Application of RIAM to the Environmental Impact Assessment of Hydroelectric Installations

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Abstract This paper evaluates an Environmental Impact Assessment (EIA) using the Rapid Impact Assessment Matrix (RIAM). It analyses and presents in a structured, friendly and transparent environment the numerous parameters and alternatives of an EIA. It considers all 4 components: physical / chemical, biological / ecological, social / cultural, economic / operational. These are then evaluated using universal criteria common to all impact consideration. Figures and tables made comparisons much easier. This Matrix was applied to the EIA of the future Vale de Madeira Hydroelectric Installation that will be situated on the River Côa of the Douro River Basin in the Municipalities of Pinhel and Figueira de Castelo Rodrigo, North of Portugal. It will be shown that such a project will be positive economically but negative otherwise (as related to the other three components evaluated in RIAM).

Key words Côa River, Environmental Impact Assessment, RIAM

INTRODUCTION

Since the beginning of the civilization, human beings always coexisted with water and looked for developing techniques in order to allow them to dominate the water resources. The great hydraulics workmanships, with effects on the distribution of the surface water flow date back to Antiquity. More than 3000 years ago in the Egypt, the Mesopotamian, the Persia, in India and in China, the hydraulics works were used to control the water resources with some remarkable knowledge about the hydrologic cycle. As the evolutionary processes took humanity into the industrial age, the construction of hydraulic structures become more and more important in domains such as river navigation, energy production, more efficient irrigation systems and more reliable water supply to bigger and bigger cities and industries (Partidário & de Jesus, 1994).

Only recently the concepts of environmental protection, water scarcity, flood damages and water quality have taken the centre stage. To develop a preventive policy, it is required that most of the projects like the construction of a dam go through an environmental impact assessment. However this process has proved to be less efficient than one expects. Sometimes the number of parameters and alternatives are so many that their comparison has greatly suffered, causing the selection of the projects less friendly to environment, or caused omitting part of the assessment (CEQ, 1978; Bisset, 1988; CEU, 1997). An integrated platform that can easily and efficiently structure all the alternatives was indeed a great asset.

METHODOLOGY

RIAM (Pastakia, 1998) is a method used to evaluate all sorts of environmental impacts. It allows the completion of subjective classifications justified for each analysed item, resulting not only in a clear way, the outcome of the assessment, but also a register for subsequent revaluations. Since Environmental Impact Assessments are the product of the work of a multi-disciplinary team, the RIAM is the ideal mechanism that guarantees the safeguard of a fast and clear evaluation of main impacts, because all the components and parameters can easily be integrated into one platform - RIAM. The importance of the method lies on a standard definition of the importance of the criterion in the evaluation of the impact and in the way semi-quantitative values, which are gathered for each one of those criteria, allow different conditions to obtain independent and precise classifications.

The impacts of the activities of the project are evaluated according to the environmental components, and for each condition a classification is determined (using the pre-defined criterion), what provides an expected impact measure for environmental components.

The importance of the evaluation criterion is divided in two groups: criteria relative to the degree of the relevance of the condition, and that individually can alter the resulting

classification (A); criteria relative to the development of the condition but individually is not capable of altering the obtained classification (B). The value designated for each group of criteria is determined by the use of a series of simple formulas. Those formulas allow the determination, in well defined bases, of the classifications for individual conditions.

Positive and negative impacts can be demonstrated using scales that pass of negative values the positive ones through zero for the group criteria (A), where the value zero presents a condition of "any alteration" or "any relevance." Using zero this way, in group A's criteria, it allows a single criterion to isolate conditions that don't present any alteration or which relevance is null for the analysis. However, the zero is a value avoided in the group B's criteria because, if the classification of all of criteria of that group was equal to zero, the final result of the ES would, naturally, be also zero. Eventually, that situation of nullity of the magnitude of the impact could happen in group A's criteria that presented some relevance degree. To avoid this situation, the scale of group B's criteria uses the unitary value (1) as classification for no alteration/ without relevance.

A measure of the importance of the relevance condition (A1) is evaluated according to the space borders or interest of the man that will be affected. The scale is defined in the following way:

0 - irrelevant:

1 - relevant just to the local condition;

2 - relevant to the areas immediately out of the local condition;

3 - relevant to the Regional / National interest;

4 - relevant to the National / International interest;

The magnitude (A2) is defined as a measure of the scale of benefit / damage of an impact or condition. The scale is defined in the following way:

3 - extremely positive benefit;

2 - moderately positive benefit;

1 - lightly positive benefit;

0 - no alteration / actual state;

-1 - lightly negative damage;

-2 - moderately negative damage;

-3 - extremely negative damage;

This permanent criterion (B1) defines if a condition is temporary or permanent, and if it should only be seen as a measure of the temporary state of the condition. The scale is defined in the following way:

1 – no alteration / actual state;

2 - temporary;

3 - permanent;

The reversibility criterion (B2) defines if a condition can be changed and if it can be seen as a measure of control on effect of the condition. The scale is defined in the following way:

1 - no alteration / actual state;

2 - reversible;

3 - irreversible;

This cumulative criterion (B3), where the effect of a condition will have a single direct impact or there will be a cumulative effect during the course of time, or, on the other hand, a synergetic effect with other conditions. Theoretically, the cumulative criterion is the mean used to judge the sustainability of a condition, and it should not be confused with a permanent situation or reversible condition. Its scale is defined in the following way:

1 - no alteration / not applicable ;

2 - non cumulative / of direct effect / singular;

3 - cumulative / of indirect effect / synergetic;

The RIAM requests the definition of specific components of impact evaluation and each one of those environmental components falls upon one this four categories:

Physical / Chemical (PC):

Includes all physical and chemical aspects of the environment, including non-renewable natural resources (no-biological) and the degradation of the physical environment through pollution.

Biological / Ecological (BE):

Includes all biological aspects of the environment, including renewable natural resources, conservation of the biodiversity, interaction between species and pollution of the biosphere.

Sociological / Cultural (SC):

Includes all human aspects of the environment, including social subjects that affect the individuals and the communities; with cultural aspects, it is included the inheritance conservation and human development.

Economical / Operational (EO):

To identify qualitatively the economical consequences of environmental change, temporary and permanent, as well as the complexities of administration of the projects inside the context of the activity project.

After necessary calculations, the RIAM classifies the degree of the damage or benefit according to Table 1:

Table 1 – Environmental classifications according to RIAM

Environmental classification (ES)	Value of the class	Value of the class (numerical)	Description of the class
72 to 108	E	5	Extremely positive impact
36 to 71	D	4	Significantly positive impact
19 to 35	C	3	Moderately positive impact
10 to 18	B	2	Less positive impact
1 to 9	A	1	Reduced positive impact
0	N	0	No alteration
-1 to -9	-A	-1	Reduced negative impact
-10 to -18	-B	-2	Less negative impact
-19 to -35	-C	-3	Moderately negative impact
-36 to -71	-D	-4	Significantly negative impact
-72 to -108	-E	-5	Extremely negative impact

CASE STUDY

This construction project of the Vale de Madeira's mini hydraulic dam is contemplated on a support policy to the production of energy based on the use of clean and alternative energies instead of other methods that involve larger environmental risks.

Its purpose is the production of electrical energy, either by the production of energy in the electrical centre that is part of the dam, or by the increase of the income of Senhora of Monforte's dam, found further ahead.

Therefore, the Vale of Madeira's dam has as its purpose the production of electrical energy to an installed potential power of 1600 KVA, allowing the annual medium production of 2,58 GWh.

The dam will be located in Rio Côa, between the townships of Pinhel and Figueira de Castelo Rodrigo in the North of Portugal. The present project has as an advantage the existence of an already built dam and it is found inserted in the river between the Senhora de Monforte's dam and a dam made for water reception for the township of Pinhel.

This dam, located between the townships of Figueira de Castelo Rodrigo and Pinhel, is inserted in the hydrographical basin of Rio Douro. The towns located in the influence area of

the dam's construction and exploration, are Colmeal and Reigada, which are part of the township of Figueira de Castelo Rodrigo, and Vale de Madeira, part of the township of Pinhel.

Given the exploration conditions, we opted to install the dam in areas with topographical characteristics and, mainly, special hydrological conditions that allowed exploration to be possible and profitable, from an economical and environmental point of view

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Application of RIAM in the environmental impact study

Before beginning the introduction of data in the RIAM, it was necessary to convert the classifications formats of the environmental impact study, into the RIAM format. After that, the different phases of the project were introduced (or, if alternatives exist, they have to be introduced). For each phase or each alternative, parameters with their descriptions were introduced. Then from the EIA, ratings for each component were introduced. Table 2 shows a sample data of the physical/chemical category for the exploration phase. The values for each component in relation to different conditions are discussed in the previous section.

Table 2: A sample data for the exploration phase of the project:

Component	A1	A2	B1	B2	B3
PC1: Geophysics	2	-1	3	2	1
PC2: Soil	2	-2	3	2	3
PC3: Water quality and water resources	2	-1	3	2	1
PC4: Climate	1	1	3	2	1
PC5: Air quality	1	0	1	1	1
PC6: Environmental noise	1	-1	3	2	1

RESULTS

Discrimination of the results for the Phase of Construction is as follows:

Summary of scores

Range	-108 -72	-71 -36	-35 -19	-18 -10	-9 -1	0 0	1 9	10 18	19 35	36 71	72 108
Class	-E	-D	-C	-B	-A	N	A	B	C	D	E
PC	0	0	1	2	3	0	0	0	0	0	0
BE	0	0	1	1	0	0	0	0	0	0	0
SC	0	0	1	1	2	0	0	0	0	0	0
EO	0	0	0	0	0	0	0	1	0	0	0
Total	0	0	3	4	5	0	0	1	0	0	0

Graphical presentation of the results according to categories for the Phase of Construction is shown in Fig. 2:

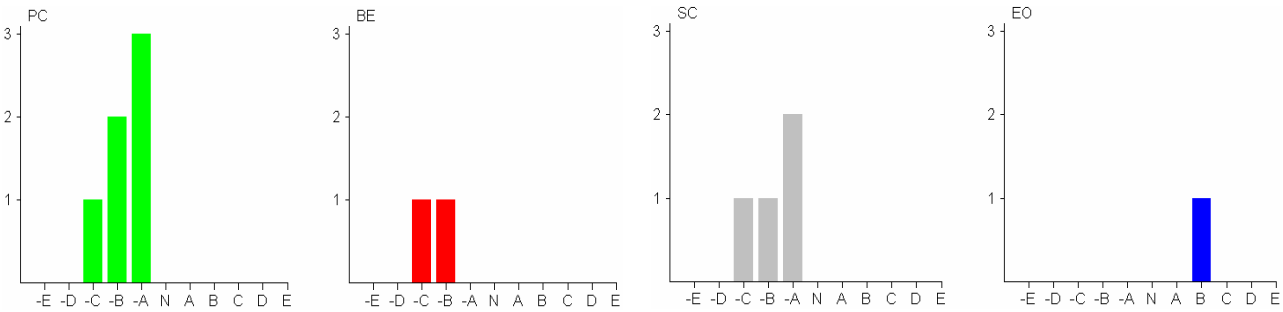

Fig. 2 RIAM results for the construction phase

Discrimination of the results for the Phase of Exploration:

Summary of scores

Range	-108 -72	-71 -36	-35 -19	-18 -10	-9 -1	0 0	1 9	10 18	19 35	36 71	72 108
Class	-E	-D	-C	-B	-A	N	A	B	C	D	E
PC	0	0	1	2	1	1	1	0	0	0	0
BE	0	0	1	1	0	0	0	0	0	0	0
SC	0	0	0	2	0	0	1	1	0	0	0
EO	0	0	0	0	0	0	0	0	0	1	0
Total	0	0	2	5	1	1	2	1	0	1	0

Graphical presentation of the results according to categories for the Phase of exploitation is shown in Fig. 3:

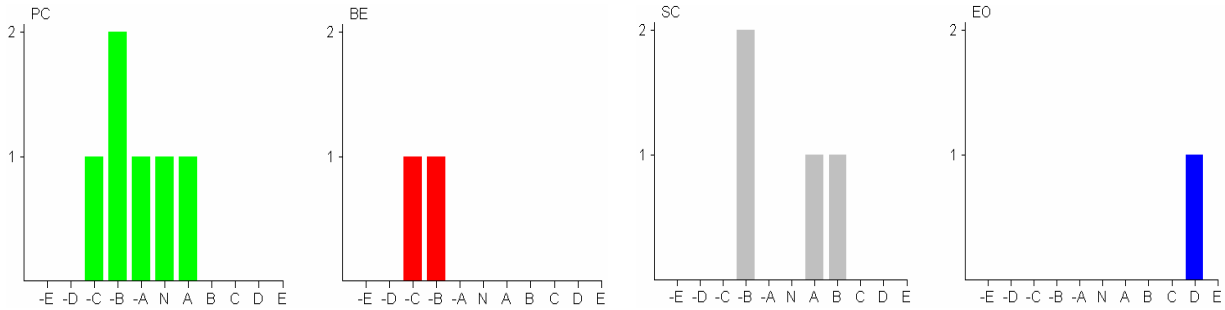

Fig. 3 RIAM results for the exploitation phase

CONCLUSIONS

Conclusions for the construction phase:

Physical and Chemical category:

In this category the following parameters have been analyzed: geophysicists, ground, water quality and hydraulic resources, climate, air quality and the sonorous environment. RIAM indicates that in this category and in this phase there are three types of impacts, being, however, all of them negative: reduced negative impacts for the sonorous environment parameters, air quality and climate; less negative impacts for the hydraulic parameters and geophysical quality of the water and resources; moderately negative ground impacts.

Biological and Ecological category:

In this category the following parameters had been analyzed: flora, vegetation, fauna and habitats. The RIAM indicates that in this category and this phase there are two types of impacts: less negative impacts for fauna and habitats and moderately negative impacts for flora and vegetation.

Sociological and Cultural category:

In this category the following parameters had been analyzed: social-economic, landscape, patrimony and areas with specific regulations. The RIAM indicates that in this category and this phase there are three types of impacts, being, however, all of them negative: reduced

negative impacts for the social-economic parameters and areas with specific regulations; less negative impacts for the landscape; moderately negative impacts for the patrimony.

Economic and Operational category:

In this category the RIAM analyzed the cost parameter. The RIAM indicates that in this category and this phase the cost parameter will have a less positive impact.

Conclusions for the exploration phase:

Physical and Chemical category:

In this category the following parameters have been analyzed: geophysicists, ground, quality of the water and hydraulic resources, climate, air quality and sonorous environment. The RIAM indicates that in this category and this phase there are five types of impacts: reduced negative impact for the sonorous environment; less negative impact for the hydraulic resources, geophysical and water quality parameters; moderately negative impacts for ground; neutral impact for air quality; reduced positive impact for climate.

Biological and Ecological category:

In this category the following parameters have been analyzed: flora, vegetation, fauna and habitats. The RIAM indicates that in this category and this phase there are two types of impacts: less negative impact for fauna and habitats moderately negative impacts for flora and vegetation.

Sociological and Cultural category:

In this category the following parameters have been analyzed: social-economic, landscape, patrimony and areas with specific regulations. The RIAM indicates that in this category and this phase there are three types of impacts; less negative impact for the landscape and patrimony; reduced positive impact for the social-economic parameter; less positive impact for the areas with specific regulations.

Economic and Operational category:

In this category the RIAM analyzed the cost parameter. The RIAM indicates that in this category and this phase the cost parameter will have a significantly positive impact.

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