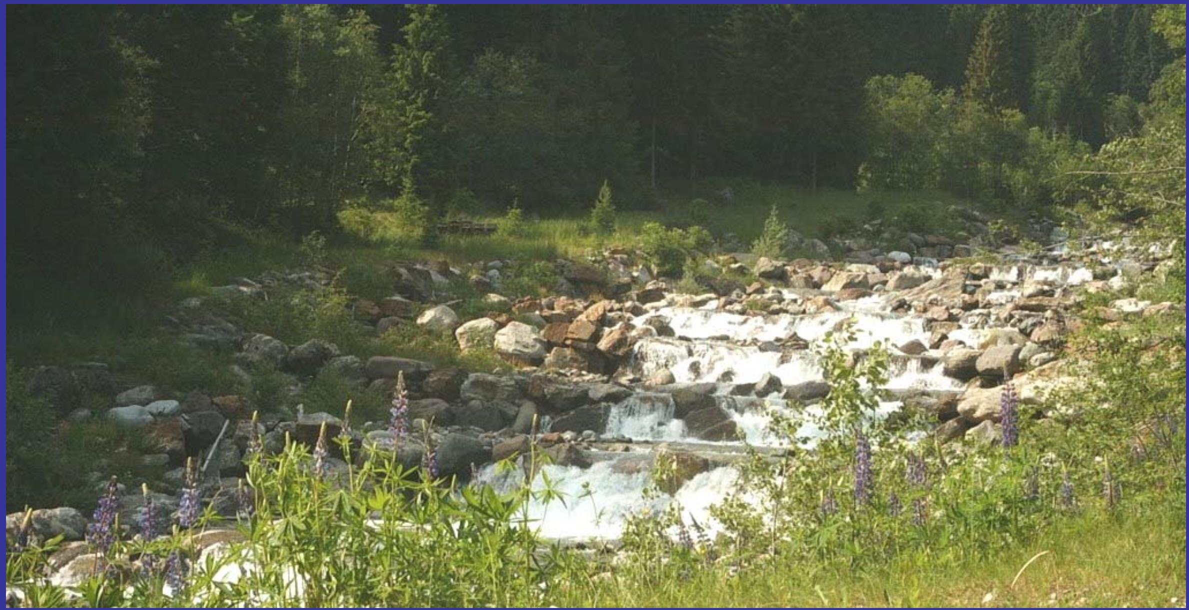
- questions 1-4 concern bank vegetative type and riparian zone width;
- questions 5 and 6 concern riverine zone morphology and river bed width
- questions 7-11 concern instream habitat; scoring of these questions is based upon the abundance and diversity of submerged stable habitats, pools, riffles, meanders
- questions 12-14 concern biological features; scoring of these questions is based upon abundance and diversity of macrobenthos, instream vegetation (periphyton) composition and detritus consistency.

The compilation of the form concludes with the calculation of the sum of the different weight given to the answers identified (one is compulsory for each question) to give a final score, which may range from a minimum of 14 to a maximum of 300, and which has been converted into 5 functioning classes, attributing a rating and colour to each to make the information more easily interpretable on a map by non-specialists.

score	Functional level	Judgement
261-300	I	**EXCELLENT**
251-260	I-II	**EXCELLENT-GOOD**
201-250	II	**GOOD**
181-200	II-III	**GOOD-FAIR**
121-180	III	**FAIR**
101-120	III-IV	**FAIR-POOR**
61-100	IV	**POOR**
51-60	IV-V	**POOR-VERY POOR**
14-50	V	**VERY POOR**

GENERAL CRITERIA TO EVALUATE THE ACCEPTABILITY OF HYDROPOWER PLANTS

The criteria used are based on the identification of the limit of functionality for the stretch of watercourse affected by the manipulation in order to ensure the continuation of dynamic-functional processes.



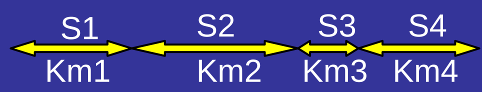
The COMBINED MODEL is used to determine the acceptability of hydropower plants.

That is the combination of FFI values of single stretches of watercourse and their lengths, setting the highest possible judgement rating – functionality **level 1** – as the ideal limit. This precept translates into a numerical reference value (**RF**), equal to the minimum FFI score for this level (261 points) for the length considered, multiplied by the total length of watercourse considered, expressed in kilometres.

$$\mathbf{RF = 261 \times km}$$

The lengths of watercourse affected by the alteration may be represented as a number of sub-sections, with different functionality levels. Therefore, a real value (AF) must be defined, which is the sum of the products of the FFI scores (Si) and the lengths of the sub-sections (kmi).

$$\mathbf{AF = \sum(Si * kmi)}$$

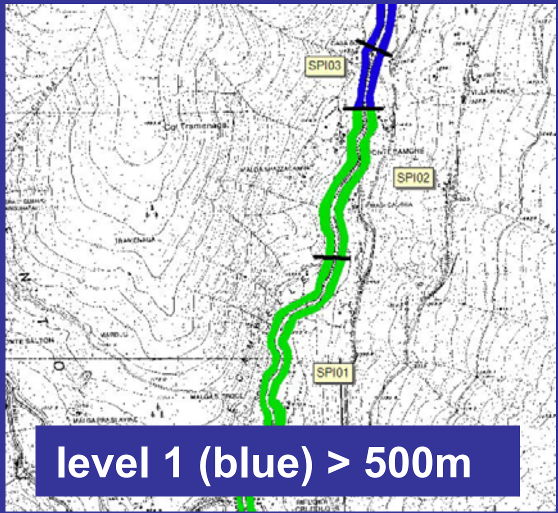


In order to define whether an application is acceptable or not, the real value (AF) must be compared against the theoretical reference value (RF).
In other terms:

if **AF > RF** the application is **NOT ACCEPTABLE**
if **AF < RF** the application is **ACCEPTABLE**

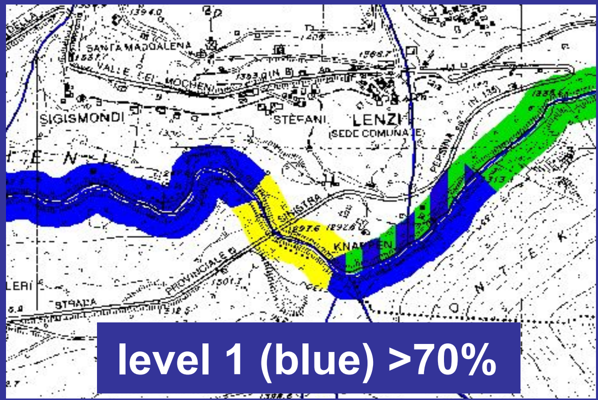
If the canalisation is deemed acceptable by the *combined model*, the application may not be deemed acceptable if any one of the following conditions is satisfied:

a) ***Continuous functionality***: the length of watercourse attaining an FFI functionality rating of level 1 for both banks must simultaneously exceed 500 metres;



level 1 (blue) > 500m

b) Assessment percentage: the percentage of the length of watercourse with a functionality rating of level 1 must be greater than 70% of the total length affected by canalisation;



level 1 (blue) >70%

Example 1

lenght (km)	bank dx	bank sx	mean score	score*km	RF
1,064	295	260	278	295,3	
1,281	255	240	248	317,0	
0,583	300	260	280	163,2	
0,361	164	182	173	62,5	
total				**838**	**858**
3,289				**AF**	**RF**

AF < RF

On the basis of the combined model, the application for a new plant is deemed **acceptable** as the **AF** value is lower than the **RF** value.

Example 2

lenght (km)	bank dx	bank sx	mean score	score*km	RF
1,383	241	221	231	319,5	
0,575	246	241	244	140,0	
0,274	280	280	280	76,7	
0,734	300	295	298	218,4	
0,295	266	231	249	73,3	
0,095	227	270	249	23,6	
0,431	250	270	260	112,1	
total				**964**	**988**
3,787				**AF**	**RF**

I Level

On the basis of the combined model, the application for a new plant is deemed **acceptable** as the **AF** value is lower than the **RF** value.
The limiting condition ***b)*** also permits **acceptability** as the stretch of watercourse with a high functionality rating (level 1) for both banks is less than 70% of the total length of watercourse subject to canalisation.
The limiting condition ***a)***, however, **does not permit acceptability** as the stretches of watercourse with high fluvial function ratings on both banks exceed the specified limit for continuous functionality (500 metres).

Example 3

lenght (km)	bank dx	bank sx	mean score	score*km	RF
0,030	61	65	63	1,9	
0,174	160	175	168	29,1	
0,139	193	295	244	33,9	
0,839	300	300	300	251,7	
total				**317**	**309**
1,182				**AF**	**RF**

I Level

In this case

AF > RF

The application for a new plant is deemed **not acceptable** as the value **AF** is greater than the value **RF.**

Furthermore, conditions a) and b) are also not met. In this instance, the total length of watercourse with a functionality rating of level 1 on both banks accounts for 71% of the length subject to canalisation. Whereas the length of watercourse with continuous functionality is 839 metres, thus exceeding the limit of 500 metres.

THANKS FOR YOUR ATTENTION

maurizio.siligardi@provincia.tn.it