Emergy study applied to permaculture in Barra da Lagoa in Santa Catarina

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Julio Cesar Lopes Borges[1], Cecilia Heidrich Prompt[2].

ABSTRACT

Permaculture has been presented as part of a complex study that references sustainability. With a holistic view, the study is effectively based on the analysis of the emergy method. From this method, it seeks the formation of the energy flow of a specific property located in Barra da Lagoa, in Florianópolis - Santa Catarina. It aims at the availability of building concrete bases for further studies on the theme of energy, in a specific study of renewable energies. In the end, it is interested in demonstrating the relationship between energy and a complete cycle of activities open to a closed system.

Keywords: Emergy, Energy Flows, Santa Catarina.

[1] Master's student in Energy and Sustainability at the Federal University of Santa Catarina
[2] Doctor in Architecture from the Federal University of Santa Catarina

INTRODUCTION

Sustainable energy is one of the important issues in modern society. Local innovations have become a necessity for the transition to new ways of life and in a more sustainable way. Sustainable and renewable energy sources are still little explored around the world, considering the potential of clean sources such as wind and solar.

On the other hand, energy flows are of fundamental importance since they are basic training in the context of Permaculture. Permaculture is an expression originated from the English "Permanent Agriculture" and was created by Bill Mollison and David Holmgren in the 70s of the last century. Over the years, it has come to be understood as "Permanent Culture", as it has come to cover a wide range of knowledge from various scientific areas, going far beyond agriculture. (NANNI, 2019). It is about understanding the different ecosystems and understanding the energy in permanent flux, as well as the thermodynamic processes.

For the production of more sustainable ways of living, permaculture understands that closing cycles can be useful by intensifying processes on a property. The second principle of permaculture planning (HOLMGREN, 2002), capture and store energy, suggests saving and investing any type of resource consumed and capturing local energy flows – renewable or not – with the intention of making long-term investments (PROMPT, 2021).

Sustainability can be seen as the concept of "sustainable development". The understandings and meanings related to a series of ethical implications and principles, inserted and applied in academic contexts, social segments, development plans and processes (HANAI & ESPÍNDOLA, 2011).

Also, the term "sustainable" appears for the first time in the United Nations report: Our Common Future (World Commission on Environment and Development, 1991), known as the Brundtland report in 1987 (MENDES, 2009). Thus, the initial term of "sustainability" was consolidated in the field of Biological Sciences and Ecology, it refers to the carrying capacity of an ecosystem and its natural elements in the face of anthropogenic modifications, allowing its reproduction or conservation (CAMARGO, 2016).

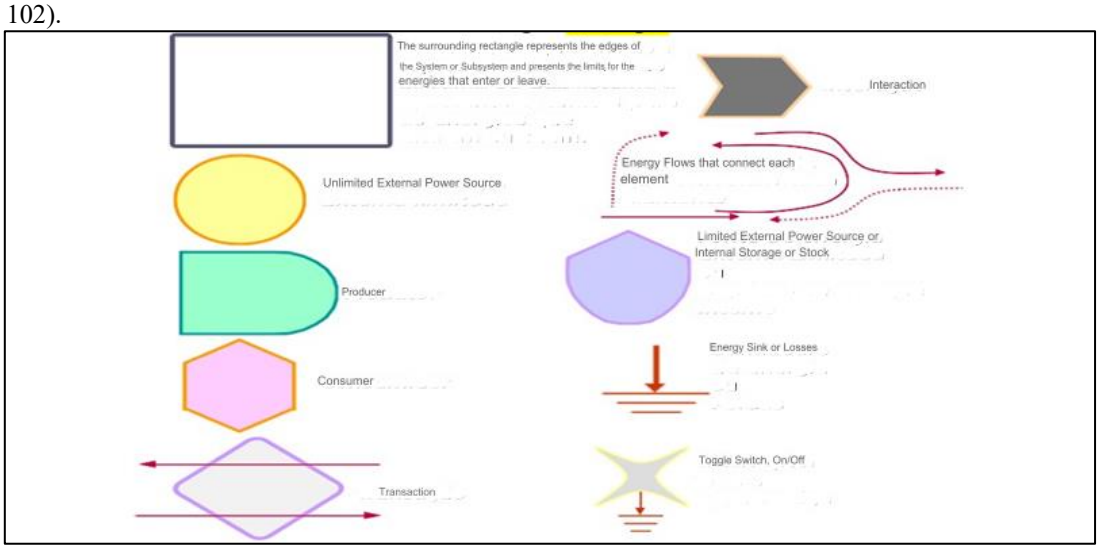
For the study of permaculture and its energy sources, in various types of systems, the emergy can be used as a methodological basis, for studies with application from diagrams. Emergy is considered as a methodology initially developed by Howard Odum. It takes shape in the analysis from environmental management tools, also maximizing economic processes. According to Venturi (2020):

> (...) Calculating the emergy of an activity or product would be a methodology to more accurately study all the energy spent in a given "ecological footprint", that is, it is an analysis closer to the actual amount of energy used and accumulated in each system. (Venturi, 2020, pg. 54).

The basis of energy on every planet comes, of course, from the energy of the Sun, measured in Joules. Unlike conventional economics, the study of emergy tends to visualize the system in its entirety. Emergy cost tends to be much more effective and true than a system of environmental costs, where there are only externalities passed on to society, proposed by conventional economics (VENTURI, 2020). It is also characterized by a distinction between environmental economics and ecological economics (BORGES & AGUIRRE, 2023).

Also according to Venturi (2020), emergy, in English, would be the junction of the expression *emboided energy* = *emergy* = emergy. To calculate the emergy, one must start by elaborating an emergy systemic diagram. This diagram serves to identify the key inputs of each system and from it the operations of the systems. Renewable resources (R) are considered to be: solar energy, precipitation, air mass movement and evapotranspiration. The non-renewable resources (N) are: eroded soil, phosphorus present in the soil, groundwater used at a rate higher than the recharge. Resources acquired in the market (F) are all those that were obtained outside the limits of the system (ROMANELLI, 2007).

Figure 1. Symbols and Their Meanings Commonly Used in Flow Diagrams of energy/emergence. Source: (VENTURI, 2002, pg. 102).



It refers to an overview of the system, combining different sources of information and organizing efforts (CARVALHO-JUNIOR, 2022). Figure 1 proposes a symbology for the realization of energy diagrams.

In a later stage, the emergy indices are calculated, in order to summarize and relate the energy flows of the economy with those of the environment. Thus, at Emergia there is a complex study that "prices" and gives value to each of the energy activities of the property in question, assisting in the analysis of energy indicators. Pricing will not be carried out in this article.

In this way, the emergy is used to identify the total demand of the system and its energy efficiency reflected by the relationship between energy produced and energy employed. There are the

incoming energies and the outgoing energies.

Thus, this project brings the possibility of a permaculture study in the Atlantic Forest of Santa Catarina, specifically in the locality of Barra da Lagoa in Florianópolis, with its special focus on the property of Juliana, a woman born in Juréia - SP, 49 years old, teacher at the Acácio Garibaldi school in Florianópolis, Santa Catarina.

In 2022, while teaching at the Acácio Garibaldi school, I met Juliana. She had fallen ill and asked me to take care of the house during the summer period. This period was important to introduce me to the energy concern of a property and ended up culminating in the beginning of my entry into the specialization in permaculture at UFSC. Helping her in this endeavor presented herself as a good alternative.

Figure 2: Map of the property's situation. Source: Image from Google Earth, Edited by the author (2024)

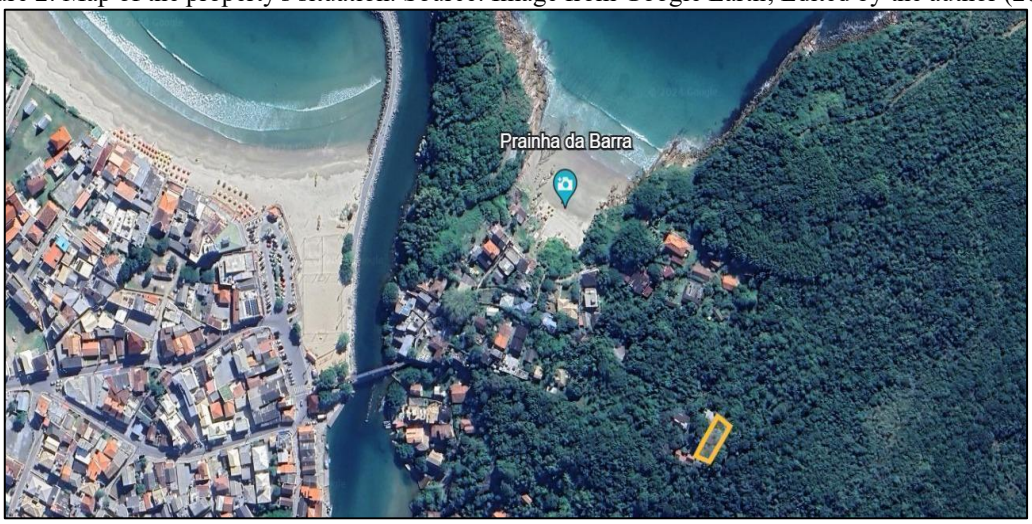


Figure 3: Juliana and her challenges. Source: Image captured by the author (2024)

JUSTIFICATION

The process of staying on the property for three months made me wonder what I could do to make it more sustainable. The property has many deficiencies, including a vegetable garden that does not have its development, lack of sewage treatment, unfinished works and absence of waste recycling processes.

Permaculture processes should emphasize and dynamically internalize appropriate technologies, such as the use and promotion of environmentally coherent and efficient equipment and the potential for closing energy cycles.

The use of emergy as a methodological tool for both analysis and permaculture projects is intended to be applied in order to bring consistency to the situations of the present study, as well as to present itself as a contribution to the theme of permaculture in broader contexts.

DELIMITATION OF THE PROBLEM

The project is then limited to the application of the emergy methodology associated with permaculture tools, up to the stage of consolidation of the emergy diagram. diagnosing and analyzing the energy flows considering the input and output of energies in the 300 m² property located on top of the hill of Prainha da Barra da Lagoa, Florianópolis, SC.

OBJECTIVES

The project also aims to capture and store energy with the possible objective of analysis in the face of the demands of the property and outside it. It also aims to study the climatic problem in the Atlantic Forest space. It focuses on energy efficiency or efficient use that uses little energy and has low impact, in a sustainable way (MARS, 2008).

OBJECTIVE

Analyze and propose design guidelines for a property using emergy diagrams.

SPECIFIC OBJECTIVES

- Describe the property in relation to its history, as well as its physical and environmental characteristics, establishing relationships with Permaculture;
- Develop a diagram of the system with the current emergy flows of the property;
- Propose permaculture strategies aimed at closing the cycles on the property;
- Simulate an emergy diagram that represents the flows from the implementation of these strategies, thus performing a comparative analysis between the two diagrams produced.

METHODOLOGY

Methodological procedures will be carried out from the emergy. permaculture. From there, analyze the property in question from the exploratory research and application of the emergy method: the understanding of the energy flows in the property, as well as the efficiency of the permaculture solutions proposed from the diagnosis will be made based on the flowcharts carried out.

Step 1: Theoretical study:

The theoretical study focuses on the bibliographic review available on Google Scholar, Scopus, Scielo and on specific bibliography, as well, with reference to the state of the art in the theme of permaculture, emphasizing energy flows and the dynamics of counterpoint in renewable energies. It will seek to list specific works on permaculture studies within the scope of the Atlantic Coastal Forest.

Step 2: Data Collection:

Data collection, an important work for carrying out analysis and emergy study, aims to obtain data on the context of the property, which may come from preliminary studies and existing open processes. The following techniques will be used for data collection: compilation and analysis of pre-existing documentation provided by the owner, participant observation, photographic survey, semi-structured interviews.

Step 3: Data processing:

The data collected will be processed through mapping, with the help of Google Earth and Google Slides tools. The mapping will be linked to the photographic survey, in order to obtain clarity about important spaces on the property. For terrain analysis, methods belonging to permaculture will be used, considering the use of zones and sectors.

Step 4: Evaluation from emergy:

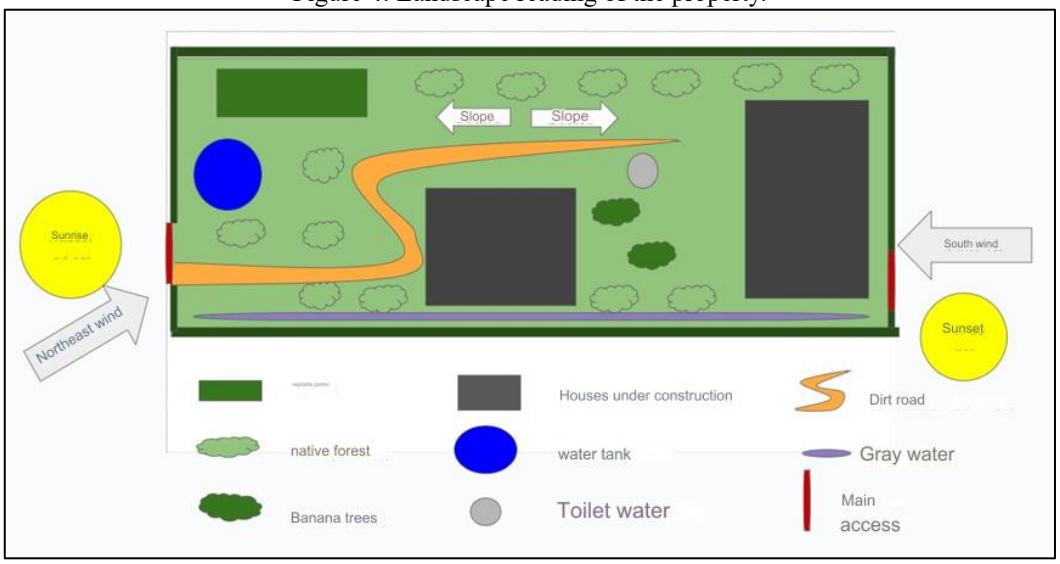
From the mapping of the existing reality, which will clarify the results obtained with the collection and treatment of data, and the theoretical study, the information will be crossed in order to obtain a map with the energy flows. This will consist of an energy/emergy flow diagram. The symbology will be based on Figure 1, and will undergo adaptations due to the feasibility of the tools used in this work. However, this work will not follow this diagram exactly, because the tools are different. By cross-referencing the data, it will be possible to understand which permaculture strategies can be applied with a focus on the movement of change over time on the property. The suggested strategies will be compiled in the form of possible guidelines for intervention in similar contexts.

RESULTS

Juliana has lived on the property since 1990. Since then, he has been building his property intuitively, without fundamental and specific repairs. The energies of his property develop in open flows, without great care and in an unsustainable way. Juliana's health problems brought more difficulties to carry out her day-to-day activities. Access is through a steep trail that requires time and resources to carry out activities.

The context of this property is very peculiar, as it is located on the hill of the little beach in Barra da Lagoa. Access is through a trail approximately 400 meters long, on a staircase made of stones without major tracts. Its land is demarcated with an entrance gate, inside a property with a slope at the front and a slope at the back. The land is fenced in front and on the sides.

Figure 4: Landscape reading of the property.



Prepared by the author (2024)

There is a large water tank in the front that is supplied by Casan and another, in the back, that is deactivated. The house is supplied by energy from the public grid - Celesc. Still in the front, there are vegetable gardens on small terraces that are currently abandoned.

Figure 5: Currently abandoned vegetable garden.

Source: Image captured by the author (2024)

The electricity from the concessionaire is moved to the end of the hill, arriving at his house and supplying the property. The property receives little sunlight and worries when there is rain, contrasting with internal leaks in the house and with the soaked land without water use, accumulating puddles for the proliferation of mosquitoes, among other things. It has two houses without sewage treatment systems. There is an internet connection but poor signal quality.

Figure 6: Front House.

Source: Image captured by the author (2024)

Homes do not have a structure for energy conservation. The front house has large openings in the walls, windows covered with plastics. They also have old roofs full of leaks, which makes it difficult to live in times of heavy rains or even worse in extreme rains. In winter the interior of the house is very cold and in summer it is very hot. It is also in the middle of the two slopes of the property, draining the gray water from the kitchen to the slope of the back of the land.

Figure 7: Back house.

Source: Image captured by the author (2024)

The back house, under construction, follows one of the slopes of the property. No sewage treatment. All made of wood, with its concrete bases. In this way, the buildings present on the property do not present sustainable forms that can deal with energy flows or develop appropriate functions in relation to extreme weather events.

Also, the idea of building the house at the end of the land aims to serve as an inn in the summer season, providing extra income for the maintenance of the two houses and with the objective of providing improvements to the property. This second house, whose works began six years ago, faces barriers to its completion due to lack of adequate planning and other various reasons.

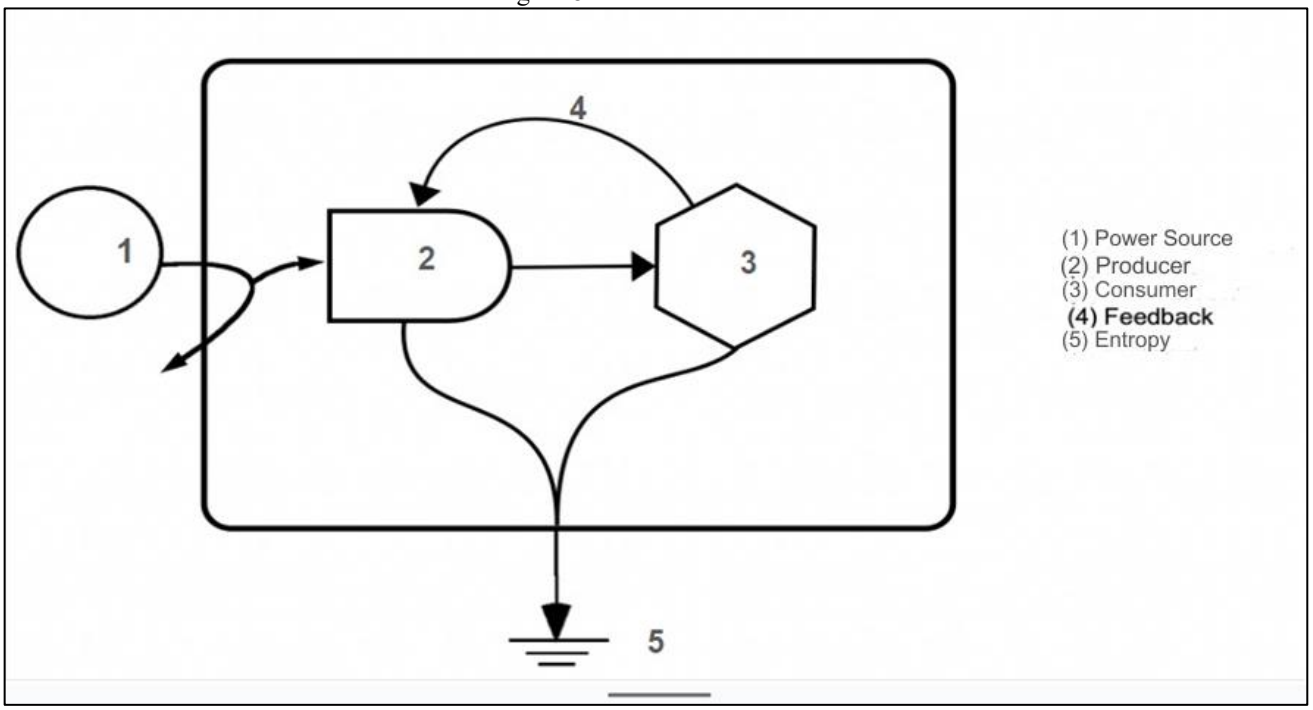
In order to improve the analysis of the terrain and make use of the permaculture zoning method, the following existing zones were identified:

Table 1: Areas of the property. Prepared by the author (2024)

Areas	Existing activities
Zone 0	House 1 (house 2, as it is unfinished, will not be considered as a Zone 0)
Zone 1	Spontaneous vegetable garden
Zone 2	Food plants, herbs for teas, zucchini
Zone 3	Banana
Zone 4	No related activities identified
Zone 5	Unmanaged native forest

For the development of the emergy diagram, the model to be followed is presented, at first, for an analysis of the energy flow and later analysis of the external dependence and environmental analysis from the flowchart. We thus have energy sources, property producers and consumers represented.

Figure 8: Flowchart exercise.



Source: Oldemar Carvalho Junior (2024)

The elements identified in the property in question are represented in Figure 4. Based on the diagram in Figure 8, we can classify them as follows:

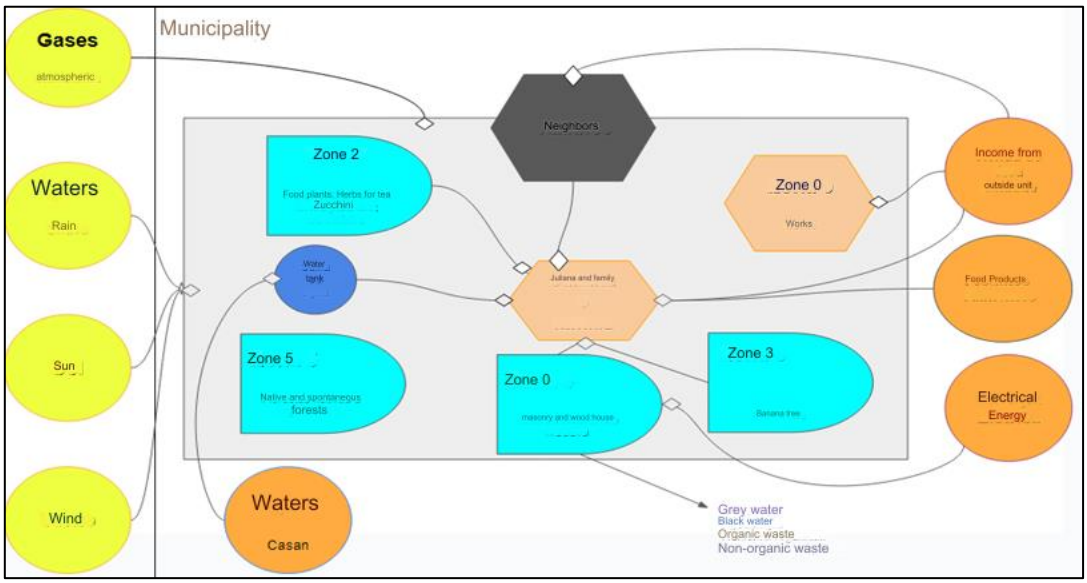
Table 1: Property elements.

Energy Sources	Producers	Consumers
Sun	Plants	Human
Wind	-	Animals
Rainwater	-	-
Utility water	-	-
Gravity	-	-
Electrical energy		

Source: Prepared by the author (2024)

Producers: Plants (autotrophic organisms) that produce biomass from organic compounds for animals that permeate the property, and serve as food for animals (including people).

For the consolidation of the emergy diagram, the classified elements were distributed with reference to the previously identified permaculture zones.



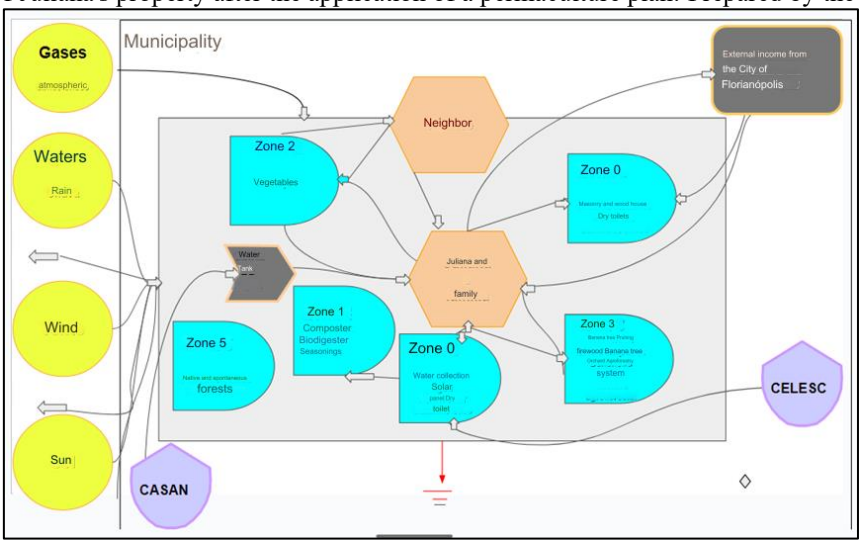
The diagram in Figure 9 shows that there are disconnected energy flows in this property. The activities are centered on Juliana, with whom the problem of the place where she lives is perceived. There are impasses and also findings of (un)sustainability. It is verified that there is a range of energies that enter the property but are not used, generating an escape of solar energy, where part enters the property and another leaves. So it is with the wind. Energy sources are misused in the way that aggravates their situation every day.

There is also a large footprint where activities are carried out with dependence on energy supply from outside the residence. Resilience in the face of property challenges is threatened if there are extreme events. There is a very great dependence on the neighborhood and the municipality for basic activities.

The activities result in the production of gray water, water contaminated with feces, organic and non-organic waste that, in addition to not being reused, returns to the environment without treatment. The lack of sewage treatment is the high point to be solved. Although there is a storage of water from the concessionaire, there is no storage of rainwater or retention systems in the soil, resulting in rapid losses, since the slopes of the land are accentuated. On the other hand, in periods of drought the soil ends up losing moisture, requiring manual irrigation of the plantations with water from the concessionaire.

From the initial diagram, which represents the current reality of the property, a diagram was developed with proposals for new elements that provide the closure of some open cycles detected (Figure 10):

Figure 10: Flowchart of Juliana's property after the application of a permaculture plan. Prepared by the author (2024)



A first step towards closing the flows is the interaction between production and consumption within the property. The use of renewable and unlimited energies in capturing property is of fundamental importance. Also, the lower use of existing sources outside the analysis site is a consequence of the attempt to close the cycle. It is proposed the use of photovoltaic panels to capture solar energy and also the use of water more efficiently, with rainwater capture and storage systems, making less use of water coming from Casan.

It is also proposed to intensify the activities of vegetable gardens and planting with a wider range spread across zones 1, 2 and 3, considered of fundamental importance, as a first step, for self-sufficiency of Juliana and her property. Also allied to the care of small animals (chickens). This aims to alleviate the total dependence on foreign food resources and consequently the sustainability of economic resources.

As the income comes from the municipality, it is recommended that you also interact with the neighbors of the properties next door to maximize the economic utility and diversification of food.

Also, a serious problem of the first order is the absence of sewage treatment. Juliana proposes the construction of a biodigester for the treatment of water contaminated with feces, to later be returned to the soil as fertilizer. An alternative is also sought to try to use gray water in the management of the property, combining the excess of water from Casan for the maintenance of the vegetable garden and the completion of the construction of the back house.

In addition, the back house has been built by neighbors who support Juliana. Its foundations were laid about 10 years ago, but only in recent years has it been one of the priorities. In this way you will use available resources for construction. All these processes reported above are of importance for the completion of the work, closing the flows in their possibility and less dependence on the municipality in the production of the owner's material life.

It is also necessary to maintain the plants and seasonal pruning, especially in winter. The

pruning residue is used as fuel for use in a wood stove to be built later, adapted to the reality of this place. It also seeks to increase interdependence with neighbors in terms of food and material resources throughout the year, proposing an alternative to jointly produce a vegetable garden that supplies the two properties.

FINAL CONSIDERATIONS

The objective of this study was to analyze a property located in Barra da Lagoa. To this end, at first, it was defined that the most appropriate was an analysis that encompassed the problem and its context. According to the visit to this territory, it was found that the processes that existed there were generally (un)sustainable.

Thus, with the exploratory research, a search for a proper methodology for the development of analysis that would be in the transition from one place to another, that would take advantage of the energy flows, began.

In this way, the aspects of the property and its possible development over time were analyzed. We sought to contextualize it in order to understand the processes that surround it. It was also necessary to introduce a model for its configuration.

Of the 12 principles of permaculture, the following were sought to contemplate: capture and store energy; Use and value renewable services and resources; Do not produce waste; Use small, slow solutions; Use and respond to change with creativity. Upon completing the closing of the cycles, it was observed that the structure of the property has a high impact and is (un)sustainable, with future alternatives to deal with its development.

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