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# Evaluation of Giant and Neotropical Otter as environmental assets in Conservation Tourism based on emergy analysis

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**Abstract**
**Purpose:** The main objective of this work is to evaluate the natural capital and ecosystem services of the Aquidauana River and the role of *Lontra longicaudis* and *Pteronura brasiliensis* as environmental assets for the development of conservation tourism.
**Research Methodology:** First, a system diagram was built to organize ideas and relationships between components and resource flows. Second, it was to construct tables of emergy flows directly from the diagrams. Quantities of stored emergy of environmental resources are calculated from the sum of the emergy of all inputs and then multiplied by the time it takes to accumulate the storage.
**Results:** The main services with market values provided by the Aquidauana River are water supply, tourism, and fishing. The neotropical otter exhibited the largest asset in the system, followed by the giant otter and the indigenous culture.
**Limitations:** Application of the emergy method to define public policies that lead to the real valuation of environmental assets and promote the social mobilization needed to change adverse realities.
**Contribution:** The giant otter and neotropical otter values represent more than 90% of all values listed as environmental assets in the Aquidauana River System. The results can be important for the definition of public policies aimed at conservation tourism. With an appropriate social mobilization program, associated with economic and environmental education, the local economy could be strengthened, along with the protection of biodiversity.
**Keywords:** Ecology of systems, Economic evaluation, Emergy, *Lontra longicaudis*, *Pteronura brasiliensis*
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## 1. Introduction

The main objective of this work is to evaluate the natural capital and ecosystem services of the Aquidauana River and the role of neotropical otter (*Lontra longicaudis)* and giant otter (*Pteronura brasiliensis)* as environmental assets for the development of conservation tourism, contributing to reducing conflicts between fishermen and otters. In the Aquidauana River, in the last 10 years, there has been a significant decrease in sightings of neotropical and giant otters (Colodetti, 2014); (Junior, Birolo, & Silva, 2017). This may be a result of a large number of motorized boats present in the river during the fishing season. Boat noise may be negatively affecting the groups of giant otters and individuals of neotropical otters distributed along the river. Adding to this fact is the decrease in fishing associated with conflicts with fishermen, resulting in a very negative scenario for the future of the otters in the Aquidauana River.

Giant otter and neotropical otter represent important environmental assets, as flags species, for the development of conservation tourism and protection of aquatic ecosystems (Junior et al., 2017); (Junior O & Birolo, 2019). The economic value of these species can be defined based on the ecology of the system and the emergy synthesis. The application of the emergy synthesis (Howard T Odum, 1983); (H.T. Odum & Odum, 1996); (H. Odum, T., 2007) aims to assess natural capital and environmental services, including the economic costs and benefits, assets, and non-commercial values of society and the environment.

Emergy represents the available energy needed to manufacture a product or service, and its unit is emjoule. It also measures the work of producing goods and services, expressed in emdollars (Campbell & Brown, 2012). It is used to evaluate the processes of the Aquidauana River related to geological, hydrological, ecological, and economic components, besides the economic values of the giant otter and the neotropical otter. The main inputs of the human economy and the environment are integrated with the application of emergy methods to address public policies and environmental management. The emdollars are defined for each item of the system as a measure of the money circulating in the local economy, because of the emergy flow. It is calculated first by determining the emergy of the flow and then converting it to emdollar, using a standard conversion factor (H.T. Odum & Odum, 1996).

Preservation of ecosystems requires a significant demand for resources, such as personal, financial, and infrastructure, which are increasingly difficult to justify due to lack of sustainability and restrictions of use (Junior O & Birolo, 2019). Tourism could be a good response, however, while goods and services that support visitation are relatively easy to account for, other less tangible environmental services, such as biodiversity, can be difficult to be valued (ul Mustafa, Afzal, & Zahoor, 2020). To evaluate these assets is important to make the best decisions for ecosystem management, such as enhancing the provision of multiple ecosystem services, minimizing conflicts between multiple uses and ecosystem service values, and balancing economic, environmental, educational also community returns, rather than economic returns alone (Martinez-Harms et al., 2015).

The giant otter and neotropical otter, as symbol species, are presented as an environmental asset that provides a relevant ecological service to society, such as controlling carbon stock in ecosystems, controlling diseases and exotic species, in addition to generating basic jobs in the community through conservation tourism (Junior O & Birolo, 2019). Therefore, the economic evaluation of natural resources is important to support public policy proposals, in addition to helping to plan and define research objectives.

The economic evaluation of natural resources seeks to show people the true wealth, biodiversity as an environmental asset, and the immense environmental heritage that Brazil has. However, this cannot be done without the involvement of people. This is where conservation tourism comes in, promoting the union between people and the environment. Environmental and social segregation prevents people from seeing each other's problems as well as environmental problems, which makes it difficult to redistribute economic wealth.

An example of this is that today a large portion of higher-income people in Brazil are opposed to social and environmental policies. People are losing affection and empathy for each other, and for the environment. The SDGs, a UN movement, seek, in this sense, to reduce social, cultural, and environmental segregation. The giant and neotropical otter are a key part of this strategy, as flagship species in the conservation of biodiversity and aquatic ecosystems. In this way, it is possible to bring to the discussion concepts such as the use of common goods and the economic valuation of environmental assets.

It is important to note that the strategic planning of the research was carried out considering the 2030 Agenda for Sustainable Development. Examples are SDG4 — Quality Education, SDG6 — Drinking Water and Sanitation, SDG7 — Affordable and Clean Energy, SDG8 — Decent Work and Economic

Growth, SDG11 — Sustainable Cities and Communities, SDG12 — Responsible Consumption and Production, SDG13 — Action Against Global Climate Change, SDG14 — Life on Water, SDG15 — Life on Earth, SDG17 — Partnerships and Means of Implementation. It is worth emphasizing the transversality of the actions and respective SDGs, with the research objectives. These are developed with the aim of generating information that can support the actions proposed in the research, and public policies aimed at sustainable development and biodiversity conservation.

This work is based on two economic trends: the circular economy and the social economy. The circular economy aims to reduce, reuse, recover and recycle materials and energy, and advocates the replacement of the end-of-life concept of the linear economy by new circular flows of reuse, restoration, and renovation (Saidani, Yannou, Leroy, Cluzel, & Kendall, 2019); activities that create social value to correct socioeconomic and regional inequalities.

The great contribution of this research is the use of the emergy concept in the economic evaluation of environmental assets (H. Odum, T,, Wiley, & Sons, 1983); (Tilley, 2004); (H. Odum, T., 2007), and the possible use of Green Bonds by local governments in the preparation of green projects applied to urban mobility, public sanitation, and climate change, important subjects to the development of tourism. Therefore, biodiversity, especially giant otter and neotropical otter, represents the main strategy adopted, as a combination of economic evaluation of endangered species and ecosystemic environmental assets.

Conservation Tourism represents the segment of tourism that uses natural and cultural heritage, through a social-environmental research project. The project relies on the participation of eco volunteers, promoting social entrepreneurship in the communities involved, focusing on living and learning in protected areas. It also contributes to the planning, use, sustainability, and conservation of these areas, promoting and encouraging the participation of the different public, with social responsibility (Oldemar Carvalho Junior, 2019); (Carvalho Junior, Barbosa, & Birolo, 2021). Therefore, this tourism segment advocates the conservation of protected areas through use. It represents a humanistic approach, favoring the inclusion of human beings in the environment for conservation.

The creation of jobs, strengthening of local commerce, and appreciation of local culture, are some examples that conservation tourism can provide. Parallel to this, due to the research project, the society receives more information and knowledge, helping in the management of the area and contributing to public policies, therefore, promoting sustainable development. Thus, the evaluation of a product is made considering all the contributions that come from nature and human society, in equivalent terms, defined as emergy.

The evaluation of the natural capital and ecosystem services and biodiversity as environmental assets can be an important ally for the development of conservation tourism, contributing to environmental conservation (Colodetti, 2014); (Junior et al., 2017). Tourism and science together can represent an important partnership for the adoption of good practices and community empowerment, driving community-based sustainable development (Yeboah, Afram, Quampah, & Kulega, 2019); (Prakoso, Pradipto, Roychansyah, & Nugraha, 2020). In this work, emergy is applied to predict the economic and environmental viability of the study area for a conservation tourism proposal. To place the value of biodiversity, giant otter, and neotropical otter in perspective, emergy synthesis of the main storage and ecological processes in the study area are calculated. For the evaluation of renewable inputs solar energy, rainfall, runoff, wind annual averages, phosphorous in the river, and river geopotential are used.

## 2. Literature review

### *Conservation tourism*

The term conservation tourism was first approached by (de Waal, 2010) without clearly separating it from the concept of ecotourism. The examples cited by Buckley represent ecotourism or adventure tourism. In Brazil, for example, the initiatives of Fazenda Rio Negro and Pousada Caiman, in Pantanal, and Cristalino Jungle Lodge in Amazonia, are mentioned. These places offer tours to observe the fauna, especially the jaguar in the Pantanal, whose owners are large Brazilian millionaire entrepreneurs, but with little involvement from the communities, located far from the farms. They represent touristic isolated places within threatened biomes, aimed at a very select public, usually rich foreigners. The other side of this tourism developed by wealthy farmers is reported by (Fernández‐Llamazares, Fraixedas, Brias‐Guinart, & Terraube, 2020) who report the low level of education of operators and the need to implement actions that include tourists in the surveys carried out and transfer of information.

Tourism is also important as an auxiliary tool in the integration between peoples, both within the same country and between countries (Wahab, 1991). It is also a form of interaction between different cultures while promoting economic development, management, and preservation of natural and historical heritage, generating jobs, training skilled labor, and promoting community-based entrepreneurship (Nogueira, 1987) (Carvalho Jr, Rodrigues, & Scoton, 2009): (Junior O & Birolo, 2019); (da Conceição Walkowski, dos Santos Pires, & Tricárico, 2019); (George, 2021). For example, the value of natural resources for tourism development in Fiji in partnership with tour operators has been demonstrated by (Mangubhai, Sykes, Manley, Vukikomoala, & Beattie, 2020). This approach is what characterizes, in part, the present conservation tourism proposal.

More recently, the concept of conservation tourism was defined by (Junior O & Birolo, 2019). The main difference between conservation tourism and ecotourism lies in the fact that the former generates information, and the latter uses information already available. The new concept of conservation tourism implies a research project with social and community-based mobilization.

***Giant and Neotropical Otter as flagships***

The Brazilian National List defines the *Lontra longicaudis* and *Pteronura brasiliensis* as vulnerable (de Almeida Rodrigues, Leuchtenberger, & da Silva, 2013); (de Almeida Rodrigues et al., 2013). The species represents a potential role for flagships in tourism. On the other hand, it is also reported the negative effects of tourism on wild animal populations (Barocas et al., 2021; Carvalho Junior et al., 2021). One of the major problems for the conservation of otters is related to the negative perception that certain sectors of society have about the species, such as fishermen and fish farmers who see the otter as competitors (Adámek, Kortan, Lepič, & Andreji, 2003); (Kloskowski, 2005); (de Castro, Stutz-Reis, Reis, Nakano-Oliveira, & Andriolo, 2014).

Otters are seen as flagship species to increase people's environmental awareness (Dias et al., 2019) (Quiñónez, Fuller, & Randhir, 2018); (van Spronsen, 2020). For this reason, the adoption of social media is critical (Gupta et al., 2020); (Hong, 2020), not only for species conservation but to support conservation tourism (Asnawi, 2021); (Sarkar & George, 2018); (Staib & Schenck, 1994). In fact, the adoption of flagships as social media has shown a political potential for creating sustainable benefits (Polgar & Jaafar, 2018; van Rees, 2018) (Thompson & Rog, 2019).

***Emergy***

Emergy is based on systems theory (Von Bertalanffy, 1973) and systems ecology (Howard T Odum, 1983), initially discussed in the book Environmental Accounting (H.T. Odum & Odum, 1996). Emergy synthesis aims to evaluate natural capital and environmental services, including economic costs and benefits, and societal and environmental non-market assets and values (Tilley, 2004). It also measures the work to produce goods and services, expressed in emdollars (H. Odum, T, et al., 1983). This method can be used to evaluate ecosystem processes related to geological, hydrologic, ecological, and economic components. Major inputs from the human economy and from the environment can be integrated by applying emergy methods to the public policy and environmental management approach (Campbell & Brown, 2012). Methods of emergy synthesis represent a quantitative decision-making tool when it comes to conflicts related to the right to property, fisheries, tourism, exploitation of water for private and public use, and the conservation of fauna and flora

(Carvalho Junior, 2016). Emergy assessment has also been applied in agriculture as a tool for analyzing the environmental performance of coffee farms in Brazil (Giannetti, Ogura, Bonilla, & Almeida, 2011); (Liu et al., 2019); (Shah et al., 2019). Emergy synthesis is especially important because it allows an overview of the system through the relationships between components and exchange paths and resource flow (Campbell & Brown, 2012).

## 3. Methods

In the present work, the emergy of the giant otter and the neotropical otter represents the necessary energy for the evolution of the species. It includes the process of natural selection transmitted through genetic information. This emergy is the potential environmental work that would be lost if the species were extinct. To estimate the emergy, mean species renewal time is defined as 3 million years for a total of 10 million species (Weir & Schluter, 2007). Based on this, the values of the giant and neotropical otter are defined. The value of the renewable emergy for wetlands (7.53E+23) is considered for giant otters and neotropical otters, respectively (Brandt-Williams & Brown, 2011).

The emergy of the species is multiplied by the values corresponding to the living area of the population relating to the total area of distribution of the species (Carvalho Junior et al., 2021) to obtain an estimate of the emergy incorporated in the species, in the Aquidauana River System (ARS), according to the equation below (Campbell & Brown, 2012).

*Emergy giant otter/neotropical otter = # species * % do total pop in the ARS * emergy to develop the species*

To place the value of the giant otter and neotropical otter in perspective, the emergy synthesis of the main stocks and ecological processes in the Aquidauana river is calculated. In addition, the flows of inputs, goods, fuel, and electricity were also evaluated.

First, a system diagram was constructed to organize thinking and relationships between components and paths of exchange and resource flow. The second step was to construct the tables of emergy synthesis flows directly from the diagrams. Finally, the emergy indices are calculated to relate the emergy flows of the economy to those of the environment. Stored quantities of environmental resources are calculated from the sum of the emergy of all inputs and then multiplied by the time needed to accumulate storage.

For the evaluation of renewable inputs for the Aquidauana River, annual averages of solar energy, rainfall, surface runoff, geopotential current, wind, and phosphorus transport were used in the water column. They are calculated by first quantifying all the emergy used in the making of the product, or service and dividing it by the energy of the product or service. The units may be in sej.$J^{-1}$ if the product is divided by energy, or sej.$g^{-1}$ if the emergy of the product is divided by mass. Emdollar is a measure of money circulating in the economy because of the emergy flow. The emdollar is obtained by dividing the total emergy that drives the economy through the Gross Domestic Product (GDP) of the economy

Transformities and specific emergies are calculated for biodiversity and services. They are calculated by first quantifying all the emergy used in making the product or service and dividing by the energy of the product or service. The Aquidauana River System services are based on the emergy evaluation, expressed as emergy, and converted to emdollars to compare with economic values. Economic values such as water and electricity were obtained directly from the related companies. Fish harvest, recreation, and information produced were obtained from the Ekko Brasil Institute Data Set.

Socioeconomic data were obtained from the IBGE website (Brazilian Institute of Geography and Statistics) and UNDP (United Nations Development Program). Educational information was obtained from the IDEB - Basic Education Development Index. The analysis of the Human Development Index (HDI) and other financial indicators for Brazil were assessed in the World Bank database.

The average fish price of the Aquidauana River is based on the prices of Ceasa, the main Brazilian fresh food market, located in São Paulo. For each price of the fish, 40% was subtracted to get a more realistic value for what is paid to local fishermen on the Aquidauana river. The main fish considered for this analysis were Pacu (*Piaractus mesopotamicus*), Pintado (*Pseudoplatystoma corruscans*), Piranha (*Pigocentrus nattereri*), and Dourado (*Salminus brasiliensis*).

From March 2014 to August 2019, 97 expeditions along the 120 km of the Aquidauana River were conducted, totaling 432 hours of observation. The navigation in the main course of the river was made in medium and small vessels, with boats equipped with engines of 40hp and 15hp, respectively, at a constant speed of 10-15 $km.h^{-1}$. The bays along the river that were not open to the river were accessed by car and a small boat equipped with an electric motor. A Bushnell 8×30 binocular with the integrated digital camera and a Sony DCR-SX45 camcorder with 70x optical zoom was used to record the presence of the animals. The data were organized into Excel and Numbers spreadsheets, and the basic descriptive statistical analyzes were performed by R statistic (Team, 2010). The geographical coordinates of the records were plotted in GIS QGIS 2.2 for vector analysis

## 4. Results

Figure 1 represents the diagram of the ARS in the study area. The components are organized as renewable and non-renewable sources, landscape, giant otter, neotropical otter, research, and assets. The flow of money is a countercurrent (dashed line) to the flow of work as it is exchanged for goods and services. Therefore, it represents the flow of energy that money releases. The main sources of energy that put the money circulating are the tourists and fish market.

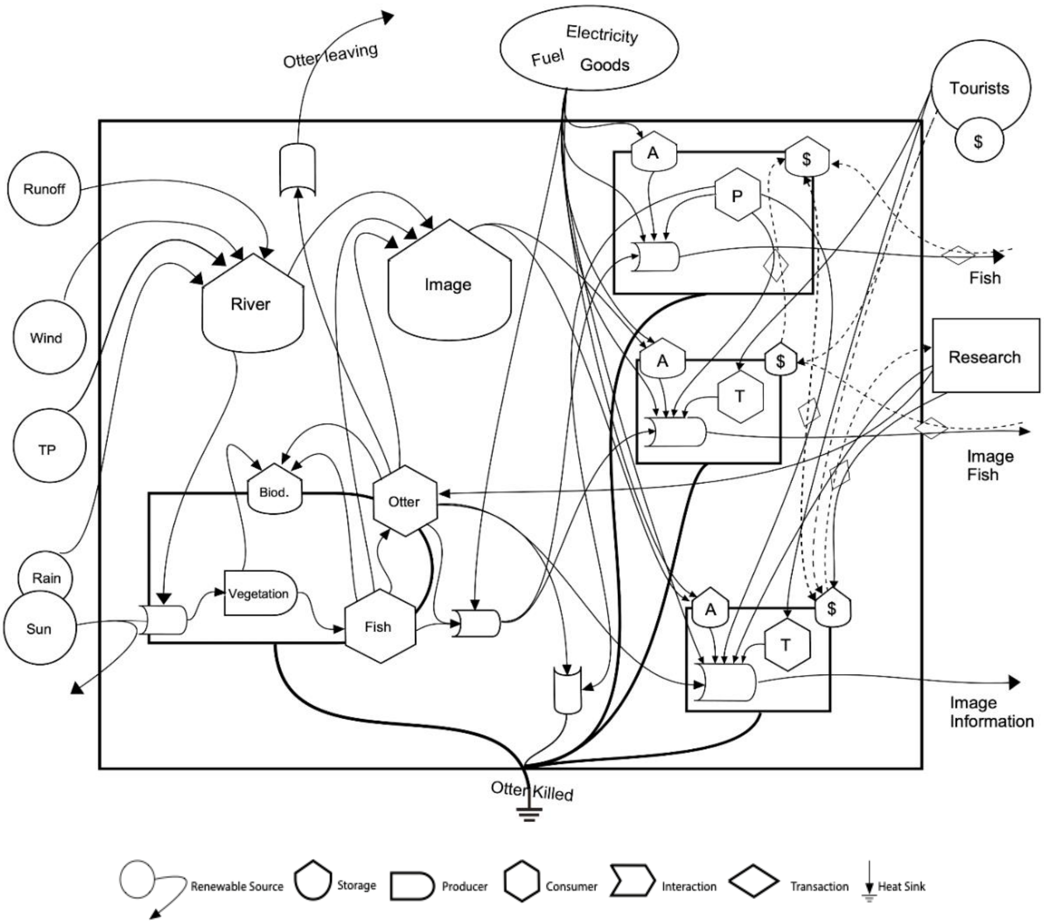


Figure 1. System diagram of the study area, the Aquidauana River, showing the connections within the ecosystem

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Table 1 below summarizes the emergy evaluation of the Aquidauana River, listing the sources of energy, the energy flow in the system, inflows and outflows, and exports of the system as it is exhibited in Figure 1. The flows of energy, material and money that cross the ARS are listed as line items. Each is multiplied by its Emergy Intensity (EI) to convert all flows into emergy. In the last column emergy flows are converted to emdollars. The Table is divided into three major categories: Renewable Resources, Purchased Inputs, and Exports. As can be seen, the total renewable energy is 9.85E+21 seJ.ano$^{-1}$, equivalent to $^{em}$\$ 2.90E+09. The total of purchased inputs is 3.31E+18 ($^{em}$\$ 9.75E+05). Exports is 3.35E+20 and $^{em}$\$ 1.04E+08.

Table 1. Emergy evaluation of the flows that sustain the Aquidauana River.

| Note | Item | Units | Quantity | Emergy Intensity (sej/unit) | Solar Emergy seJ/Year | EmDollars |
|---|---|---|---|---|---|---|
| | **RENEWABLE RESOURCES** | | | | | |
| **1** | Sunlight | J | 1.92E+20 | 1.00E+00 | 1.92E+20 | 5.64E+07 |
| **2** | Rain | J | 1.93E+17 | 3.10E+04 | 5.99E+21 | 1.76E+09 |
| **3** | Wind | J | 1.10E+17 | 2.45E+03 | 2.70E+20 | 7.94E+07 |
| **4** | TP in river | g | 5.11E+14 | 2.00E+06 | 1.02E+21 | 3.00E+08 |
| **5** | TP out river | g | 1.28E+15 | 2.00E+06 | 2.55E+21 | 7.51E+08 |
| **6** | River, geopotential | J | 2.84E+10 | 1.85E+03 | 5.25E+13 | 1.54E+01 |
| **7** | Runoff | J | 1.89E+17 | 5.19E+01 | 9.79E+18 | 2.88E+06 |
| | Total Renewable Resources | | | | 9.85E+21 | 2.90E+09 |
| | **PURCHASED INPUTS** | | | | | |
| **8** | Goods Professional Fishing (equipment, canoes, motors) | g | 2.46E+07 | 1.13E+10 | 2.78E+17 | 8.19E+04 |
| **9** | Goods Amateur Fishing (equipment, canoes, motors) | g | 1.92E+08 | 1.13E+10 | 2.17E+18 | 6.40E+05 |
| **10** | Fuel (Professional Fishermen) | J | 6.22E+04 | 1.11E+05 | 6.90E+09 | 2.03E-03 |
| **11** | Fuel (Amateur Fishermen) | J | 4.86E+05 | 1.11E+05 | 5.39E+10 | 1.59E-02 |
| **12** | Electricity Professional Fishery | J | 3.35E+11 | 2.92E+05 | 9.77E+16 | 2.87E+04 |
| **13** | Electricity Amateur Fishery | J | 2.61E+12 | 2.92E+05 | 7.63E+17 | 2.24E+05 |
| | Total Purchased Inputs | | | | 3.31E+18 | 9.75E+05 |
| | **EXPORTS** | | | | | |
| **14** | Information (research) | hrs | 3.14E+04 | 2.35E+14 | 7.38E+18 | 2.17E+06 |
| **15** | Water, Chemical Potential | J | 2.26E+14 | 8.1E+04 | 1.83E+19 | 5.37E+06 |
| **16** | Water, Geopotential | J | 2.19E+13 | 4.7E+04 | 1.03E+18 | 3.03E+05 |
| **17** | Surface Water Supply | J | 2.38E+13 | 8.10E+04 | 1.93E+18 | 5.67E+05 |
| **18** | Fishing, Professional | J | 1.17E+13 | 1.68E+07 | 1.96E+20 | 5.77E+07 |
| **19** | Fishing, Tourist | J | 6.33E+12 | 1.68E+07 | 1.06E+20 | 3.13E+07 |
| **20** | Wildlife watching (Image exported with tourists) | J | 1.48E+12 | 1.50E+07 | 2.22E+19 | 6.53E+06 |
| | Total Exports | | | | 3.53E+20 | 1.04E+08 |

The emergy value of fishing (professional and tourist) using the natural resources of the Aquidauana River is quite significant, equivalent to about $^{em}$\$ 89 million. On the other hand, the value of the emergy of the exports, including information (research), water chemical and water geopotential, surface water supply, fishing professional and fishing tourist, and wildlife watching, is 3.53E+20 seJ.ano$^{-1}$ or $^{em}$\$ 1.04E+08. The largest exports are fishing (professional and tourist) followed by observation of wildlife, geopotential, and chemical energy in the water.

Table 2 shows the natural capital of the Aquidauana River System, within the study area. Ecosystem services are generated from natural capital, while species and cultural capital are used by man to manage and enjoy the ecosystem. The total emergy of the natural capital, including riparian forest, vegetation of high fields and low fields, and savannah, was $ 6.89E+15 seJ, equivalent to $^{em}$\$ 6.11E+17, while the total emergy in cultural and species capital, including Indian artifacts, giant otters and neotropical otters, was 3.90E+26 seJ/year, or about $^{em}$\$ 1.15E+14. The giant otter groups, accounts to $^{em}$\$ 1.58E+12, and the neotropical otter individuals to $^{em}$\$ 1.15E+14

Table 2. Emergy in natural, cultural, and endangered species capital of Aquidauana River System (ARS).

| Note | Item | Quantity | Emergy Intensity (sej/unit) | Solar Emergy (sej/year) | EmDollars |
|---|---|---|---|---|---|
| | **Natural Capital** | | | | |
| 1 | Surface Water, J | 1.54E+10 | 8.10E+04 | 1.24E+15 | 3.66E+02 |
| 2 | Riparian Forest, J | 5.74E+10 | 3.62E+04 | 2.08E+15 | 6.11E+02 |
| 3 | Vegetation of high fields, J | 6.40E+09 | 3.62E+04 | 2.32E+14 | 6.82E+01 |
| 4 | Vegetation of low fields, J | 2.37E+09 | 3.62E+04 | 8.60E+13 | 2.53E+01 |
| 5 | Savannah, J | 8.98E+10 | 3.62E+04 | 3.25E+15 | 9.56E+02 |
| | Total natural capital | | | 6.89E+15 | 6.11E+17 |
| **Cultural and species capital** | | | | | |
| 6 | Value of Indian Artifacts, J * | 4.14E+15 | 1.89E+07 | 7.82E+22 | 2.30E+10 |
| 7 | Value of *Pteronura brasiliensis*, # of ind., J ** | 3.54E+20 | 1.52E+04 | 5.38E+24 | 1.58E+12 |
| 8 | Value of *Lontra longicaudis*, J *** | 2.53E+22 | 1.52E+04 | 3.85E+26 | 1.13E+14 |
| | Total cultural and species capital | | | 3.90E+26 | 1.15E+14 |

Brazil Emergy Money Ratio (EMR) sej/$ (Total emergy used/GDP) = 3.4E+12

* Value for 5,714 Indians in Aquidauana region (IBGE, 2010)

** Value for 40 individuals

*** Value for 120 individuals

Table 3 lists some of the ecosystem services provided by the Aquidauana River System, based on cultural and provision values (Cardoso & Freitas, 2006). Professional and tourist fishing have the highest values of emergy, representing about 91% of the services of supply or $^{em}$\$89 million, while its economic value is US$ 408 thousand. In all cases, except water supply, the dollar value of the service exceeded the economic value. The economic value of water supply is about 13 times greater than the value in emdollars. The scientific information generated by the research results in about $^{em}$\$ 2 million. Thus, the total emdollar value of the provisioning services is $^{em}$\$ 98.3 million, while the estimated monetary amounts totaled US$ 8.5 million, the largest of which was water supply (US$ 7.6 million).

Table 3. Emergy, emdollar and economic values of the services of the Aquidauana River.

| Note | Item | Emergy Value | Emdollars | Economic Value |
|---|---|---|---|---|
| | **Provisioning Services** | | | |
| 1 | Research | 7,38E+18 | 2,17E+06 | 4,68E+05 |
| 2 | Water supply | 1,93E+18 | 5,67E+05 | 7,61E+06 |
| 3 | Fishing Professional | 1,96E+20 | 5,77E+07 | 4,63E+04 |
| 4 | Fishing Tourist | 1,06E+20 | 3,13E+07 | 3,61E+05 |
| 5 | Wildlife watching (image exported with tourists) | 2,22E+19 | 6,53E+06 | 2,30E+04 |
| | Total Market Services, yr. | | 9,83E+07 | 8,51E+06 |

The diet of giant otters includes *Piractus mesopotamicus*, *Pigocentrus nattereri* and Brycon hilarii (Rojas Rojas, 2009). These species are also part of the main fishery resources of the Aquidauana River (Catella, Campos, & Albuquerque, 2015). Neotropical otters eat smaller fishes to about 400 grams, especially the ones used for bait. Therefore, it can be expected that, with the reduction of fishing resources, conflicts between fishermen and giant otters may worsen.

The average monthly income of the fishermen of the Aquidauana River is today US$ 207.37 (2019), resulting in an annual income of US$ 2,488.42. If the income depended only on professional fishing, it would be about US$ 171.50 per fisherman per year, which represents 6.89% of annual income. The difference is obtained through the service provided as a guide for tourist fishermen. If the professional fisherman receives at least one trip per week during 8 months of the year; and additional 12 trips during September, October and November, maximum capture period of the tourist fishing (Catella et al., 2015), income can reach US$ 2,315.79 per year.

***Discussion***

The Aquidauana River System is dominated by renewable energy. Within the system, there is a significant storage of phosphorus that contributes to a great export of fishing. Fishing, professional and tourist, accounts for 86% of total exports. Wildlife observation accounts to only 2% of the total. Research information is 6%. Water chemical responds to 5%. This accounting is important to think the sustainability and support capacity of tourism in the study area.

The Brazilian Pantanal is visited by 150,000 tourists per year, resulting in a general revenue of approximately US$ 14,250.00. Estimating a spend of US$ 100 per day; for 10% of that total; and an average stay of 3 to 5 days, Aquidauana and Anastácio could earn around US$ 3,400,000 per year, representing 2.5% of the GDP of Aquidauana.

The Aquidauana River System offers multiple ecosystem services, totaling em$ 98.3 million for services of market value and em$ 2.2 million for services with no market value. The largest services of market value are professional and tourist fishing (em$ 89 million). When compared to dollar value, outbound services are about 11.5 times greater. The image, represented by wildlife observation, is valued at em$ 6.5 million, followed by the chemical potential of water (used to dilute, cool, carry, react, or conduct physical processes) and information (research) at em$ 5.4 million and em$ 2.2 million, respectively.

For example, the amount of phosphorus in the study area represents 24% of renewable resources, equivalent to em$ 751 billion. Any changes in energy flows and nutrient cycling within the ecosystem can be disastrous. It is believed that one of the main impacts resulting from the dams projected for the upper Pantanal would be the change in nutrient concentration.

The storage and flow of phosphorus between vegetation biomass and animal biodiversity, and how it varies within the Pantanal, with and without neotropical otters and giant otters, still needs to be determined. The effects of retention and storage of nutrients in the trophic chain may have an important economic dimension. The riparian forest, the neotropical and giant otter, for example, represent important assets for the Pantanal. Only the riparian forest within the study area accounted for em$ 611,000, while *Lontra longicaudis* and *Pteronura brasiliensis* accounted for em$ 1.13E+14 and em$ 1.58E+12, respectively. Whatever the scenario, the absence of a top predator such as the neotropical otter or the giant otter, can lead to a dramatic simplification of the ecosystem, followed by a series of extinctions, causing serious damage to many other organisms and to the economy. The situation of conflict between fishermen, and the neotropical and giant otter on the Aquidauana River is alarming when people tend to relate the decrease of the fish to the presence of these species.

On the other hand, the presence of groups of giant otters, close to Aquidauana and Anastácio, may represent the beginning of a community-based conservation tourism program. Biodiversity clearly dominates the environmental assets of the study area. Biodiversity represents the information of the ecosystem reflected in the diversity of the species. It can also result in a large input of grants from sponsors, driving most of the research in the area.

The limitation of this study is mainly in the definition and application of public policies aimed at the development of sustainable community-based tourism in the region with biodiversity conservation. Fishermen and schoolchildren represent fundamental stakeholders for the modification of an adverse reality. This is evidenced by the incentive to replace combustion boat engines with electric or battery-powered solar-powered engines, which produce less noise and, consequently, less impact on otters and fauna in general. This involves a change in behavior that must be worked on in schools, in young people and adults.

The application of the methods recommended by Paulo Freire (Freire, 2018) for adult literacy, considering the reality of each one, in the search for a critical citizen, may represent an important further stage for this study. Based on the actual assessment of environmental assets provided by the emergy method, and on the knowledge of the functioning of the energy processes of the Aquidauana River system, it will be possible to define management strategies and tools that enable the rational and sustainable exploitation of tourism in the region, associated with social mobilization. In this regard, the inclusion of the 2030 Agenda for Sustainable Development agenda in schools could represent an advance in the way of thinking about the future of the next generations, within an international movement, strengthening government strategies aimed at sustainable development.

With an appropriate social mobilization program, associated with economic and environmental education, the local population could be strengthened. Local government would be responsible for coordinating a public policy with the different stakeholders involved. If the community could realize the economic and social benefits associated with conserving biodiversity and aquatic systems, and with a better quality of life, it could be co-responsible for effective local sustainable development projects.

## 5. Conclusion

Thus, bearing in mind that flagship species such as giant otter (*Pteronura brasiliensis*) and neotropical otter (*Lontra longicaudis*) represent important environmental assets, it is important to emphasize that they should not be seen as simple economic resources, but as fundamental pieces in the energy flow of the system and therefore in maintaining the health of the environment. They also represent a tool for social mobilization and environmental education, therefore increasing environmental awareness. The position of the giant otter and the neotropical otter in the energy chain has the highest emergy value within the system, which highlights the not only economic but strategic importance of sustainable development in the region. Therefore, emergy analysis can be an important management tool for sustainable economic development in the study area, considering the main assets to be preserved, in addition to the energy processes that must be maintained at all costs. It is within this context that conservation tourism can play a leading role in defining an alternative path in the pursuit of community-based sustainable development, promoting social justice and economic development, with biodiversity conservation. The most important differential of conservation tourism in this respect is the generation and transmission of information. The moral and political construction based on equal rights and collective solidarity depends on information. The participation of ecovolunteers of various nationalities, engaged in a cause represented by a flagship, promotes peace and understanding between peoples, to show that environmental conservation knows no borders. In this way, conservation tourism is not only good business, which promotes development and job creation, but also values ethics and morals in science and the economy.

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| | APPENDIX 1 - NOTES TO TABLE 1 | | | |
|---|---|---|---|---|
| | **Notes** | | | **Sources** |
| 1 | **Sunlight** | | | |
| | Annual energy = | (Avg. Total Annual Insolation J/yr)(Area)(1-albedo) | | Brown and Campbell, 2007 |
| | Insolation, J/m$^2$/yr = | 6.57E+09 | | ATLAS Solarimétrico do Brasil, 2000 |
| | Area, m$^2$ = | 3.56E+10 | | |
| | Albedo = | 1.8E-01 | | Brown and Campbell, 2007 |
| | Annual energy, J/yr = | 1.92E+20 | | |
| 2 | **Rain** | | | |
| | Annual energy = | volume*1000kg/m3*4940J/kg | | |
| | Rain (m/yr) = | 1.10 | | ANEEL, 2015 |
| | Area (m2) = | 3.56E+10 | | |
| | Volume, m3 = | 3.91E+10 | | |
| | Runoff coeff. = | 6.00E-01 | | |
| | Annual energy = | 1.93E+17 | | |
| | Transformity, sej/J = | 3.10E+04 | | Odum, 2000 |
| **3** | **Wind kinetic energy** | | | |
| | Area = | 3.56E+10 | m^2 | |
| | Density of Air = | 1.30E+00 | kg/m^3 | |
| | Avg. annual wind velocity = | 5.04E+00 | mps | Amarante et al., 2001 |
| | Geostrophic wind = | 8.40E+00 | mps | observed winds are about 0.6 of geostrophic wind (Brown and Campbell, 2007) |
| | Drag Coeff. = | 2.00E-03 | | Miller, 1964 quoted by Kraus, 1972 |
| | Energy (J) = | (area) (air density) (drag coefficient) (velocity^3) | | |
| | = | (m^2) (1.3 kg/m^3) (1.00 E-03) (mps) (3.14 E7 s/yr) | | |
| | Energy(J) = | 1.10E+17 | J/yr | |
| | Transformity, sej/J = | 2.45E+03 | | Odum,2000 |

| | | | | |
|---|---|---|---|---|
| | Solar Emergy = | 4.11E+26 | | |
| **4** | **TP in river** | | | |
| | (Volume, cfs) (P, mg/l) (0.02831m3/f3) (3.1536E+7sec/yr) ((1E-3g/mg) (1E+6L/m3)) | | | |
| | volume, cfs = | 3.11E+03 | | Carvalho et al., 2000 |
| | P, mg/l = | 1.84E+02 | | |
| | densidade, m3/f3 = | 2.83E-02 | | |
| | sec/yr = | 3.15E+07 | | |
| | g/mg = | 1.00E-03 | | |
| | L/m3 = | 1.00E+06 | | |
| | Average TP mass = | 5.11E+14 | | |
| **5** | **TP out river** | | | |
| | (volume, cfs) (P, mg/l) (0.02831m3/f3) (3.1536E+07sec/yr) ((1E-03g/mg)(1E+6L/m3)) | | | |
| | volume, cfs = | 3.11E+03 | | |
| | P, mg/l = | 4.60E+02 | | |
| | density, m3/f3 = | 2.83E-02 | | |
| | sec/yr = | 3.15E+07 | | |
| | g/mg = | 1.00E-03 | | |
| | L/m3 = | 1.00E+06 | | |
| | Average TP mass = | 1.28E+15 | | |
| **6** | **River, geopotential (J.yr$^{-1}$)** | | | |
| | flow, cfs = | 3.11E+03 | | Carvalho Junior et al., 2017 |
| | Density = | 0.028317 | m3.f-3 | |
| | | 31536000 | | |
| | | 1000000 | | |
| | dh, 0.20 m/km = | 46 | m | Brandt-Williams, 1999) |
| | Extension (Aquidauana-Porto Ciriaco), km = | 230 | | |
| | gravity= | 7000000 | | |
| | Stream, geopotential (J.yr$^{-1}$) = (flow volume) (density) (dh) (gravity) | | | |
| | Energy,yr-1= 18 cfs * 0,028317 m3.f-3 * 3,1536E+07 sec.yr-1 * 1E+06 gm-3 * 7 = 1,20 E+13 | | | |
| | Annual energy = | 2.84E+10 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **7** | **Runoff, J** | | | | | | | |
| | Volume, $m^3$/yr = | 3.91E+10 | | | | | | |
| | J/g = | 4.82E+00 | | | | | | |
| | J/Cal = | 1.00E+06 | | | | | | |
| | Energy/yr = | 1.89E+17 | | | | | | |
| | Transformity, sej/J = | 6.31E+04 | | | | | | |
| | Transformity, sej/J = | 5.19E+01 | | | | | | |
| **8, 9** | **Machinery and Equipment** | | | | | | | |
| | Total investment, $ = | 1.11E+03 | | | | | | |
| | Unit Emergy Value, sej/$ = | 1.90E+12 | | | | | | |
| | Canoa, g = | 7.50E+04 | | | | | | |
| | motor, g = | 1.50E+04 | | | | | | |
| | avg. mass, g/vehicle = | 9.00E+04 | | | | | | |
| | avg. mass total, g/vehicle = | 6.66E+06 | | | | | | |
| | avg. vehicle lifespan, yrs = | 2.00E+01 | | | | | | |
| | # Professional Fishermen Aquidauana = | 7.40E+01 | | | | | | |
| | # Amateur Fishermen Aquidauana = | 5.78E+02 | | | | | | |
| | use per yr = | mass*#motorboats/avg life | | | | | | |
| | Professional goods use per yr = | 2.46E+07 | | | | | | |
| | Amateur goods use per yr = | 1.92E+08 | | | | | | |
| | Transformity, sej/J = | 1.13E+10 | | | | | | |
| **10, 11 Fuel, J per expedition** | | | | | | | | |
| | (litros * 0,35 J/l) | | | | | | | |
| | Energy J/l = | 3.50E-01 | | | | | | |
| | Liters/fisherman/day = | 1.50E+01 | | | | | | |
| | Liters/total/Professional fishermen/day = | 1.11E+03 | | | | | | |
| | Liters/total/Amateur fishermen/day = | 8.67E+03 | | | | | | |
| | # days = | 1.60E+02 | | | | | | |
| | Liters/total/Professional fishermen/yr = | 1.78E+05 | | | | | | |
| | Liters/total/Amateur fishermen/yr = | 1.39E+06 | | | | | | |
| | Litros R$ = | 5.33E+05 | | | | | | |
| | Litros $ = | 1.67E+05 | | | | | | |
| | Professional Fishermen Annual | 6.22E+04 | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | energy, J = | | | | | | | |
| | Amateur Fishermen Annual energy, J = | 4.86E+05 | | | | | | |
| | Emergy per unit input = | 1.11E+05 | | | Odum, 1996 | | | |
| | | | | | | | | |
| **12** | **Professional Fishery Electricity, J** | | | | | | | |
| | Annual energy=KWh*3.6E+06 J/KWh | | | | | | | |
| | Conversion = | 3.60E+06 | | | | | | |
| | KWh/person/month = | 1.57E+02 | | | | | | |
| | Professional Fishermen KWh/year = | 9.29E+04 | | | | | | |
| | Annual energy = | 3.35E+11 | | | | | | |
| | Transformity = | 2.92E+05 | | | | | | |
| **13** | **Amateur Fishery Electricity, J** | | | | | | | |
| | Annual energy=KWh*3.6E+06 J/KWh | | | | | | | |
| | Conversion = | 3.60E+06 | | | | | | |
| | KWh/person/month = | 1.57E+02 | | | | | | |
| | Amateur Fishermen KWh/year= | 7.26E+05 | | | | | | |
| | Annual energy = | 2.61E+12 | | | | | | |
| | Transformity= | 2.92E+05 | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **14** | **Annual production of information** | | | | | | | |
| | # of papers = | 39 | Google Academic, results for 2015 | | | | | |
| | average time spent, hours/paper = | 8.05E+02 | | | | | | |
| | research hours, hours/yr = | 3.14E+04 | | | | | | |
| | Transformity, sej/J = | 2.35E+14 | | | | | | |
| 15 | Water, Chemical Potential | | | | | | | |
| | Total export from Aquidauana River, $m^3$/yr = | 4.57E+07 | Oliveira and Ferreira, 2003 | | | | | |
| | Density, kg/$m^3$ = | 1000 | | | | | | |
| | Heat capacity, J/kg = | 4940 | | | | | | |
| | Chemical Potential = | volume total (m3/yr) * density * heat capacity | | | | | | |
| | Chemical Potential = | 2.26E+14 | | | | | | |

| | | | |
|---|---|---|---|
| | Transformity, sej/J = | 8.1E+04 | Odum, 2000 |
| 16 | Water, Geopotential | | |
| | Total export from Aquidauana River, m3/yr= | 4.57E+07 | Oliveira and Ferreira, 2003 |
| | Elevation, m = | 49 | |
| | Density, kg/m3 = | 1000 | |
| | Gravity, $m/s^2$ = | 9.8 | |
| | Geopotential, J = | volume*avg elevation*density*gravity | |
| | Geopotential, J = | 2.19E+13 | |
| | Transformity, sej/J = | 4.7E+04 | Odum, 2000 |
| 17 | Surface Water | | |
| | Volume, m3 = | 4,818,000.00 | Santos et al., 2009 |
| | Density, kg/m3 = | 1000 | |
| | Gibbs Free energy of water, J/kg = | 4940 | |
| | Energy (J) = | volume*density*Gibbs | |
| | Energy, J = | 2.38E+13 | |
| | Transformity, sej/J = | 8.10E+04 | |
| 18 | **Fishing, Professional** | | |
| | Total fish caught, g = | 6,840,600.00 | Catella et al., 2014 |
| | Total fish caught, kg = | 6.840,60 | |
| | Total fish caught per person/yr, kg = | 92.44 | |
| | Average price kg fish, $ = | 1.86 | assume Ceasa price minus 40% for the price at the producer |
| | Total income fishery per person/yr, $ = | 171.50 | |
| | avg. mass, g/fish = | 4.54 E+02 | assume avg weight, kg=0.45 |
| | energy content, J/g = | 1.88E+04 | 4.5Cal/G*4187 J/cal |
| | energy fish caught, J = | Tot fish * avg. mass * energy content * 0.2 | |
| | energy fish caught, J = | 11,677,177,824,000.00 | assume 20% dry weight |
| | Transformity, sej/J = | 1.68E+07 | |
| | # fishermen = | 74 | |
| | monthly income, $ = | 207.37 | assume 1 minimum salary/month, Anjos et al., 2010 |

| | | | |
|---|---|---|---|
| | Yearly income, $ = | 2,488.42 | |
| 19 | **Fishing, Tourist** | | |
| | Total fish caught, g = | 3,710,300.00 | Catella et al., 2014 |
| | Total fish caught, kg = | 3,710.30 | |
| | Total fish caught per person, kg = | 6.42 | |
| | avg. mass, g/fish = | 4.54E+02 | assume avg weight, kg=0.45 |
| | energy content, J/g = | 1.88E+04 | 4.5Cal/G*4187 J/cal |
| | energy fish caught, J = | Tot fish * avg. mass * energy content * 0.2 | |
| | energy fish caught, J = | 6,333,630,512,000.00 | assume 20% dry weight |
| | Transformity, sej/J = | 1.68E+07 | |
| | # fishermen = | 578 | |
| | # days/year = | 44 | assume 1 trip per week during 8 months of the year + 12 extra trips during Sept/Oct/Nov |
| | price/day trip, $ = | 52.63 | estimated day trip of 200.00 Brazilian Reals, Dollar at 3.8 Reais |
| | income year/fishermen, $ = | 2,315.79 | |
| | Total income/yr, $ = | 2,487.29 | |
| 20 | **Wildlife watching (Image exported with tourists)** | | |
| | Pantanal, visits/yr = | 85,000.00 | Araujo et al., 2005 |
| | Aquidauana, visits/yr = | 8,500.00 | |
| | Tourism time in Pantanal, total hours/person= | 120.00 | |
| | Average spent day/tourist = | 100.00 | |
| | Total spent/tourist = | 400.00 | |
| | Total spent year = | 3.40E+06 | |
| | Tourism time in Pantanal, total hours = | 10,200,000.00 | |
| | Tourism fishery in Pantanal, visits/yr = | 13,856.00 | Catella et al., 2014 |
| | Ecovolunteers 2014 (Otter Project - Santa Catarina), # = | 76.00 | |
| | Ecovolunteers 2014 (Otter Project - Santa Catarina), $ = | 12,832.67 | |
| | Ecovolunteer total hours stay 2014 = | 7,870.00 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average stay, hours ecovolunteer = | 103.55 | | | | | | | |
| | Avg. energy/hr, kcal/hr = | 1.04E+02 | | | | | | | |
| | total energy expenditure = | kcal/hr*hrs*4186J/Kcal | | | | | | | |
| | total energy expenditure, J/yr = | 1.48E+12 | | | | | | | |
| | Transformity, sej/J = | 1.50E+07 | | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **APPENDIX 2 - NOTES TO TABLE 2** | | | | | |
| 1 | Surface Water, J | | | | | |
| | energy, J = | volume*1000kg/$m^3$*4940J/kg | | | | |
| | volume, $m^3$ = | 3.11E+03 | | | | |
| | water density, kg/$m^3$ = | 1.00E+03 | | | | |
| | Gibbs free energy of water, J/kg = | 4.94E+03 | | | | |
| | energy, J = | 1.54E+10 | | | | |
| 2 | Riparian Forest, J | | | | | |
| | mass, kcal/g = | $m^3$*kg/$m^3$*1000g/kg | | | | |
| | Average height, m = | 12 | | | Damasceno-Junior et al., 2005 | |
| | Quantity, $m^2$ = | 159,450.02 | | | | |
| | Quantity, $m^3$ = | 1,913,400.24 | | | | |
| | Weight, kg/$m^3$ = | 30 | | | | |
| | mass, kcal/g = | 5.74E+10 | | | | |
| | Transformity, sej/J = | 3.62E+04 | | | | |
| 3 | Vegetation of high fields, J | | | | | |
| | mass, kcal/g = | $m^3$*kg/$m^3$*1000g/kg | | | | |
| | Average height, m = | 6,700 | | | Soares e Oliveira, 2009 | |
| | Quantity, $m^2$ = | 191,125.02 | | | | |
| | Quantity, $m^3$ = | 1,280,537.634 | | | | |
| | Weight, kg/$m^3$ = | 5 | | | | |
| | mass, kcal/g = | 6.40E+09 | | | | |
| | Transformity, sej/J = | 3.62E+04 | | | | |
| 4 | Vegetation of low fields, J | | | | | |
| | mass, kcal/g = | $m^3$*kg/$m^3$*1000g/kg | | | | |
| | Average height, m = | 6.70 | | | Silva et al., 2000 | |
| | Quantity, m2 = | 70,875.00 | | | | |
| | Quantity, $m^3$ = | 474,862.50 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Weight, kg/m$^3$ = | 5 | | | | |
| | mass, kcal/g = | 2.37E+09 | | | | |
| | Transformity, sej/J = | 3.62E+04 | | | | |
| 5 | Savannah, J | | | | | |
| | mass, kcal/g = | m$^3$*kg/m$^3$*1000g/kg | | | | |
| | Average height, m = | 9.00 | | | Silva et al., 2000 | |
| | Quantity, m$^2$ = | 453,600.06 | | | | |
| | Quantity, m$^3$ = | 4,082,400.5<br>4 | | | | |
| | Weight, kg/m$^3$ = | 22 | | | | |
| | mass, kcal/g = | 8.98E+10 | | | | |
| | Transformity, sej/J = | 3.62E+04 | | | | |
| 6 | Information Indians on Aquidauana | | | | | |
| | Energy of Population, J = | population*J/yr/Indian*year | | | | |
| | # indians MS (population) = | 73,295 | | | IBGE, 2010 | |
| | # indians Aquidauana (population) = | 5,714 | | | | |
| | J/yr/Indian (energy per capita), J/yr = | 1,896.32 Cal/day*365 d/yr * 4186 J/Cal | | | | |
| | Consume Cal/day = | 1,896.32 | | | Gondi, 2007 | |
| | Days/yr = | 365 | | | | |
| | J/Cal = | 4186 | | | | |
| | J/yr/Indian (energy per capita), J/yr = | 2.90E+09 | | | | |
| | Yrs to develop information, # = | 2.5E+02 | | | | |
| | Energy, J = | 4.14E+15 | | | | |
| | Transformity, sej/J = | 1.89E+07 | | | | |
| 7 | Value of *Pteronura brasiliensis*, # of ind. | | | | | |
| | # species*% of viable population in distribution area*em. required to dev. | | | | | |
| | Endangered/Threatened Species, # = | 40 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Viable population area to the otter distribution area estimated, % = | 4.01E-05 | | | Colodetti, 2014 | |
| | emergy per species, sej/species = | 2.21E+23 | | | | |
| | Emergy in Pteronura brasiliensis = | 3.54E+20 | | | | |
| | Transformity, sej/J = | 1.52E+04 | | | | |
| 8 | Value of Lontra longicaudis | | | | | |
| | # neotropical otters Rio Aquidauana = | 120 | | | | |
| | Aquidauana river length (km) = | 120 | | | | |
| | Aquidauana river width (km) = | 10 | | | | |
| | Aquidauana river area (km2) = | 1200 | | | | |
| | %Viable population area to the otter = | 0.000044 | | | | |
| | Viable population core area (Home Range) ($Km^2$) estimated = | 5.00 | | | | |
| | %Viable population area to the otter distribution area estimated = | 4.44E-05 | | | | |
| | Distribution of neotropical otter, $Km^2$ = | 11,257,192 | | | | |
| | emergy per species (sej/species) = | 4.75E+24 | | | | |
| | average value for turnover time of species (Weir, 2007) (million yrs) = | 3.00E+06 | | | | |
| | median estimate for total number of species (million) = | 1.00E+07 | | | | |
| | renewable emergy budget of the globe (sej/yr) = | 1.58E+25 | | | | |
| | Transformity Swamps/floodplains = | 1.52E+04 | | | | |
| | Emergy in critical sp (neotropical otter) estimated = | 2. 53E+22 | | | | |

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| | **APPENDIX 3 - NOTES TO TABLE 3** | | | | |
| 1 | Research | | | | |
| | Emergy of UFMS/Aquidauana and Embrapa - MS engaged in research activities | | | | |
| | Number of staff = | 156 | estimated: 4 persons/paper, 39 papers | | |
| | Emergy/person (sej) = | 4.704E+17 | | | |
| | Emergy (sej) = | 7.34E+19 | | | |
| | Economic costs of research (Salary) | | | | |
| | Dollar costs = | 468,000.00 | estimated salary $3000/person | | |
| 2 | Water supply | | | | |
| | a. Emergy value of surface water | | | | |
| | Emergy, sej = | 1.93E+18 | | | |
| | b. Dollar value | | | | |
| | Price, $\$/m^3$ = | 1.58 | Sanesul (MS) https://www.sanesul.ms.gov.br/2015 | | |
| | Volume of water, $m^3$ = | 4,818,000.00 | | | |
| | Dollar value, $ = | 7,607,368.42 | | | |
| 3 | Fishing Professional | | | | |
| | a. Emergy of fish harvested | | | | |
| | Emergy, sej = | 1.96E+20 | | | |
| | b. Estimated dollar expenditure for fishing | | | | |
| | # professional fishing = | 74.00 | | | |
| | Expenditure/fisher, $ = | 625.20 | Cardoso e Freitas, 2006 | | |
| | Total expenditures, $ = | 46,264.80 | | | |
| 4 | Fishing Tourist | | | | |
| | a. Emergy of fish harvested | | | | |
| | Emergy (sej) = | 1.06E+20 | | | |

| | | | | | |
|---|---|---|---|---|---|
| | b. Estimated dollar expenditure for fishing | | | | |
| | Numbers persons fishing (sej) = | 578.00 | | | |
| | Expenditure/fisher, $ = | 625.20 | | | |
| | Total expenditures, $ = | 361,365.60 | | | |
| 5 | Wildlife watching (image exported with tourists) | | | | |
| | Emergy of ecovolunteers | | | | |
| | Number of wildlife watchers = | 76.00 | | | |
| | Expenditure/ecovolunteer, $ = | 302.97 | | | |
| | Total expenditures, $ = | 23,025.72 | | | |
| | Emergy (sej) = | 2.22E+19 | | | |