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Conservation Tourism for the Sustainability of Coastal Areas. Case Study: Otter Project

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Abstract

Conservation Tourism can be defined as the segment of tourism that uses natural and cultural heritage, through a socio-environmental research project that promotes the social entrepreneurship of the communities involved. It involves the participation of ecovolunteers and focuses on the experience and education of protected areas, contributing to the planning, use, sustainability and conservation of these regions. This concept is new and does justice to a type of tourism that, although still incipient in Brazil, has been practiced by serious projects of research and conservation for years. Their purpose is self-sustainability, based on social entrepreneurship. The actions focused on conservation tourism described here, have the support of several partner organizations such as *Cybèlle Planète* and *Secret Planet* in France, *Frontier* in the United Kingdom, *ie3Global* in the United States, *Volunteer World* in Germany, *Ecojourney* and *Intern Brazil* in Brazil. The Otter Project is a unique program because it involves the participation of ecovolunteers. In Brazil, this is rare. Most of the ecovolunteers participating in the Otter Project come from Europe and the United States. The profile of the ecovolunteer is presented, in order to better understand this niche market. The main objective of the Otter Project's Ecovolunteer Program is to obtain labor and financial help in order to be sustainable and independent from government funds. The Ecovolunteer Program is an important financial source for the research, operations, and maintenance of the facilities located in the protected area. This work is based on data acquired from 2002 to 2017, in Santa Catarina Island, from the Otter Project. The most significant non-renewable resources are the inflow from ecovolunteers and the labor they provide - ecovolunteers with em$66,114.18 and em$25,643.65 to the labor. The research activities at the Project are mainly sustained through the participation of ecovolunteers from different countries, including Brazil. In this way, the ecovolunteers can also contribute, not only with financial donation, but also through monitoring of the visited areas. The regular presence of groups formed by researchers, students, and ecovolunteers, provides collaborative monitoring within protected areas.

Resumo

Turismo de Conservação pode ser definido como o segmento do turismo que utiliza o patrimônio natural e cultural, através de um projeto de pesquisa socioambiental, com a participação de ecovoluntários, promovendo o empreendedorismo social das comunidades envolvidas, focado na experiência e aprendizado em áreas protegidas, contribuindo para o planejamento, uso, sustentabilidade e conservação destas, com responsabilidade social. Esse conceito é novo e faz justiça a um tipo de turismo que, embora ainda incipiente no Brasil, tem sido praticado por projetos sérios de pesquisa e conservação, cuja proposta é a auto-sustentabilidade, baseada no empreendedorismo social. As ações focadas no turismo de conservação descritas aqui, contam com o apoio de diversas organizações parceiras como Cybèlle Planète e Secret Planet na França, Frontier no Reino Unido, ie3Global nos Estados Unidos, Volunteer World na Alemanha, Ecojourney e Intern Brasil no Brasil. No Brasil, projetos com perfil de pesquisa e conservação, com participação de ecovoluntários, são raros, com exceção do Projeto Lontra. A maioria dos ecovoluntários participantes do Projeto Lontra vem da Europa e dos Estados Unidos. O perfil do ecovoluntário é apresentado, a fim de melhor entender esse nicho de mercado. O principal objetivo do Programa de Ecovoluntários do Projeto Lontra é obter ajuda por meio da mão de obra e financeira, para ser sustentável e independente dos recursos do governo. Um Programa de Ecovoluntários constitui uma fonte financeira importante para a pesquisa, funcionamento e manutenção das instalações localizadas em uma área protegida. Este trabalho é baseado em dados adquiridos de 2002 a 2017, na Ilha de Santa Catarina, a partir de um Projeto do Programa Internacional de Ecovoluntários, o Projeto Lontra. As fontes não renováveis mais significativas são a entrada de ecovoluntários e mão de obra, dominada pelo fluxo de ecovoluntários com em$66.114,18 e em$25.643,65 com o trabalho. As atividades de pesquisa no Projeto são sustentadas principalmente pela participação de ecovoluntários de diferentes países, incluindo o Brasil. Desta forma, os ecovoluntários também podem contribuir, não apenas com doações financeiras, mas também através do monitoramento das áreas visitadas. A presença regular de grupos formados por pesquisadores, estudantes e ecovoluntários, pode ser uma forma alternativa de monitoramento colaborativo dentro de áreas protegidas.

Palavras-chave: Biodiversidade, ecoturismo, ecovoluntário, análise emergética, modelagem.

1. Introduction

Conservation Tourism can be defined as the segment of tourism that uses natural and cultural heritage, through a socio-environmental research project, with the participation of ecovolunteers, promoting the social entrepreneurship of the communities involved, focused on the experience and learning in protected areas, contributing to the planning, use, sustainability and conservation of these, with social responsibility. This concept is new, and does justice to a type of tourism that, although still incipient in Brazil, has been practiced by serious projects of research and conservation, whose proposal is self-sustainability, based on social entrepreneurship. It can represent a real option for the sustainability of protected areas, without burdening the taxpayer.

According to the Brazilian System of Protected Areas (SNUC), in Brazil there are 324 federal protected areas managed by the Chico Mendes Institute for Biodiversity Conservation. In Santa Catarina State, there are 65 municipal, 10 state, 56 private, and 16 federal protected areas (Martins *et al.,* 2015). There are 27 protected municipal areas on the Island of Santa Catarina, 2 federal protected areas, and 2 state protected areas (Figure 1). These represent about 27.46% of the territory of the municipality as free from occupation areas. This proportion can be considered great or good at first glance. However, it is necessary to take into account the number of people affected, the social conflicts generated and management plans that normally fail in the connectivity and maintenance of ecological processes.

Florianópolis represents one of the most important tourist centers in Brazil and South America. Tourism has a positive impact on the entire economy of the municipality, including helping to generate and maintain small businesses. In the period between 1970 and 1985, there was an increase of 150% in the number of establishments, small to medium size, represented by hotels, restaurants and bars (IBGE, 1985). The State received 2.8 million tourists annually, accounting for about 7% of its GDP. Florianópolis was responsible for 20% of this total. On the other hand, from 2008 to 2016, the State received an average 20.6 million tourists, 10% from other countries (Santur, 2017). For the

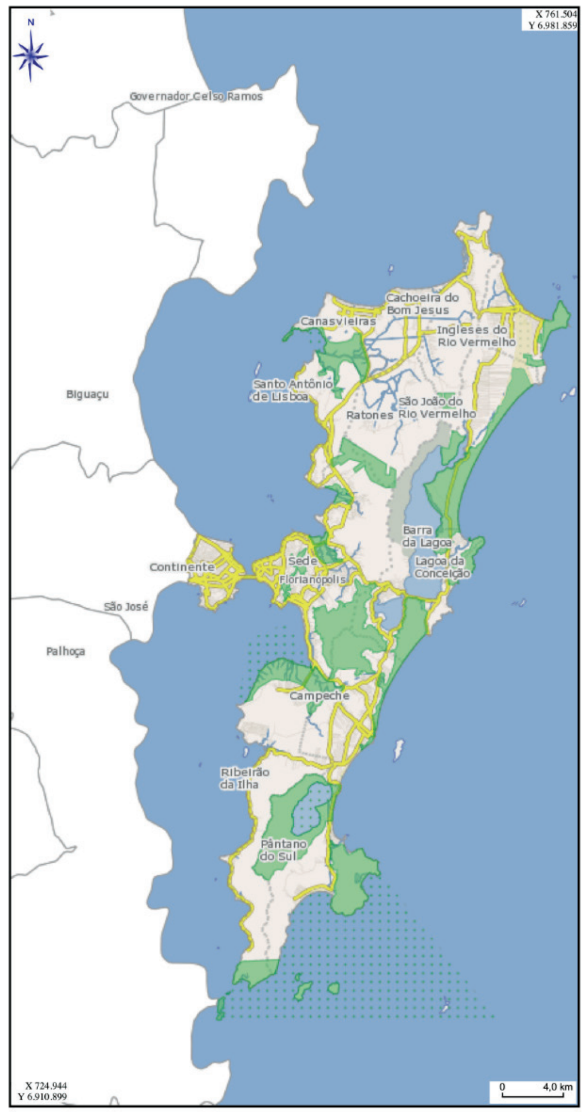

Figure 1. Distribution of protected areas on the Santa Catarina Island, South Brazil. Source: Fortkamp (2011).

same period, the average annual revenue was US$ 3.6 billion, 18.6% of this total from international tourists.

Despite the numbers, only the Municipal Tourism Council allows some participation of civil society. Just as sustainable tourism depends on the protection of socio-environmental assets, it is necessary to implement different forms of tourism, such as Conservation Tourism. An example of this is the Ecovolunteer Program of the Ekko Brazil Institute, which attracts tourists from Europe and the United States to work for a cause, in the protection of biodiversity and the Neotropical otter. Initiatives like the Otter Project help tourists to understand and respect the historical and environmental aspects of Brazil and can contribute to local development.

However, several problems can be related to the difficulty of implementing these sustainability projects. These include inoperative governmental environmental agencies, lack of interdisciplinarity of government tourism and environmental offices, the inflexibility of the Brazilian legislation in developing activities within protected areas, and the costs, related to the conduction of activities. The main objective here is to show how an Ecovolunteer Program can be useful to generate sustainability to research and protected areas.

2. The study area

The Peri Lake and its fauna and flora is a result of millions of years of adaptation of physical, chemical and biological processes. The beginning of its existence can be traced back to the Proterozoic/Pre-Cambrian era, 600 million years ago, when the intrusive granite geological arc was formed, creating a small protected marine bay. About 500 million years later, already in the Quaternary, this bay was closed off by a sand barrier, as a result of the oscillation of the sea level, waves and winds (Santa Catarina, 1986). The ecological services of today are fruits of this evolutionary process, just as biodiversity carries in its DNA all this information, keeping the services in operation. For example, in the Peri Lake, the mountains around are formed by Guabiruba intrusive granite, a common rocky formation along the Brazilian south coast. This formation results in semi-closed environments, that provides caves and shelters for many species, such as the Neotropical otter (*Lontra longicaudis*), with the outside covered by typical Atlantic Forest vegetation.

Lagoa do Peri is located at 27°42'S and 48°30'W, in the southeast of Santa Catarina Island, South Brazil. It has approximately 5 km^2 of water surface, maintained mainly by precipitation. Depth average is 7 meters with a maximum of 11 meters. It has a contact with the Atlantic Ocean through a narrow 4 km long channel, parallel to the coast, not affected by tides. This channel represents a vital ecological corridor for the *Lontra longicaudis* to reach the ocean and, at least, two other important areas, Lagoinha do Leste Beach and Naufragados Beach (Carvalho Junior, 2007) (Figure 2). The species is organized as a metapopulation, small subpopulations separated by geographic barriers, but that maintain contact between themselves. The individuals need to migrate from one place to another in order to guarantee the genetic flow and keep a viable and healthy population (Carvalho Junior *et al.,* 2004, Carvalho Junior, 2007; Carvalho Junior *et al.,* 2010).

According to Köppen classification, the climate is defined as humid mesothermal, with rains distributed throughout the year. Total annual precipitation is 128.5 mm, with a minimum of 78 mm in June and a maximum of 189 mm in February. Monthly average temperature is 20.50 (+/-3.09)^{o}C, a minimum of 16.4^{o}C in July, and a 24.6^{o}C maximum during February (Wrege *et al.,* 2012). The water temperature ranges from 15ºC in June to 30ºC during January, with a monthly average of 19.2 (+/-2.06)ºC (Simonassi et al. 2010). Average annual insolation is 14.65 (+/-3.51) MJ/m²/day (Wrege *et al.,* 2012).

The crystalline complex that border the Peri Lake is waterproof material that promotes rapid drainage of water into the lagoon. As a consequence, the geomorphological compartments present in the area are represented by rocky shores, sand dunes and small wetlands, influenced by creeks and streams. On the west side of the basin, the streams have a strong longitudinal profile in fairly steep slopes. This slope results in occurrences of several waterfalls and rapids. In lower areas, where the waters run through the plains, they form meanders and the small wetlands (Carvalho Junior, 2016).

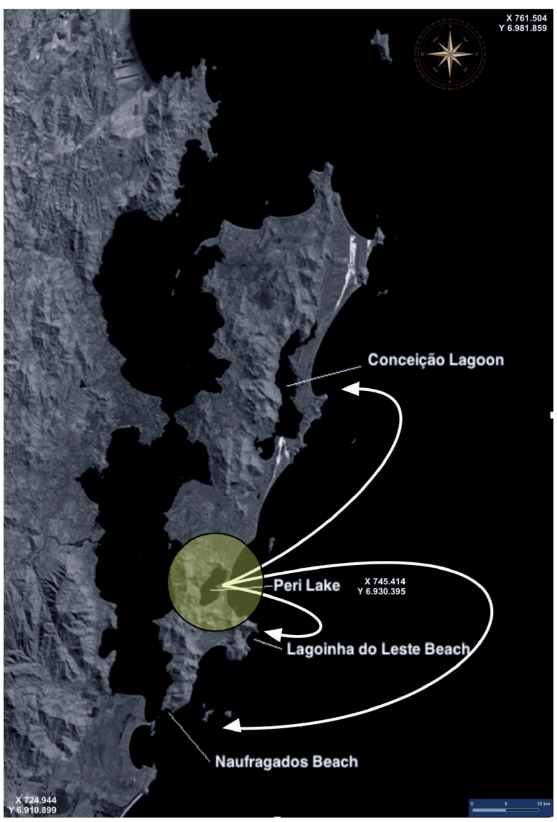

Figure 2. Connectivity of the Peri Lake with the surrounding areas. Arrows show the ecological connectivity of the Peri Lake, related to the distribution of *Lontra longicaudis*, with the other study areas (Conceição Lagoon, Lagoinha do Leste Beach, and Naufragados Beach). Source: Modified from CBERS Satellite raw (INPE 2011).

The streams in the watershed depend on rainfall. The majority are considered intermittent, disappearing in the absence of rains. However, regular rainfall distributed throughout the year, guarantee the supply of these sources. These watercourses have two maximums, spring and late summer, and two minima in early summer and fall. The drainage system of the lake occupies an area of 20 km². This area is equivalent to 4.66% of the territory of the Santa Catarina Island, representing one of the most important ecological features in the south of the Island (Carvalho Junior, 2016; Oliveira, 2002; Santos *et al.,*1989).

Ecosystems within the Atlantic Rain Forest, such as the Peri Lake, are known by the high biodiversity. The area is home to numerous species (Table 1), however, indices of richness, such as Shannon and Simpson formulae, have not yet been employed to define local species diversity. We can find in the Peri Lake 19 species of amphibians (Laudares Silva, 1999), 7 species of phytoplankton (Assis, 2012), 18 species of zooplankton (Figueiredo & Giani, 2009), 17 species of butterflies (Nemar, 1999), 244 species of birds, 7 species of fish (Carvalho Junior, 1990), 3 species of crustacean (Figueiredo & Giani), and 13 species of mammals (Silva, 2008; Carvalho Junior, 2007; Graipel *et al.,* 2006).

Table 1. Number of species in Peri Lake System. Due to the lack of inventories in the area this number is probably underestimated.

Group	# Species
Plants	80
Invertebrates	53
Reptiles	6
Birds	244
Fish	7
Amphibians	19
Mammals	13
Total	422

3. Methods

First, a system diagram is constructed to organize the thinking and relationships between components and pathways of exchange and resource flow (Brown & Campbell, 2007). It is an overview of the system, combining different sources of information and organizing the efforts. The second step is to construct the emergy synthesis tables of flows directly from the diagrams (Odum 1983). It accounts for the annual flows of material, energy, and information that support the system.

Finally, emergy indices are calculated in order to summarize and relate emergy flows of the economy with those of the environment (Odum, 1976). Quantities of stored emergy of environmental resources are calculated from the sum of the emergy of all inputs multiplied by the time it takes to accumulate the storage. The required time is estimated from the literature. To calculate the emergy of economic storages, all inputs of energy, materials and labor to produce them are summed (Odum, 1996).

The objective is to be able to predict the economic and environmental viability of the project. For the evaluation of renewable inputs to the Peri Lake System, solar energy, rainfall, runoff, and wind were used. For economic inputs, the most recent data available from the Ekko Brazil Institute sources were applied. These were sponsor, ecovolunteer, fuel, electricity, and labor. This work is based on data acquired from 2002 to 2017.

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 units can be in sej/J if the product is divided by the energy or sej/g if the emergy of the product is divided by the mass. Emdollar is a measure of the money circulating in the economy as a result of the emergy flow. The emdollar is obtained by dividing the total emergy driving the economy by the economy's Gross Domestic Product (GDP). The Peri Lake System services are based on the emergy evaluation, expressed as emergy and converted to emdollars in order 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 Brazil Institute Data Set.

Figure 2 was modified from CBERS Satellite raw (INPE 2011) using GVSig and Intaglio 3.9.5 (Purgatory Design) softwares. Figure 3 was drawn using Intaglio 3.9.5 (Purgatory Design) softwares.

3. Results

The productive work includes all facilities of the Otter Project: the research and laboratory building, the visitation center, the otter shop, the otter buildings (Animal Refuge-Scientific Breeding and Conservation), the social mobilization nucleus building, office equipment, research equipment, the hostel (ecovolunteer and researcher accommodation), cars, knowledge (information published), and the Ecovolunteer Program (Figure 3). The sustainability of the Otter Project and of the Ekko Brazil Institute depends on the growth of the assets. If the storages of assets become larger, it can be used to obtain new energies.

The flow of money is a countercurrent (dashed line) to the flow of work as it is exchanged by goods and services. Therefore, it represents the flow of energy that money releases. The sources of energy that circulate the money are the sponsor, the ecovolunteers, and the labor. Other sources of money to the project include

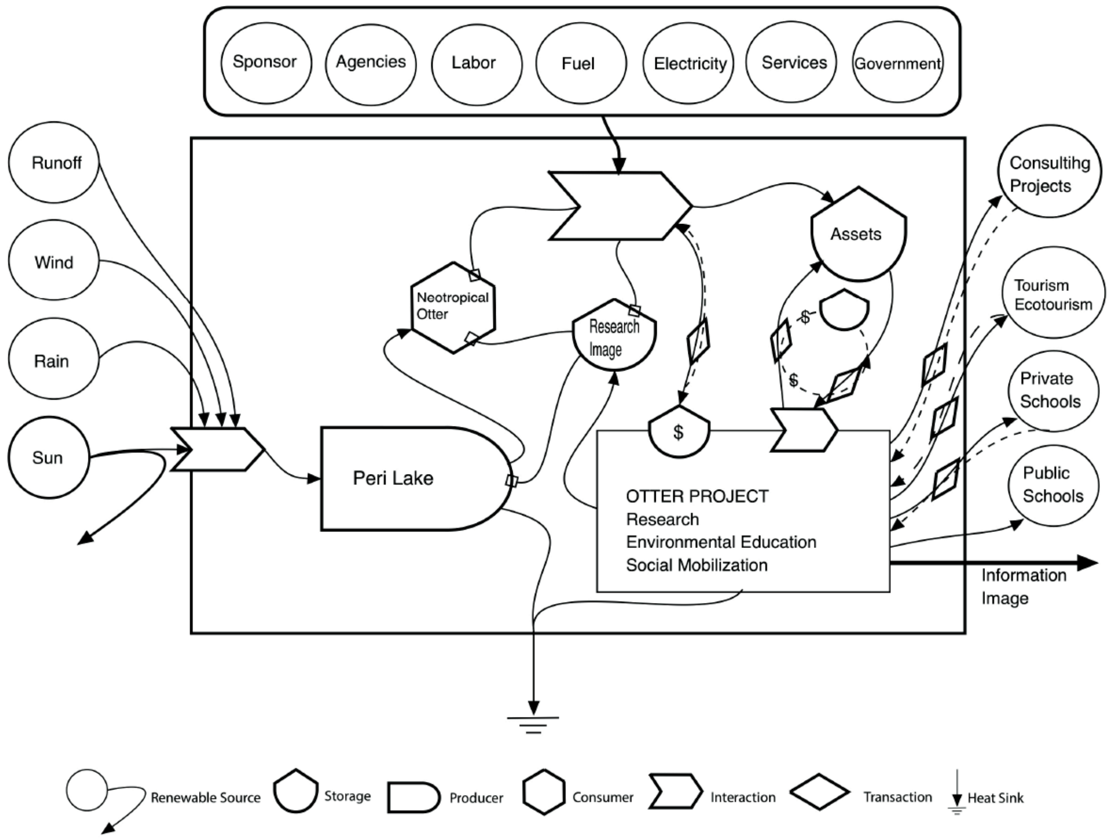

Figure 3. Energy-flow model for Peri Lake System, showing main driving energies, components, pathways of energy, material and information flows, and exports, taking into consideration the Neotropical otter and the Otter Project. Source: author.

consulting projects, tourists (visitors), and private schools.

Table 2 exhibits the emergy evaluation for the Peri Lake Ecosystem as it is exhibited in figure 3. The flows of energy, material and money that cross the Peri Lake system 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 five major categories: Renewable Resources, Imports/Purchased Inputs, Economic Payments Received, Exports, and Economic Payments made by the Institution to outside parties.

Renewable resources are annual inflows that result from overall global processes such as sunlight, rain, runoff, wind. These annual inflows are responsible for driving the global and economic processes within the system and, at the same time, for maintaining the environmental integrity of it.

Imported resources are sponsors, fuel, ecovolunteer agencies, services, labor, electricity, and government. These represent purchased energy, material, labor and the inflow of ecovolunteers. Economic payments received are the flows of money received from visitors, ecovolunteers, and sponsors. Export is basically information produced and exported from the researches developed by the Ekko Brazil Institute through the Otter Project at the Peri Lake System. Finally, economic payments made represent monetary payments

Table 2. Emergy in natural and economic capital of Peri Lake system. Data is organized and calculated using Numbers 5.2. Notes detailing the calculations are shown in Appendix 1.

Note	Item	Units	Quantity	Emergy Intensity (sej/unit)	Solar Emergy seJ/yr	Solar Emergy xE18	EmDollars
	Renewable Resources						
1	Solar	J	1.15E+20	1.00E+00	1.15E+20	115.00	33,691,377.03
2	Rain	J	1.30E+14	2.79E+04	3.61E+18	3.61	1,061,192.70
3	Wind	J	3.02E+13	1.50E+03	4.54E+16	0.05	13,339.87
4	Runoff	J	5.20E+13	6.31E+04	3.28E+18	3.28	964,309.05
	Imports/Purchased Inputs						
5	Fuel	J	1.01E+03	1.11E+05	1.13E+08	0.00	0.00
6	Ecovolunteer	hours.yr-1	1.50E+10	1.50E+07	2.25E+17	0.22	66,114.80
7	Labor	hours.yr-1	5.81E+09	1.50E+07	8.72E+16	0.09	25,643.65
8	Electricity	J	2.54E+08	2.92E+05	7.41E+13	0.00	21.79
9	Food for otters	$	1.28E+04	1.68E+07	2.14E+11	0.00	0.06
	Economic Payments Received						
10	Payment from visitors	$	1.11E+03	1.90E+12	2.11E+15	0.00	621.60
11	Payment from ecovolunteers	$	6.78E+04	1.90E+12	1.29E+17	0.13	37,893.04
12	Sponsors	$	5.58E+05	1.90E+12	1.06E+18	1.06	312,009.04
13	Otter Shop	$	3.37E+03	1.90E+12	6.40E+15	0.01	1,884.91
	Exports						
14	Information (research)	hrs	2.50E+03	2.35E+14	4.81E+17	0.48	141,552.94
15	Surface water (drinking)	J	5.19E+11	8.10E+04	4.21E+16	0.04	12,371.39
16	Fish harvest	J	4.06E+11	1.68E+07	6.82E+18	6.82	2,006,512.94
	Economic Payments Made						
17	Payments for labor (2014)	$	1.58E+05	2.40E+12	3.78E+17	0.38	111,269.92
18	Payments for services	$	9.12E+04	2.40E+12	2.19E+17	0.22	64,363.41
19	Payment for government	$	3.73E+04	2.40E+12	8.96E+16	0.09	26,340.47

made by the Ekko Brazil Institute within the system to outside parties that include labor, services, and government taxes.

Overall, the number of ecovolunteers has increased through the years, with the support of international agencies such as *Cybèlle Planète* and *Secret Planet* in France, *Frontier* in the United Kingdom, *ie3Global* in the United States, *Volunteer World* in Germany, *Ecojourney* and *Intern Brazil* in Brazil. It has been a great support for the maintenance, equilibrium and self-sustainability of the Otter Project and the Ekko Brazil Institute (Figure 4).

From payments received and made, it is possible to observe that there is a great dominance of the financial inflow from the sponsors with an annual average of $^{em}\$$312,000.00 (Figure 5). This influence is reflected in the total amounts received and paid. The total inflow from ecovolunteers and sponsors account for $^{em}\$$349,902.00 while the economic payments made are $^{em}\$$201,975.00. However, the sponsor input usually lasts only 1-2 years, while the ecovolunteers income are within the value chain of the institution, regularly distributed through years.

From the payments made, the highest one is for labor with $^{em}\$$111 thousand, followed by services ($^{em}\$$64,364.00) and then government ($^{em}\$$26,340.47). Payment for labor represents a major expense to the Otter Project representing 16% of the total, followed by payment for services (9%) and payment to the government (4%).

The assets of the Peri Lake System are organized in environmental (natural capital) and economic assets. Table 3 summarizes the emdollar values for the assets related to the Peri Lake system and to the Otter Project. In addition to the largest value of biodiversity ($^{em}\$$354 billion), shrub and herb biomass were valued $^{em}\$$14 billion while the tree biomass at $^{em}\$$6 billion. These were followed by soil organic matter with $^{em}\$$272 million, land area with $^{em}\$$618 thousand and surface water with $^{em}\$$12 thousand. In all, environmental assets respond to about $^{em}\$$374 billion.

Considering the facilities of the Otter Project in the Peri Lake System, the economic assets account for $30 thousand dollars. It is dominated by the Visitation Center (23%), followed by the Machinery and Tools (22%), the Hostel (20%) and Office Equipment (16%) (Figure 6). These are support to the sustainability of the Otter Project based on the visitors and ecovolunteers, directly related to the Visitation Center and Hostel.

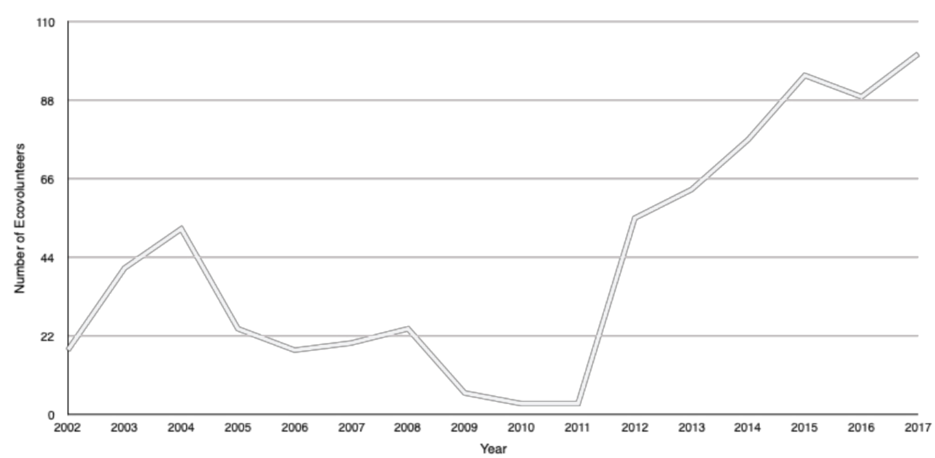

Figure 4. Number of ecovolunteers to the Otter Project from 2002 through 2017. Source: Author.

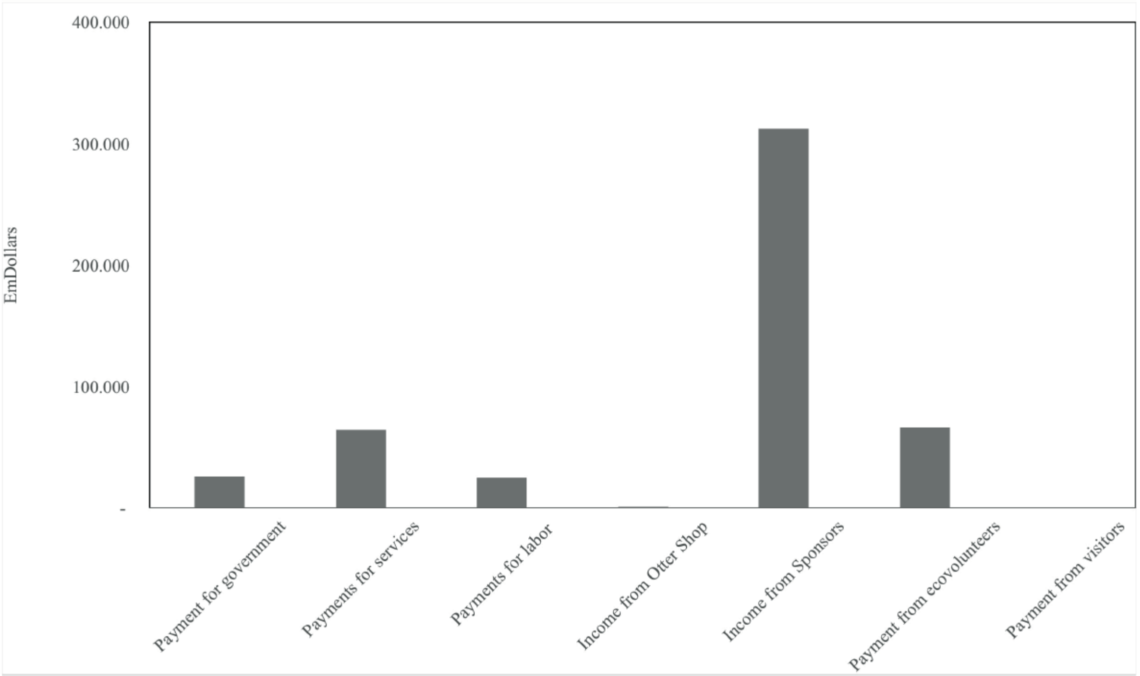

Figure 5. Payments made, payments received (income) in the Otter Project. Source: Author.

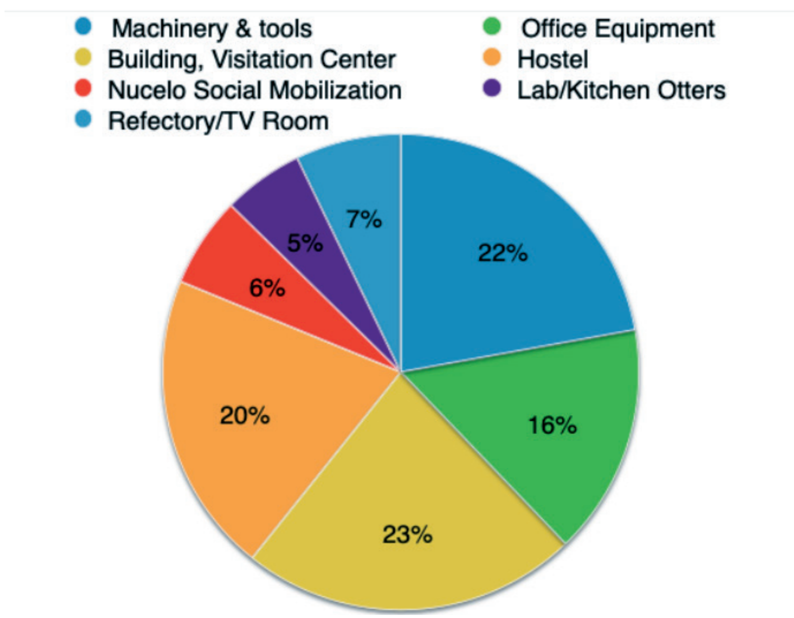

Figure 6. Assets of the River Otter Project. Source: Author.

Table 3. Environmental and economic assets of Peri Lake System. Notes detailing the calculations are shown in Appendix 2.

Note	Item	Units	Quantity	UEV	Emergy	Em$/yr
Environmental Assets						
1	Tree Biomass	J	5.37E+17	3.62E+04	1.94E+22	5,717,470,588.24
2	Shrub/Herb Biomass	J	4.90E+18	9.79E+03	4.80E+22	14,109,117,647.06
3	Land Area	ha	2000	1.05E+15	2.10E+18	617,647.06
4	Soil OM	J	7.46E+16	1.24E+04	9.25E+20	272,050,602.35
5	Surface Water	J	5.19E+11	8.10E+04	4.20E+16	12,364.41
6	Biodiversity	# of spp	4.22E+02	2.85E+21	1.20E+24	353,735,294,117.65
7	Neotropical otter					7,679,353.55
	Total Environmental Assets				1.27E+24	373,842,242,320.32
Economic Assets						
8	Machinery & tools	g	2.00E+06	1.13E+10	2.26E+16	6,647.06
9	Office Equipment	g	1.42E+06	1.13E+10	1.60E+16	4,719.41
10	Building, Visitation Center	g	5.99E+06	3.90E+09	2.34E+16	6,870.88
11	Hostel	g	5.36E+06	3.90E+09	2.09E+16	6,148.24
12	Nucelo Social Mobilization	g	1.61E+06	3.90E+09	6.28E+15	1,846.76
13	Lab/Kitchen Otters	g	1.43E+06	3.90E+09	5.58E+15	1,640.29
14	Refectory/TV Room	g	1.88E+06	3.90E+09	7.33E+15	2,156.47
	Total Economic Assets				1.02E+17	30,029.11

4. Discussion

The economy of Santa Catarina Island depends heavily on tourism. Nevertheless, there is no clear policy for the sector. The concern with the urban development of the island and the resulting environmental impacts are reflected in the definition of a large number of protected areas, which already reaches more than 20% of the total area of the island. The intensity with which natural resources are used in tourism is also unknown.

The use of quantitative methods for assessing natural capital is especially important when it comes to protected areas. The objective is to evaluate the efficiency of conservation measures imposed on civil society, facilitating the understanding of ecological services in the socio-economic context (Vassallo *et al.,* 2017). Franzese *et al.*(2017), argues that marine protected areas can be exploited economically, from a biophysical perspective based on the costs of environmental accounting to the generation of stocks of natural capital and ecosystem services.

In the Peri Lake system, the annual renewable resources are dominated by sunlight (em$33.7 million), rain (em$1.1 million), inflow of runoff (em$964 thousand), followed by wind (em$13.3 thousand). Sunlight accounts for about 94% of the total renewable resources imported to the system, followed by rain and runoff (3%). Wind accounts for less than 1% of the total. The most significant non-renewable resources are the inflow from ecovolunteer and labor, dominated by the influx of ecovolunteers with ^{em}\$66,114.18 and ^{em}\$25,643.65 to the labor. While payment from ecovolunteers represents 11%, payment from sponsors responds to 89% of the total.

The Ecovolunteer Program, in this sense, is of greater importance, since it is part of the Institution's value chain, as a business plan. The Otter Shop is less than 1% of the total received. On the other hand, the exported information, that represents scientific papers, books, technical reports and data set generated by the Project in the study area, responds to ^{em}\$142 thousand, the highest feedback value to the sponsors payment. Within the Peri Lake System, the presence of the Neotropical otter is determinative, which result in a large input of grants from sponsors, driving most of the research and, as a consequence the exports as information.

Most ecovolunteers represent individuals with university degrees and/or important experience in their area of expertise. In the case of an NGO, the dedicated hours of work are maximized due to the motivation in participating in a cause. The cause is the conservation of the Neotropical otter in the wild, and the rescue and recovery of orphans and adults in captivity. The *Lontra longicaudis* is as a flag species in social mobilization campaigns to promote conservation and good practices applied in the management of biodiversity and aquatic ecosystems.

The assets in the figure 3 represents an important connection between the financial inputs and the research, social mobilization and environmental education, the Ecovolunteer Program and the sponsor. Biodiversity represents the largest of the environmental assets accounting to 95% of the total. In this particular case, biodiversity represents the flow of information within the system, not to be confounded with tree, shrub biomass and fish harvest.

When evaluating tourism, it is necessary to take into account the environmental resources and services that are consumed and give support to the tourist (Brown and Ulgiati 2001). In fact, it can be said that when the majority of the emergy consumed by tourism in the coastal zone depends on external sources, this cannot be sustainable (Vassallo et al., 2009). In terms of emergy, the study area is dominated by its renewable emergy sources and by exports (information).

Surprisingly, drinking water extracted from the Peri Lake System accounts for only 1% of total exports while information represents 4%. The fish harvest represents 95% of the total exported. These numbers are not in line with the local policy of the system as it is based in a single use (water extraction). These results show that the local government strategy, focused in the water extraction is not a good one. Tourism conservation based on natural assets, for example, could be much more attractive, as it is the case for the Ekko Brazil Institute Ecovolunteer Program. For the Ekko Brazil Institute, the Neotropical otters are a flagship for research and social mobilization.

The use of natural resources and the role of protected areas in relation to public policies is discussed within the Brazilian government by the Nucleus of Studies and Research of the Senate. The study analyzes economic values of ecosystem goods and services, including biodiversity, with the objective of incorporating them into the decision-making process in public policies. The Brazilian legal framework points to the rational use of these resources, instead of maintaining a pristine nature. Protected areas in Brazil are recognized by the precarious functioning and inefficiency of their economic use for development (Fraxe Neto, 2012).

Creation of jobs, strengthening of local commerce, and appreciation of local culture are some examples that conservation tourism can provide. In addition, 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. However, it has to be considered how much emergy is used for tourism.

A place that has a high budget for tourism shows a high dependence on the income obtained from tourism (Vassallo *et al.,* 2009). In this regard, the role of biodiversity in sustainability and ecologic services is usually ignored or barely incorporated into the discussion. In general, studies on the function of biodiversity often examine communities whose structures differ from those that provide services in real landscapes (Kremen, 2005). Examples of such services are the aesthetic and cultural values provided by populations, species, communities and ecosystems. Costanza *et al.* (1997) presents an estimate of the monetary value of goods and services provided by the Earth's ecosystems provided by 16 biomes and found the underestimated value of $ 16 trillion to $ 54 trillion per year, averaging $ 33 trillion.

On the other hand, the difficulty in using the concept of "sustainability" in economic and social development is the result of the use of different indicators (Liu *et al.,* 2017). An example of an indicator is what measures changes in the size of wild populations to indicate trends in the overall state of global biodiversity (WWF, 2012). Trends within a given population show only what is happening to a species within a particular area, such as the *Lutra lutra*, whose population in Denmark, recovered after improvements in water quality and water exploration after 1984 (Normander *et al.,* 2009).

Biodiversity clearly dominates the environmental assets of the Peri Lake System. It is followed by shrub/herb biomass and tree biomass. Of particular interest is the Neotropical otter. It is treated separately, but if it is included within the environmental assets it would account to $7.7 billion, more than 90% of total assets. Tree biomass, shrub/herb biomass, and biodiversity are different manifestations of the same resources. Biodiversity represents the information of the ecosystem reflected in the diversity of species present.

Ecosystem services come from environmental assets. The total environmental assets of the Peri Lake System, including the Neotropical otter, is about em$373 billion while the economic assets account for em$30 thousand. This difference in part reflects the influence of the Neotropical otter as a flagship and the impact of this on the Ecovolunteer Program of the Ekko Brazil Institute.

The Peri Lake System provides an array of ecosystem services. The largest service is fish harvest that accounts for em$2 million. It is followed by organized recreation from Ecovolunteer Program of the Otter Project (em$211 thousand), clean air (em$179 thousand), information produced (em$142 thousand) and water supply (em$43 thousand). Despite what the numbers show, the local government strategy is based only on water extraction by a state governmental company. However, the local government and the Park itself, do not have any feedback or financial return from this service.

The use of emergy accounting to evaluate the Peri Lake System represents an alternative approach to valuing flows of energy, services and assets that are not taken into account by the conventional economy. In general, the monetary values and emergy values were not aligned. The emdollar of fish harvest is 7 thousand times larger than the economic value. On the other side, the economic value of water supply is about 23 times larger than the emdollar value. The exception is the information produced that is quite similar between emdollar (em$142 thousand) and economic value ($150 thousand). Even considering the uncertainty of the estimated sources and parameters, the large orders of magnitudes, reveal the importance of the resources within the Peri Lake system.

Understanding the interactions between biodiversity, ecosystem services and people is fundamental for the sustainable development with social benefits (Millennium Ecosystem Assessment 2005a b c, Stern 2006, TEEB 2010). Conservation actions such as the implementation of protected areas should encourage the sustainable use and responsible management of resources within these areas, improving ecological connectivity between ecosystems. This ensures that we keep the health of the ecosystem services while promoting social and economic benefits.

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7. Appendix 1

1 Sunlight

Annual energy = (Avg. Total Annual Insolation J/yr)(Area)(1-albedo)
Insolation, J/m^2/yr = 6.66E+12
Insolation, J/m2/yr = 5.30E+09
Area, m^2 = 2.00E+07
Albido = 0.14
Annual energy, J = 1.15E+20

2 Rain

Annual energy = (in/yr)(Area)(0.0254 m/in)(1E6g/m3)(4.94J/g)(1 - runoff)
(area, m^2)*(%runoff, m)*(avg elevation, m)*(density, kg/m^3)*(gravity, m/s^2)
Rain (in/yr)= 60.71
Rainfall, m/yr= 1.54
Area (m^2)= 20,000,000
Runoff (%)= 0.17
Runoff (%)= 2.00
Runoff (%)= 3.20
Runoff coefficient= 0.07
avg elevation, m= 330.50
density, kg/m^3= 1.00E+03
gravity, m/s^2= 9.80
Annual energy = 1.30E+14
Transformity, sej/J= 2.79E+04

3 Wind

Area, m^2 = 2.00E+07
Density of Air, kg.m^{-3} = 1.30E+00
Avg. annual wind velocity, mps = 5.00E+00
Geostrophic wind, mps = 8.33E+00
Drag Coeff. = 1.00E-03
Energy, J = (area)(air density)(drag coefficient)(velocity^3)
= (m^2)(1.3 kg/m^3)(1.00 E-3)(___mps)(3.14 E7 s/yr)
Energy, J = 3.01E+13
Transformity, sej/J= 1.50E+03

4 Runoff, J

Runoff=(Volume,m3)(4.82J/g)(1E6g/m3)
Rainfall, m/yr= 1.54
Area, m^2 = 20,000,000
Volume total, m^3= 3.08E+07
Volume runoff, m^3=1.08E+07
4.82E+00
1.00E+06
Energy/yr= 5.20E+13
Transformity, sej/J= 6.31E+04

5 Fuel
(litros * 0,35 J/l)

Energy J/l= 3.50E-01
Litros (2014)= 2900.00
Litros, R$= 2900.00
Litros, $= 906.25
Annual energy, J= 1.01E+03
Emergy per unit input= 1.11E+05

6 Ecovolunteer
total energy expenditure=kcal/hr*hrs*4186J/Kcal
(total hrs/yr)*(2500 kcal/day)*(4186J/Cal) / (8 pers- hrs/day)
Total hours=3.44E+04
Conversão= 4.19E+03
hrs/day= 2.40E+01
kcal/day= 2.50E+03
annual energy, J= 1.50E+10
Transformity= 1.50E+07
Emergy per unit input (sej/J) = 4.45E+06
7 Labor
Total hours= 3.11E+04
Conversão= 4.19E+03
hrs/day 5.60E+01
kcal/day= 2.50E+03
annual energy, J= 5.81E+09
Transformity= 1.50E+07
Emergy per unit input (sej/J) = 4.45E+06
8 Electricity, J
Annual energy=KWh*3,6E+06 J/KWh
Conversion= 3.60E+06
KWh = 7.05E+01
Annual energy = 2.54E+08
Transformity= 2.92E+05
9 Food for otters
Total spent= 1.28E+04
Unit Emergy Value, sej/$= 1.90E+12
10 Payment from visitors
Unit Emergy Value, sej/$= 1.90E+12
Total payment= 1.11E+03
11 Payment from ecovolunteers
Total received= 6.78E+04
Unit Emergy Value, sej/$= 1.90E+12
12 Payment from sponsors
Total received= 5.58E+05
Unit Emergy Value, sej/$= 1.90E+12
13 Payment from the Otter Shop (2015)
Total received (dollar)= 3.37E+03
14 Information (research)
working days 2014= 2.56E+02
working research days= 1.28E+02
working hours full= 2.05E+03
working hours= 1.02E+03
Transformity= 2.35E+14
Total sej of research= 2.40E+17
15 Surface water drinking
energy=volume*density*Gibbs Free energy of water
Price (R$/10m3)= 3.00E+01
Price (US$/10m3)=8.57E+00
Volume of water (m3/yr)= 1.05E+05
Volume of water (US$)= 9.01E+04
density of water, kg/m^3= 1.00E+03

Gibbs Free energy of water, J/kg= 4.94E+03
energy, J= 5.19E+11
Transformity, sej/J= 8.10E+04

16 Fish Harvest
Fish caught, Kg= 400.00
Fish caught, g= 400,000.00
avg. mass, g/fish= 270.00
% dry weight, 20% 0.20
energy content, J/g=1.88E+04
energy fish caught, J= 4.06E+11
Transformity, sej/J= 1.68E+07

17 Labor
Total (2014), $/yr= 1.58E+05
Emergy per unit input, sej/$ =2.40E+12
Annual emergy= ($/yr)*(sej/$)

18 Payment for services (2014)
Total (2014), $/yr= 9.12E+04
Emergy per unit input, sej/$ =2.40E+12
Annual emergy= ($/yr)*(sej/$)
Annual emergy= 2.19E+17

19 Payment for government
Total (2014), $/yr= 3.73E+04
Emergy per unit input, sej/$ =2.40E+12
Annual emergy= ($/yr)*(sej/$)
Annual emergy= 8.96E+16

8. Appendix II

1 Tree Biomass, g/m^3
Tree Biomass, Kg/m^3
Altura, m= 20
Area de árvores, km^2= 57
Area de árvores, km^3= 1.14
Area de árvores, m^2= 57000000
Area de Árvore, m^3= 1.14E+09
Peso kg/m^3 25.00
Peso total, kg/m^3 2.85E+10
mass, g dry weight= 2.85E+13
Kcal/g tree biomass= 4.50E+00
J/kcal= 4.19E+03
energy, J= 5.37E+17
Transformity, sej/J 3.62E+04

2 Shrub/Herb Biomass
Area, km^2= 13
Area, km^3= 52
Area, m^3= 5.20E+10
Peso Kg/m^3, dry weight 5
Peso total Kg/m^3, dry weight 2.60E+11
mass, g dry weight 2.60E+14
energy, J= 4.90E+18
Transformity, sej/J 9.79E+03

3 Land Area
Area, ha= 2.00E+03
Transformity, sej/J= 1.05E+15

4 Soil OM, J
volume, m^3= 3.00E+06
Bulk density, kg/m^3= 1.10E+03
g/kg= 1.00E+03
mass OM= 3.30E+12
kcal/g of OM= 5.40E+00
j/kcal= 4.19E+03
Energy, J= 7.46E+16
Transformity, sej/J 1.24E+04

5 Surface water
volume, m^3/yr= 1.05E+05
density water, kg/m^3= 1000
Gibbs Free energy of water, J/kg= 494
Energy, J= 5.19E+10
Transformity, sej/J 3.02E+05

6 Biodiversity
# of spp= 4.22E+02
Transformity, sej/J=2.85E+21

7 Neotropical Otter
Emergy in critical sp = (1#endangered species LP * 4,71 %LP area to the island) * 4,74E24 emergy per species (sej/species)
Endangered species (n.) in LP= 1
LP area (km2)= 20
%LP area to the island= 4.710000
%Viable population area to the otter distribution area estimated= 0.005330
Viable population are (Home Range) (Km^2) estimated= 600.00
Neotropical otter area distribution (Km^2)= 11,257,191.66
emergy per species (sej/species)= 5.54E+18
National Emergy Money Ratio (EMR) sej/$ (Total emergy Used/GDP)= 3.40E+12
average value for turnover time of species (Weir, 2007) (million yrs)= 3E+06
median estimate for total number of species (million)= 1.00E+07

8 Machinery, Equipment
vehicles= 4
avg. mass, g/vehicle= 2001500
avg vehicle lifespan, yrs= 2.00E+01
use per yr= 4.00E+05
Transformity, sej/J 1.13E+10

9 Office & Equipment
mass, lbs= 3124
g/lb= 4.54E+02
energy of office & equipment, g= 1.42E+06
Transformity, sej/g= 1.13E+10

10 Buildings, Visitation Center
units per m^2, g/m^2= 2.98E+04
area, m^2= 201
building mass, g= 5.99E+06
Transformity, sej/g= 3.90E+09

11 Buildings, Hostel
units per m^2, g/m^2= 2.98E+04
area, m^2= 180
building mass, g= 5.36E+06
Transformity, sej/g= 3.90E+09

12 Nucleo, Social Mobilization
units per m^2, g/m^2= 2.98E+04
area, m^2= 54
building mass, g= 1.61E+06
Transformity, sej/g= 3.90E+09

13 Lab/Kitchen Otters
units per m^2, g/m^2= 2.98E+04
area, m^2= 48
building mass, g= 1.43E+06
Transformity, sej/g=3.90E+09

14 Refectory/TV Room
units per m^2, g/m^2= 2.98E+04
area, m^2= 63
building mass, g= 1.88E+06
Transformity, sej/g= 3.90E+09