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ECONOMIC ECOLOGICAL ZONING FOR THE SITING OF NEW HYDROPOWER PLANTS IN THE AMAZON BIOME, MATO GROSSO STATE

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Abstract

The Brazilian instruments of environmental policy are mainly geared toward specific uses. They are not usually integrated into an analysis of all land uses. Economic Ecological Zoning is an instrument which can consider multiple land uses. However, in Brazil, this instrument is still not appropriately used to assist with the siting of planning projects. In this context, this paper aims to analyze the 'usefulness' of Economic Ecological Zoning for the siting of hydropower plants prior to an Environmental Impact Assessment. The study focuses on Mato Grosso state in the Amazon region. It takes into account the fact that this region is the main target for locating new Brazilian hydropower plants. The case study assessed 24 spatial criteria for the siting of new Amazon hydropower projects. These criteria were analyzed in the Socio-Economic Ecological Zoning - SEEZ - of Mato Grosso state. From the results obtained it is possible to argue that SEEZ can assist in the siting of hydropower plants in the Amazon state of Mato Grosso. This zoning instrument appropriately addresses a broad range of physical, biotic and socio-economic criteria which have been established for this purpose. Nevertheless, it is important to stress that SEEZ has some limitations for this type of planning, given that it does not adequately address the following criteria: biome conservation, urban and rural settlements, demographics and the regional economy, as well as hydrological regimes. Thus, this paper concludes that SEEZ is useful for the siting of new Amazon hydropower plants when used prior to Environmental Impact Assessment. However, this 'usefulness' is limited and SEEZ must be employed carefully, given that it may lead to land use conflicts, affecting the planning process and Environmental Impact Assessment, making them overly complex.

Key words: Amazon, Economic Ecological Zoning, hydropower plant, impact assessment, location siting

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1. Introduction

Environmental management is ***"****a set of procedures that aims to reconcile development and environmental quality. This reconciliation takes place by observing the environment's carrying capacity and the needs identified by either society or the government (the most common situation), or by both (the most desirable situation)*" (Souza, 2000). Therefore, a systemic approach to environmental issues is essential to develop a new way of treating nature, contributing to the development of economic activities based on the sustainable use of natural resources. In order to do so, it is necessary to use environmental policy instruments in an integrated way, taking into account the environmental factors

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affected by and affecting socio-economic development. Cumberland (1990) presented a policy matrix for environmental management based on emissions regulation, command-control and spatial zoning. In his view, these instruments should follow economic efficiency criteria and be scientifically validated, particularly in relation to ecological sustainability.

The Brazilian Environmental Policy was created in 1981 and established a set of instruments for environmental planning and management (Brasil, 1981). After three decades, there are still gaps and uncertainties concerning the effectiveness of these instruments, relating to issues such as their integration and the fragmented scenarios of implementation.

Environmental Impact Assessment (EIA) is defined as "*the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decisions being taken and commitments made*" (IAIA, 1999). According to Brazilian law (Brasil, 1988), EIAs are associated with the environmental licensing of projects, which may cause significant environmental degradation. However, EIAs do not provide an adequate integrated analysis of land uses for siting projects. In most cases, the project location is already defined exclusively on economic criteria prior to EIAs being conducted. Therefore, in practice, EIAs are only used to evaluate the impacts of a pre-defined site and not specifically to assist in a genuine choice of location (Moretto et al., 2012).

Another form of EIA, Strategic Environmental Assessment (SEA), is applied to policies, plans and programs. It is important to provide a holistic understanding of the environmental and social implications of the proposal, widening the focus (perspectives, objectives and constraints) beyond a single land use (Brown and Therivel, 2000). SEAs can include relevant environmental issues earlier in the decision-making process, helping to anticipate the resolution of problems that may arise in the future. Although in Brazil SEAs are not formalized by any specific laws, they are used on a voluntary basis (Sánchez, 2008). The country is still beginning to understand the actual applications of this instrument. Ometto et al. (2006) argue that EIA processes, either on a project basis or at a strategic level, should rest on territorial analyses. Environmental Zoning can provide analyses of spatial weaknesses and potentialities, helping to determine environmental criteria for the siting of projects.

In Brazil, Environmental Zoning is known as Economic Ecological Zoning and aims to improve the spatial distribution of economic activities, taking into account the ecological significance, limitations and vulnerabilities of ecosystems. Economic Ecological Zoning must establish restrictions and alternatives for land use planning, determining the relocation of activities which do not conform to general guidelines (Brasil, 2002). Therefore, Economic Ecological Zoning is a strategic instrument for the territorial planning and siting of activities. It sets out environmental criteria which can have an impact on a region and increase land use conflicts (Montaño et al., 2007). For this reason, it can improve the environmental licensing process of projects occupying large areas - such as hydropower plants - assisting in the siting of projects and preventing future negative impacts. The Amazon region has been chosen as the main site for several new hydropower plants because of its untapped hydropower potential. The region is characterized by fall lines, deep incisions and narrow valleys that favor the development of hydropower plants (Costa, 2002). However, in many cases, this option disregards the possibility of other water resource uses, causing conflicts between different users (Moreira, 1998).

Hydropower plants represent approximately 84% of the Brazilian energy supply and almost two-thirds (63.6%) of unused hydropower potential is concentrated in the Amazon region, especially in the Tocantins, Araguaia, Xingu and Tapajós rivers (Moretto et al., 2012). This type of project involves significant environmental impacts such as changes in hydrological conditions, soil erosion and siltation, and the emission of greenhouse gases from organic decomposition in reservoirs. In addition, there are issues related to social aspects, particularly with respect to the riparian communities affected by the project (Bermann, 2002; Fearnside, 2001, 2008).

The impact of hydropower plants extends beyond the area surrounding the reservoir, damaging wetland ecosystems. Moreover, it causes problems downstream of the dam, due to changes in volume and patterns of water outflow and sediment retention by the dams (Manyari and Carvalho, 2007). These impacts have been widely discussed in the literature. However, they are not adequately addressed by EIA/EIR processes (Glasson and Salvador, 2000).

The Brazilian Growth Acceleration Program, established in 2007, aims to grow the economy by implementing infrastructure projects, including hydropower plants. The Ten-Year Energy Plan, 2007-2016, proposes twelve new hydropower plants for the Amazon region which will provide approximately 16.2 MW when they in operation (Moretto et al., 2012).

The location of a number of Amazon hydropower plants will be defined over the next few years. It is therefore important to understand the potential use of Economic Ecological Zoning prior to the environmental impact assessment process, in order to improve the siting of projects.

2. Economic ecological zonings in the Amazon

In Brazil, Economic Ecological Zoning began before it was legally formalized. It relates to the history of regional planning in the Amazon region, mainly due to pressure from international agencies and funding programs (Montaño et al., 2007).

During the Brazilian military government (1964-1985), the Amazon region was considered an isolated territory and became the object of several

development programs aiming to economically exploit its resources. The so-called "Legal Amazon" region (Fig. 1) was defined as a planning region, approximately 5 m km^2 representing 59% of the country's total area, which included lowland rainforests (Kohlhepp, 2002).

In 1988, the Brazilian government introduced Economic Ecological Zoning for the Amazon region (Del Prette and Matteo, 2006). Its objective was to set out a new environmental policy to regulate the occupation and exploitation of the area (Mello, 2006). In the 1990s, all nine Amazon states began to draft specific Economic Ecological Zonings, based on a major technical and financial initiative: "The Pilot Program to Conserve the Brazilian Rain Forest" (PPG-7) (Del Prette and Matteo, 2006). This program was started in 1992 as a multilateral initiative managed by the World Bank (Mello, 2006). However, different approaches of Economic Ecological Zoning were used in the Amazon region, with no convergence of methodologies, objectives and concepts.

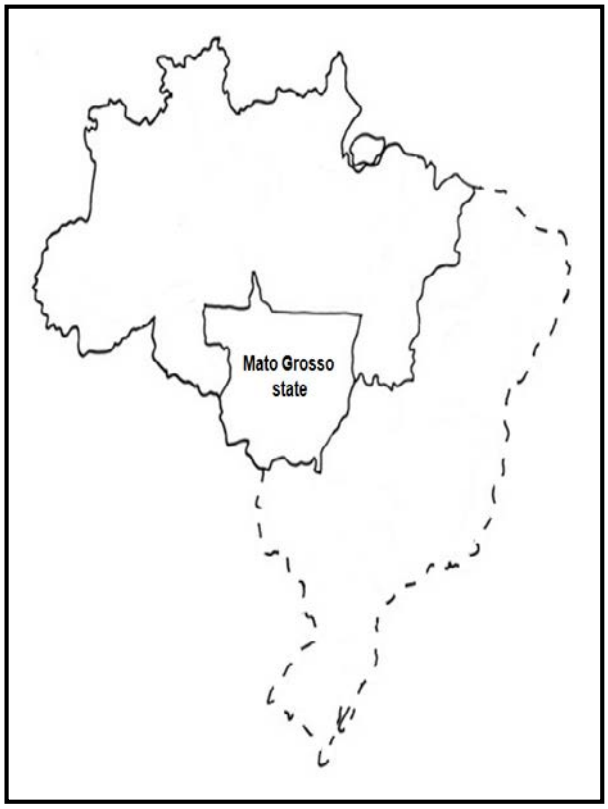

Fig. 1. The Brazilian Legal Amazon Region (continuous line), highlighting Mato Grosso state

Economic Ecological Zoning requires an eco-developmental, pragmatic and precise methodology in order to improve knowledge of the dynamics of urban surroundings and conservation areas, and thus provide an understanding of the patchwork of plans, programs and projects proposed for the region (Ab'Saber, 1989). In practice, the confused history of Economic Ecological Zoning in the Amazon did not fulfill this premise.

In 2000, the Ministry of Environment conducted a new Economic Ecological Zoning for the Amazon region and identified discrepancies between this zoning and other regional programs (Millikan and Del Prette, 2000). In 2010, the Economic Ecological Zonings developed in the nine Amazon states were brought together into a macro-scale zoning exercise known as the Amazon Macro Economic Ecological Zoning (Brasil, 2010). However, according to Rebello and Homma (2005), this mechanism alone cannot be used as the only instrument to reach final decisions on land use planning for the Amazon region. The authors argue that Economic Ecological Zoning constitutes the initial step in land use planning.

Mato Grosso, one of the Amazon states and a main target for the siting of hydropower plants, has experienced acute changes in land use since the 1970s, driven by the modernization of agriculture and the expansion of regional markets. These changes were promoted by the Midwest Development Program (Prodoeste), administered by the Amazon Development Agency (SUDAM) in 1975 (Cunha, 2006) and given impetus by the National Development Plans I (1970-1972) and II (1975-1979) (Mello, 2006). The opening of major highways in the 1970s, such as the federal highway BR-163 (Cuiabá-Santarém), was a turning point for local economic development (Cunha, 2006).

Today, Mato Grosso is a heterogeneous state in terms of its economy and population; each region has its own characteristics, influenced by three distinct biomes (rainforest, savannah and wetland).

Mato Grosso state has a specific zoning system, known as Social Economic Ecological Zoning (SEEZ), an enhanced version of an initial zoning exercise which includes primary data and socio-economic aspects (Mato Grosso, 2008). In order to consolidate the current SEEZ version, the state developed an ecological-economic diagnosis, employing resources from the Agro-Development Program of Mato Grosso (PRODEAGRO), funded by the International Bank for Reconstruction and Development (IBRD) (Rivera, 2000).

According to this author, the SEEZ studies generated a database for subsequent assessments, including a model for land use management. The scale used in the physical, biotic and socioeconomic inventory was 1:250,000. By successive data crossing, it was possible to define socio-economic and environmental units.

Results comprise of reports, data and maps containing information and four classes of territories: Consolidated or Consolidating Agriculturally Productive Areas; Areas Requiring Restructuring of Management Systems; Areas Requiring Specific Management; and Protected Areas. Each category is composed of specific sub-categories (Fig. 2).

SEEZ divided Mato Grosso state into 97 sustainable use zones and subzones, 173 Protected Areas (including indigenous lands) and 15 Proposed Protection Areas (Mato Grosso, 2008).

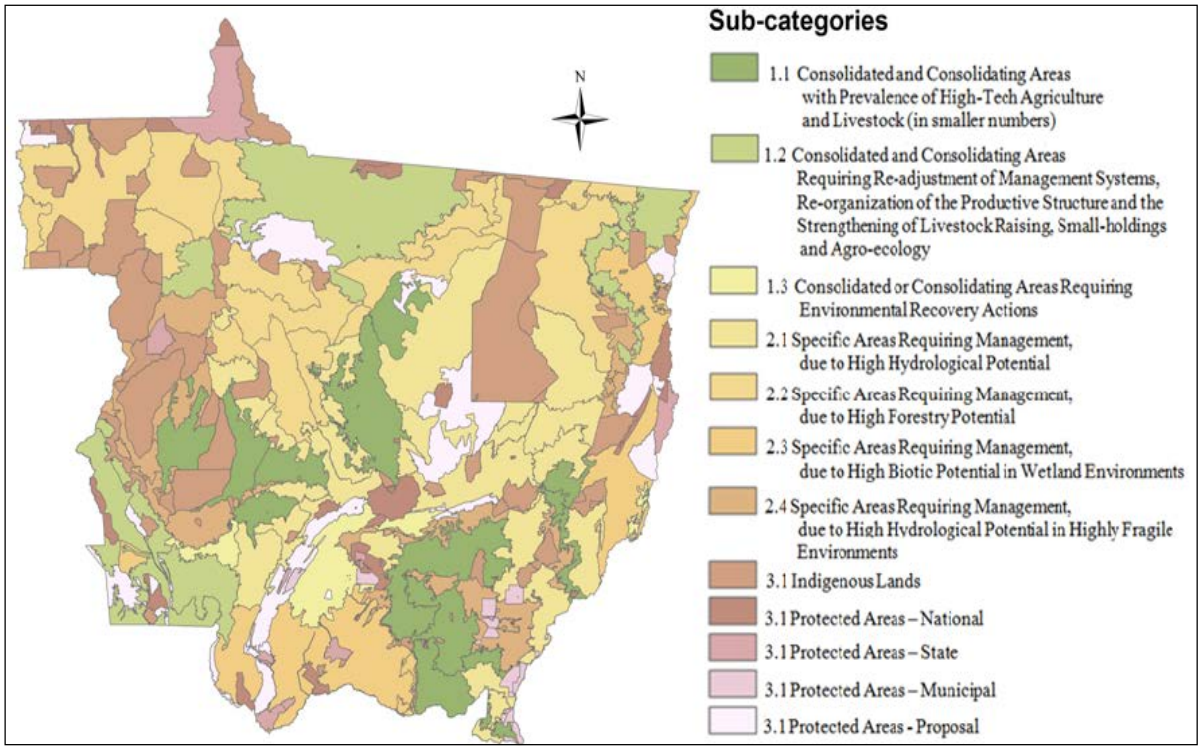

Fig. 2. Land use categories of the current version of SEEZ (based on SEPLAN, 2010)

In 2008, a draft version of SEEZ was presented for public discussion at the State Legislative Assembly (AL/MT); 15 public audiences were held in all regions of the state and a number of different proposals from civil society were collected and systematized. These proposals were incorporated in the new version of SEEZ. Subsequently, others versions were produced which did not involve the participation of society and were disputed by various sectors (ICV, 2010). Currently, the new version of SEEZ is being discussed by the National Economic Ecological Zoning Commission.

2. Objectives

This paper aims to analyze the 'usefulness' of SEEZ for the siting of new Amazon hydropower plants prior to the environmental impact assessment process. It also analyzes how this zoning regards the spatial criteria for the environmental planning of hydropower plants.

This understanding is important for the integrated and harmonious operation of environmental policy instruments.

3. Methods

This paper is based on the conceptual framework relating to the relationship between zoning and planning levels, as shown in Fig. 3. It highlights the gap between the "proposal of the project" and the "preliminary location analysis" which occurs prior to the "environmental impact assessment" process. It is in this gap that we identify the main research question of this paper: is SEEZ useful for the siting of new hydropower plants in the Amazon region?

This paper focuses on the Amazon region (Fig. 1) and uses as a case study the current version of Socio-Economic Ecological Zoning (SEEZ) of Mato Grosso state (Fig. 2) which has already been approved.

In this study, 24 criteria for the siting of hydropower plants were selected from the Brazilian guidelines for hydropower plants inventory, produced by Brazilian Electricity Company (Eletrobrás, 1997). These criteria were divided in five groups and are shown in Table 1.

The SEEZ analysis assessed how each criterion was considered in the SEEZ Diagnosis produced by SEPLAN (2010), according to the following classification:

- When the SEEZ Diagnosis fully considers a criterion: SEEZ is assessed as being "useful" with regard to this criterion;
- When the SEEZ Diagnosis only partially considers a criterion, omitting some information: SEEZ is assessed as being "restrictive" with regard to this criterion;
- When SEEZ Diagnosis does not consider a criterion: SEEZ is assessed as "not useful" with regard to this criterion.

4. Results and discussion

This section presents the SEEZ 'usefulness analysis' for the siting of hydropower plants. Tables 2 and 3 show when SEEZ is either 'useful' or 'restrictive'; it takes into account each hydropower plant planning criterion established in the Eletrobrás

Guidelines (1997). None of the criteria employed classified SEEZ as 'not useful' for siting hydropower plants.

In relation to water resources, SEEZ was only found to be 'restrictive' with regard to the hydrological regime. This is because it is not as widely discussed as other issues related to water resources. There is a lack of specific data concerning the hydrological regimes of the Mato Grosso rivers.

The hydrological regime is essential for economic efficiency and information concerning this subject is very important for hydropower planning. The lack of data regarding this criterion is not crucial for the development of planning because zoning scales are not suitable for engineering models. However, its absence in environmental impact assessment can aggravate conflicts between hydropower plant projects and others water uses already in existence.

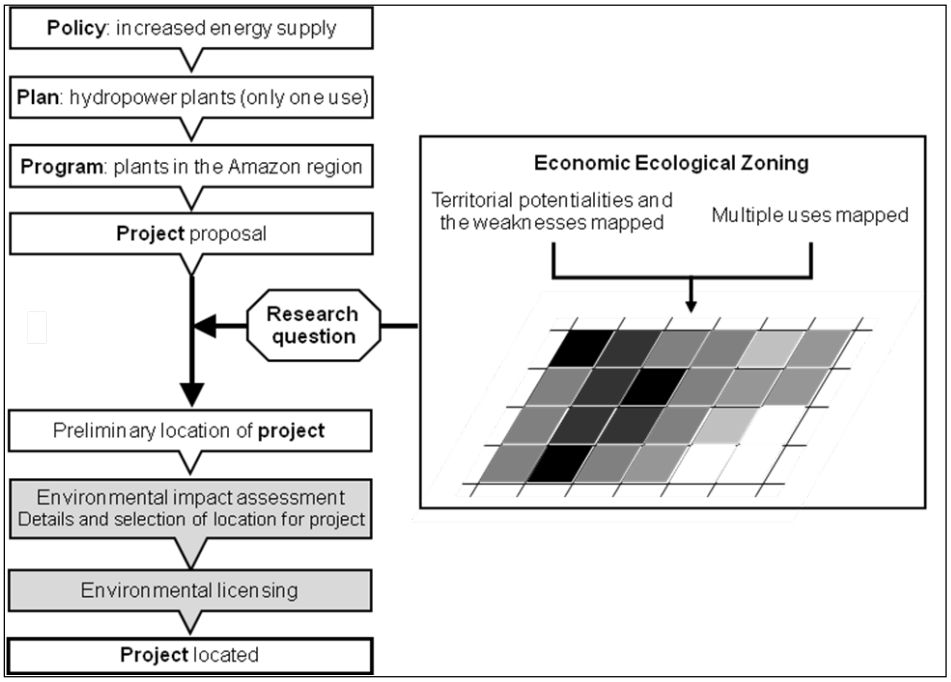

Fig. 3. Conceptual framework: relationship between zoning and planning levels

Table 1. Brazilian criteria for the siting of hydropower plants (Eletrobrás, 1997)

Topic	***Criteria***
Water resource	1. Hydrographic network
	2. Hydrological regime
	3. River flow
	4. Water quality
	5. River classification in terms of use
Soil	6. Topography
	7. Pedology
Biodiversity	8. Aquatic fauna
	9. Terrestrial fauna
Land use	10. Vegetation cover
	11. Conservation area
	12. Permanent Protection Area
	13. Biome area
	14. Existing dams
	15. Rural settlements
	16. Urban settlements
	17. Land use and occupation
Social-cultural-economic	18. Social, demographic and regional economic dynamics
	19. Anthropization / stress factors
	20. Social, cultural and political organization of the population
	21. Historical, cultural, archaeological and speleological heritage
	22. Indigenous and afro-descendant populations
	23. Tourism
	24. Navigation

Table 2. SEEZ is classed as 'useful' for the siting of hydropower plants

Hydropower planning criteria	***Justification of SEEZ's 'usefulness' for hydropower planning***
Hydrographic network	There are data and maps on the entire river network of the state. They include information on all institutional aspects, water availability and current uses.
River flow	There are data and maps on river flow, particularly with regard to the sub-category "areas requiring specific management with high biotic potential in wetland environments". River flow is not considered.
Water quality	There are adequate data and maps on water quality.
River use classification	This framework is appropriately cited in the information on the quality of water resources.
Topography	There are adequate data and maps on geology and geomorphology.
Pedology	There is adequate information and maps on pedology.
Aquatic fauna	There are data on the diversity of aquatic fauna, including ictofauna, and information on fisheries. In areas requiring specific management, fauna and threat to fauna are considered important; in proposed protected areas biodiversity is one of the characteristics cited.
Terrestrial fauna	There are data on the diversity of land fauna. In areas requiring specific management, fauna and threats to fauna are considered important; in proposed protected areas biodiversity and wild fauna are cited.
Vegetation cover	There are various maps and data on vegetation, including a Mapping exercise and the Characterization of Vegetation Formation/Land Use and Occupation which classifies vegetation cover into Savannahs and Fields, Riparian Vegetation, Forests and Contact Vegetation. Vegetation types and different formations are included within the different Intervention Categories and Uses.
Conservation area	The Protected Areas category encompasses areas legally established as Conservation Units, as well as proposals for Protected Areas. It takes into account relevant ecological criteria and respects the environment's capacity for sustainability.
Biome area	Presents maps and data on the different biomes – Forest, Savannah and Wetlands.
Dams	Existing hydropower plants are addressed within the section providing information on existing uses of water resources in river basins. Dams are considered in the subcategory Areas Requiring Specific Management with High Biotic Potential in Wetland Areas.
Land use and occupation	There are maps and data regarding land use and occupation, including the Mapping and Description of Vegetation Formations/Land Use and Occupation. The different categories of Intervention and Use consider multiple land uses.
Social, cultural and political organization of the population	There is information on civil society organizations, including an analysis of the private institutions, identifying leading figures in the state of Mato Grosso.
Historical, cultural, archaeological and speleological heritage	The Proposed Protection Areas category considers the presence of archaeological sites and sites of outstanding natural beauty potential (e.g. Caves)
Indigenous and afro-descendant populations	There is information on indigenous groups. Furthermore, in the Protected Areas category, indigenous lands are considered.
Tourism	There are maps and information on areas with tourism potential and touristic regions. The Areas Requiring Specific Management in Environments of High Forestry Potential and Wetland Environment are described as having potential for tourism. including
Navigation	Waterways are considered within the information on existing uses of water resources.

Table 3. SEEZ is classed as 'restrictive' for the siting of hydropower plants

Hydropower Planning Criteria	***Justification of SEEZ's 'restrictiveness' for hydropower planning***
Hydrological regime	Hydrological regime is sparingly addressed within information on water resources and climatology.
Permanent Protection Area	Some Conservation Units overlap Permanent Protection Areas, but their limits along rivers are not shown.
Rural settlements	Rural settlements are considered together with land ownership issues resulting in a superficial analysis of this problem. There are data on the quality of life of rural producers.
Urban settlements	Urban areas are highlighted and only some infrastructure is shown.
Social, demographic and regional economic dynamics	Demographic and economic dynamics (population flows and projections) are mainly described on specific data and maps. Social aspects are included in the quality of life category and are insufficiently described in the Intervention and Use categories.
Anthropization / stress factors	Human stress factors and their levels affecting the environment, together with 'anthropization' of some areas are described in various Intervention and Use categories.

The other criteria listed under water resources, as well as under soil and biodiversity, classified SEEZ as 'useful'. They were adequately addressed in the diagnosis document. The topic of 'land use' contains the largest number of criteria not considered in the diagnosis. SEEZ fully considered criteria on vegetation cover, permanent protection areas and dams. There are maps and data relating to these criteria, including several types of vegetation, protection areas and others dams already in existence in and around the rivers of Mato Grosso.

Other criteria within the land use category are partially considered due to lack of information, in particular, in relation to rural and urban settlements, since some information is mixed with data on social, demographic and regional economic dynamics and anthropization/stress criteria (criteria of social-cultural-economics category, also partially considered by SEEZ). One of the many topics addressed by the diagnosis is that data needs to be better organized.

In relation to the social-cultural-economic topic, SEEZ is considered as 'restricted' with regard to the social, demographic and regional economic dynamics and anthropization/stress criteria. They are simply mentioned in the SEEZ Diagnosis, without further analysis.

5. Conclusions

The analysis of the SEEZ Diagnosis shows that zoning can assist the siting process of hydropower plants in the Amazon state of Mato Grosso. It adequately addresses a broad spectrum of physical, biotic and socio-economic criteria which have been set out by the Brazilian government.

Nevertheless, it is important to consider that there are some limitations to the SEEZ Diagnosis in relation to this type of planning, given that it does not adequately address the criteria of biome conservation, urban and rural settlements, demographics and the regional economy, as well as hydrological regimes.

Thus, this paper concludes that SEEZ is a useful instrument for the siting of new Amazon hydropower plants when it is carried out prior to Environmental Impact Assessment. However, its usefulness is limited and SEEZ must be carefully employed, given that it may lead to land use conflicts, affecting the planning process and the environmental impact assessment, making it overly complex.

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