APPLICATION OF THE MULTIMODAL SYSTEMIC METHOD TO AN ISLAND COMMUNITY ON THE PARANÁ RIVER - ANALYSIS OF INTERMODAL LINKS

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1. INTRODUCTION

Science has advanced and sought to solve social and structural problems to promote the quality of life of human beings and, at the same time, promote sustainable development with less impact on the environment. Several studies have been conducted and some answers found, but they are rarely put into practice, or, when they are put into practice, they do not produce the expected results. This inefficiency is based on the fact that modern scientific enterprise is far removed from its real purpose, which is to serve humanity, and not bureaucratic institutions.

Modern scientific studies that aim to develop social projects tend to focus on a single theme and exclude other factors, as if problems were isolated and could also be solved in isolation (De Britto, 2010). Ben Orlove and Steven C. Caton's (2010) research on water as a "total social fact", based on Marcel Mauss's theory, highlights the web of connections between water and a variety of social domains, transcending the conventional approach. By recognizing the breadth of social, economic, political, religious and aesthetic influences associated with water, they emphasize the pressing need for a systemic perspective to address issues initially perceived as exclusively related to biology. The adoption of Multimodal Systems Thinking (MMST) becomes crucial given the understanding that water not only impacts, but is also impacted by, a complex network of social interactions. This approach proves essential for deeply analyzing challenges and enables a more comprehensive understanding of the interrelationships between water and the various aspects of social, economic and environmental life.

In their quest to develop a more effective methodology for resolving crises affecting communities and providing a normative analysis of social systems to guide their activities, researchers Donald and Veronica de Raadt found that the challenges faced by human beings are remarkably complex. This complexity is revealed in the multiplicity of aspects involved and the interconnections between them.

Through these studies, Multimodal Systems Thinking (MMST) was born, inspired by

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three scientific schools, namely: Historiology by Miguel de Unamuno and José Ortega y Gasset (Unamuno, 1927, 1996; Ortega Y Gasset , 2004); Theory of Modalities by Herman Dooyeweerd (Dooyeweerd, 2021); and finally General Systems Theory by Ludwig von Bertalanffy (Bertalanffy, 2012). In “A Brief Introduction to the Multimodal Systems Method”, Christian Maciel de Britto (2010) wrote:

> “A new scientific proposal and a new application method that can support communities and other social systems to ensure their viability and manage the crises they face are essential.”

This new perspective approaches social projects by considering the diverse problems experienced by citizens, such as: economic, political, social, health, environmental, family, and structural crises, and access to health and education. In the search for sustainable development of a community, a methodology that considers the multiple factors that affect it must be used. However, it is not enough to simply identify the factors and the modalities to which they belong; it must be understood that they are interconnected through a systemic approach, just as the limbs are not separate from the body (Perdigão, unpublished; de Raadt, 2013; de Raadt & de Raadt, 2014). In this way, MMST seeks to identify the interactions between the factors and how to present a solution to these crises.

Studies conducted using MMST have already addressed biotic factors that influence urban communities in Australia (de Raadt, 2011; de Raadt & de Raadt, 2008). In the respective studies, the environment influenced the social structures studied, both positively, in terms of people's mental health and negatively, when the environment in which they lived was affected. In Argentina, a study with a multimodal approach evaluated the impacts of agribusiness on the community in the region (Casiello *et al.*, 2010). In Brazil, De Britto (2013) applied MMST in the city of Pontal do Paraná to evaluate the impacts resulting from the “Pontal do Pré-Sal” program, which could compromise some communities living in the region. Upon completing the application of the method, De Britto (2018) identified some positive impacts that include population growth, construction of roads, infrastructure and port activity; and negatively affecting water quality, ichthyofauna and consequently, fishing.

There is a proverb that states: “Speak up for those who cannot defend themselves; ensure justice for those who are afflicted. Yes, speak up for the poor and helpless, and see that they receive justice” This should be a motivation for this kind of research.[2] There are also national laws in Brazil. Article 225 of the Federal Constitution (Brazil, 1988), states: “Everyone has the right to an ecologically balanced environment, a common good for the people and essential for a healthy quality of life, imposing on the Government and the community the duty to defend and preserve it for present and future generations”. Thus, because of the dire consequences of damming the Parana River to a community of fishing villages and islanders,

2 (Proverbs 31:8-9).

this study sought to take the first steps towards applying MMST in this community, by identifying the main factors that interfere with its viability and their relationship with the environmental (biotic) aspects of the community.

The search for the application of MMST is based on the principle of re-establishing the healthy development of the community, which was previously a reality before everything changed by the damming of the river. This community is formed by fishermen who depend on the river to survive. They have spent all of their lives fishing; it is the way they were brought up and is their sole livelihood. But it all changed when the hydroelectric dam came, an enterprise to generate electric energy, but with enormous environmental and social impacts. The dam, inaugurated in 1986, caused the flooding of thousands of square meters of land above it, and below it; it also lowered the water level and changed the habitat of the fish and their migrations. Because of these changes, the fishermen's work changed, and then their financial conditions, and then their families, including their mental health and social structures. This environmental change made impacts that cannot be compensated for or replaced, because they are systemic. The pastor of the local church reported:

> "They had a good quality of life; they were fishermen who had fish to catch. So that was enough. They lived a simple life, but they were happy. They had their own car in the city, they could change boats every now and then to go fishing, they even did well, they took care of their children. It was an okay life; the children stayed there, they married the girls there, and the community was developing. But as everything changed and the fish numbers decreased, the environmental impact of the hydroelectric plant began to define people's lives in the long term; they could no longer support themselves."

2. MATERIALS AND METHOD

2.1. Focus of the study

The Paraná River stretches from São Paulo, Mato Grosso do Sul, to Buenos Aires in Argentina, and has four large hydroelectric plants along its length: Jupiá, Ilha Solteira, Porto Primavera and Itaipu (Itaipu , 2021). The Porto Primavera hydroelectric plant is located in the Pontal do Paranapanema region, in the municipality of Rosana, SP. The hydroelectric plant has been in operation for over 20 years and has an area of influence over 12 municipalities, half on the São Paulo side and the other half on the southern side of Mato Grosso (Ferreira *et al*, 2021).

According to Köppen classification, the climate of the region is tropical, with a dry winter (Aw), with rains concentrated in the summer, from November to April, and a dry winter, from May to October (IPEF, 2014). In the coldest month, the average temperature is above 18ºC,

and rainfall can reach 1800 mm per year (IPEF, 2014). The biome is Atlantic Forest, and the region is Semi-deciduous Seasonal Forest (Roderjan *et al.* , 2002).

Several reports describe the impacts on these communities when the Porto Primavera dam was built (Ferreira *et al.*, 2021). Firstly, the flooding of several lands caused many small producers and residents to lose their properties and, consequently, the main source of income for many residents (Arantes and Souza, 2021; Oliveira, 2004). These changes in the limnological ecosystem to this day presents noticeable changes in the fishing community.

The riverside community in the region is made up of approximately 150 inhabitants, who live on three islands in the Paraná River below the Porto Primavera hydroelectric dam: São Francisco Passifico Island, Criminosa Island and Moreira Island (Figure 1). Criminosa Island belongs to the municipality of Rosana, SP, and the other two to the municipality of Batayporã, MS. Access to the islands is only by boat. The location between two states makes it difficult to access public policies, since residents often study and vote in one state when they are from the other state. This ultimately means that neither state assumes responsibility for meeting the needs of these islands.

The islands are mainly inhabited by caretakers, who take care of houses that are occasionally visited by tourists, for sightseeing purposes and sport fishing. There are few residents, most of whom are fishermen, and they rely on tourism as an alternative to fishing for financial security to stay on the island, since fishing no longer seems sustainable. The lack of fish may be indifferent to the hydroelectric plant and those who profit from it, but this factor has impacted the fishermen in all areas of their lives.

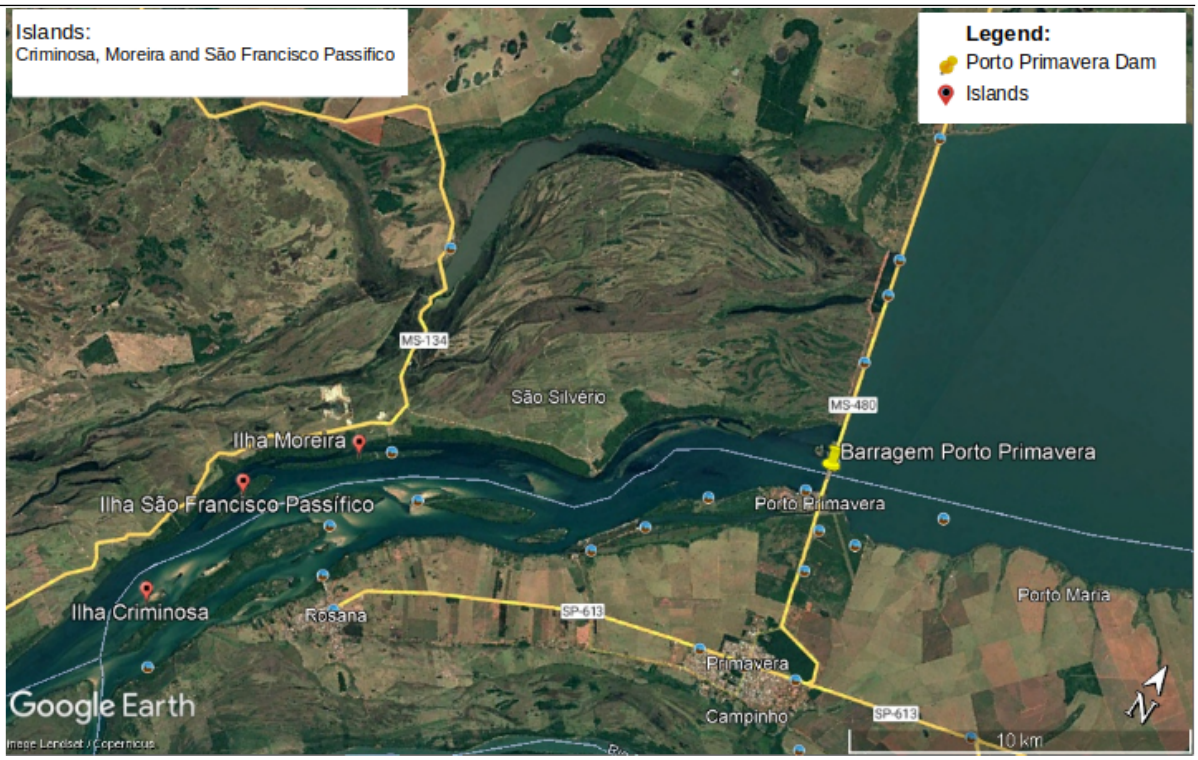

Figure 1. Location of the islands Moreira, Criminosa and São Francisco Passífico , in the Paraná River

Source: Google Earth (2023).

On the island of São Francisco Passifico there is a non-denominational church, founded just over 2 years ago by missionaries who moved to the island with the aim of serving the residents not only with their faith, but also to seek social justice and so improve their quality of life. The missionaries promote projects in bioconstruction, community tourism, agroforestry, distance learning, higher education scholarships, purchasing water filters for church members and their families, raising funds for the community, environmental education, and also providing emotional support and assistance with other difficulties that the residents face.

2.2. Methodology

The main challenge in the pursuit of sustainable community development lies in addressing complex problems that require an appropriate methodology. Thus MMST works by identifying factors, and their respective modalities, that describe the dynamics of community life. This study, in line with previous research, focuses on factors that affect the proper functioning of a community, with the aim of restoring health to the social organism as a whole.

2.2.1. Modalities

Figure 2 shows two axes; the vertical axis represents a hierarchy of modalities, while the horizontal axis encompasses the diversity of living systems. In this context, we identify four systems: social, animal, plant and environmental.

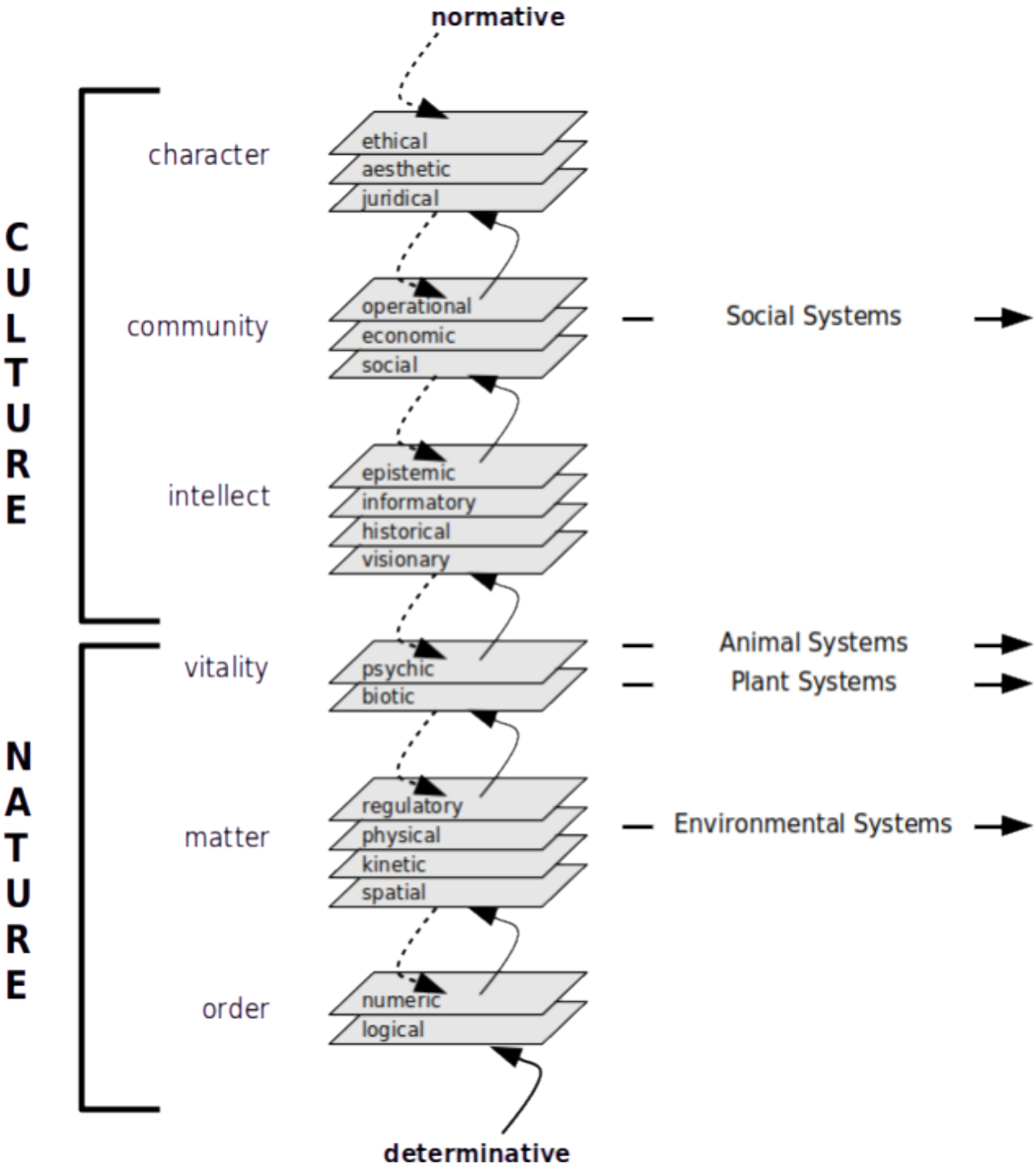

Figure 2. Modalities of human life.

Source: de Raadt (2023).

The aspects of community life that will be addressed in this work belong to specific areas of human life, organized according to the theory of modalities (Dooyeweerd, 2021).

As shown in Figure 2, these aspects, referred to in the methodology as factors, are visualized through modalities represented by parallelograms. These modalities are grouped into six categories, three of which (character, community and intellect) belong to culture, and the other three (vitality, matter and order) belong to the terrain or material. Each group has specific modalities to guide the analysis. The “community” group, for example, is composed of the operational, economic and social modalities.

The assignment of modalities to each of the identified factors provides normative guidance that will direct the researcher in the process of analysis and formulation of possible solutions to the problem. It also integrates a framework of scientific disciplines and their perspectives, to bring about an understanding of their factors and vulnerabilities.

2.2.2 Intermodal links

Addressing complex sustainability issues goes beyond simply identifying factors and modalities; systemic links must be created between them. MMST incorporates these systemic principles as a basis for identifying vulnerable factors in a community. This incorporation is visualized in Figure 2 through a systemic axis.

Intermodal links represent normative and determinative connections between modalities, organized in a sequence that goes from the logical modality to the most normative modalities.

The various modalities of community life are all connected, and each modality contributes to the community when it acts in accordance with its normal functioning. For example, a school, as a social system, fulfills its vocation by acting in accordance with the “epistemological” modality. Thus, because of its connections, a threat in any modality affects not only the system dedicated to it, but the entire community. When a factor, such as education, is threatened, the school and the entire community suffer in the “epistemic” modality.

In MMST, such interconnections between modalities is referred to as normative and determinative links. In Figure 2, these connections are represented by arrows that link the modalities. The initial set is determinative, indicating what occurs, and points upwards. The second set is normative, establishing what should happen, and points downwards.

2.3. Empirical method

To conduct the research in the riverside community of the Paraná River and apply MMST methodology, interviews were conducted with the community to collect more accurate and direct information. With this data it was possible to organize the information from the different people interviewed and assess the strengths and weaknesses of the community. This also allows us to identify the main factors that determine the viability of the community in the long term.

Interviews with residents were conducted from October 16th to 22nd, 2023; factors were identified; and inter-connections proposed through a literature review. The interviews were conducted as guided conversations, audio-recorded with the participants' consent, and later transcribed. Table 1 presents relevant data from the interviewees, with a total of 17 interviews conducted.

Table 1. Occupation of people from the riverside community interviewed

Interview No.	Occupation
1	Pastor of the local church
2	Housewife
3	Housewife
4	Homemaker and fisherman
5	Fisherman
6	Homemaker and fisherman
7	Fisherwoman
8	Homemaker and fisherman
9	Fisherman
10	Homemaker and fisherwoman
11	Local church missionary
12	Homemaker and fisherwoman
13	Homemaker
14	Island teenagers, students
15	Fishing couple
16	Homemaker and fisherwoman
17	Fisherman

The data was collected and loaded into a database using SmCube software, which has been especially designed for the empirical application of MMST. Two types of sources were distinguished: primary data, obtained by the researcher in interviews, and secondary data, extracted from the literature. The transcription of both sources was organized into items that report two or more factors.

I then selected the factors and overlaid the multimodal theoretical framework, as shown in Table 2. This table lists the modalities to which the factors belong and the disciplines that study them.

Table 2. Factors identified in the community and their modal aspects.

Factor	Modality	Discipline

Utilitarianism	Ethics	Ethics
Bureaucracy	Legal	Jurisprudence
Work	Operational	Administration
Economic Dependence	Economic	Economics
Social Structure	Social	Sociology
Education	Epistemic	Philosophy, pedagogy
Christian faith	Visionary	Historiology
Health and Environment	Biotic	Biology, medicine

The selected factors are: utilitarianism, which only addresses concerns of individual interests to the exclusion of the collective; bureaucracy, related to the installation of the dam as an enterprise of an industrial bureaucracy, and to the laws and impartial distribution of rights; work, which points to the vision of work as a vocation, and not only as a job and source of income for survival; economic dependence, which relates to the lack of financial independence and communities that are not self-sustainable but that depend on external financial aid; social structure, linked to the interpersonal relationships of the community, family structure and developing communities; education, which concerns training to perform a useful service to the community, an acceptable level of literacy, general knowledge, access to education and continuation of studies; christian faith, based on christian values and morals, the presence of the christian church on the island and the effects of its ideals; health and environment, which concerns access to health, quality of life, and also to nature, ecological balance, environmental impacts and environmental education.

After assigning all items which have been extracted from the empirical and literary data and assigned to their respective factors and modalities, a matrix was constructed using SmCube to analyze the relationships between the factors. Like the modalities, the factors are interrelated by links as shown in Figure 3.

Normative Factor	Arrow	Determinative Factor	Literature	Survey	Total
01 Utilitarianism	↔	03 Bureaucracy	3	5	8
01 Utilitarianism		05 Economic Dependence	0	2	2
01 Utilitarianism	→	07 Education	0	7	7
03 Bureaucracy	→	04 Work	2	16	18
03 Bureaucracy	↔	05 Economic Dependence	7	24	31
03 Bureaucracy		06 Social Structure	0	4	4
03 Bureaucracy	→	12 Health and Environment	17	19	36
04 Work	←	05 Economic Dependence	1	32	33
04 Work	⇔	07 Education	0	17	17
04 Work	←	12 Health and Environment	1	16	17
05 Economic Dependence	⇔	06 Social Structure	1	45	46
05 Economic Dependence	↔	12 Health and Environment	0	29	29
06 Social Structure		07 Education	0	3	3
06 Social Structure	⇐	10 Christian Faith	0	12	12
06 Social Structure	⇒	12 Health and Environment	0	26	26
07 Education	⇐	10 Christian Faith	0	9	9
10 Christian Faith		12 Health and Environment	0	1	1

Figure 3. Matrix of analyzed factors and their modalities generated by SmCube software

The matrix presents all possible pairs of factors and the number of items that link each pair of factors. The three columns on the left list all possible pairs of factors, starting with the relationship between "utilitarianism" and "bureaucracy" and continuing sequentially with the other factors finishing with the relationship between "christian faith" and "health and environment". The next two columns detail the number of items, both from the primary data collected through surveys and the secondary data from the literature, that link each pair of factors.

The last column lists the total number of items in both categories. These numbers indicate the degree of convergence between the respondents and the literature in considering each pair of factors. The arrows in the second column represent the links between the factors, where a blank arrow symbolizes a beneficial effect of one factor on another, while a bold arrow indicates an unfavorable effect.

Some factors have between them a two-way arrow, while others have just a one-way arrow. When the factors have a one-way arrow, it means that the first factor influences the second, but the second does not influence the first. But when we have factors with a two-way arrow, it means that both of them influence one another, and it can be positive or negative influences in for example, “utilitarianism” and “bureaucracy”, and “work” and “education”.

3. ANALYSIS

After careful analysis of the data, factors and their modalities were isolated and are represented in Figure 4.

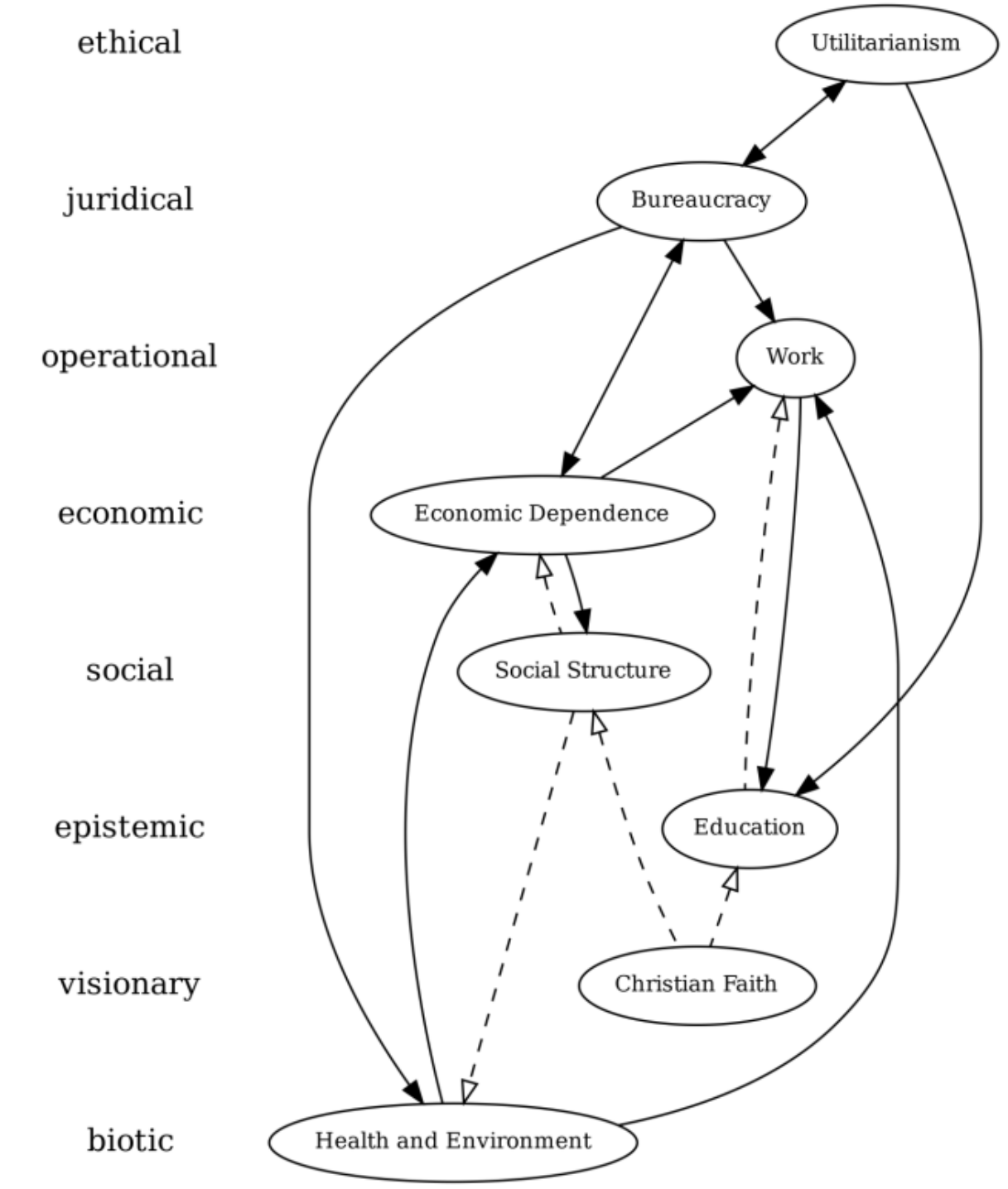

Figure 4. Multimodal Scheme of selected Factors and their Modalities generated from SmCube software.

3.1 The impacts of a utilitarian ethic

Utilitarianism 🔄 Bureaucracy (normative and determinative)

The construction of a hydroelectric dam on a river that supplies water to a riverside community can be understood as a bureaucratic undertaking, influenced by a utilitarian ethic. The lack of interest in the local community illustrates the prioritization of economic gains over the well-being of the population.

Unfortunately, bureaucracy, far from facilitating, often hinders the community's ability to achieve its goals; it hinders the direct participation of workers, churches and families in decisions that impact their surroundings. In this context, the construction of the dam reflects a utilitarian approach, prioritizing benefits to the general population to the detriment of local village needs. The implementation of this infrastructure neglects equity in the distribution of benefits, accentuating social and economic inequalities. The interviews highlight the unequal impact of bureaucracy on the lives of residents; among such impacts we include:

Injustices in Compensation: A village fisherman highlighted the inequality in compensation for the dam. He said there was a period when the hydroelectric plant compensated some fishermen, but most of those who received compensation were those least impacted by the changes in the river, and those who needed it most did not receive it. Utilitarian ethics fail to consider the real impact on the lives of residents, reflecting the lack of equity in the distribution of benefits.

Fernando Porfírio describes the moment when CESP was ordered to compensate fishermen for moral and material damages (Porfírio, undated). However, according to one fisherman, this compensation was distributed unequally, which ultimately did not solve the problem: “I have a compensation that has been going on for about 15 years, this CESP 'business', some received it and others did not. Those who had never fished in their lives received it, and the fisherman was left behind. There are people who don't even know how to fix a hook, and they received compensation, and that fisherman who has been on the island for many years received nothing.”

Challenges in the Intervention of Environmental Preservation Agencies: ICMBio (Instituto Chico Mendes de Biodiversidade) is a Brazilian special regime agency linked to the Ministry of the Environment; they work on the preservation of the Brazilian forests, through inspection of preserved areas. One of them is an area located on the São Francisco Passífico island. Right now, they have not approved sustainable tourism projects on the island and intend to remove the existing housing for tourists, claiming that the presence of tourists is degrading the environment. Permanent people are also feeling threatened. A housekeeper reports: “I don't intend to leave the island. ICMBio is working to remove the residents.” However, the houses are not large or very luxurious, and they attract more simple people and amateur fishermen. The solution to the problem would not be to destroy the houses, but to reuse them in a sustainable way that benefits the community.

The struggle between utilitarianism and environmental preservation is evident in ICMBio's attempt to control tourism, revealing the difficulty in reconciling utilitarian and environmental interests. Bureaucracy complicates the implementation of solutions to preserve the site.

Inequality in Access to Benefits: Bureaucracy creates obstacles for residents to obtain benefits. This is reflected in the fact that island residents need to go to the city to request what they are entitled to, such as medical care, a basic food basket, and even to request assistance during the “piracema” season when fishing is prohibited. Traveling along the river is expensive and often inaccessible, as it requires a full day of work. The need to go to the city to seek assistance highlights the lack of accessibility.

This convergence of utilitarianism and bureaucracy shows how administrative decisions directly affect the quality of life and future prospects of the community, highlighting the need for more equitable approaches that are sensitive to local realities.

Utilitarianism → Education (normative)

In the interplay between utilitarianism and education on the island of São Francisco Passífico, a challenging scenario emerges in which utilitarian ethics have transformed education into something disconnected from local needs. The removal of local schools and the reliance on boats to take children to school reveal the structural barriers that challenge access to education.

The search for knowledge is marked by logistical challenges and family displacement in search of educational opportunities. Families have been forced to move to provide education for their children; this highlights the effort they must make to overcome the limitations of the local system.

However, some young people are seeking higher education and specialization. This shows some hope that may overcome the problems they face, and the recognition for access to education that addresses local problems rather than being influenced by utilitarian ideas. One teenager who was interviewed said she wants to graduate from high school and begin studying administration at college. Another told about his dream to study gastronomy after high school. It is visible they are seeking not just work, but for a calling, a vocation.

3.2 Hydroelectric Dam (bureaucratic undertaking) and its Impacts on the Community

Bureaucracy → Work (normative)

In the interaction between bureaucracy and labor on the islands, the hydroelectric dam emerges as an enterprise in which bureaucratic standards prevail that are far removed from the needs of the riverside population. This model directly impacts the work and livelihood of

families in the community. The interviews highlight the direct impact on the local economy including dependence on tourism (daily rates for holiday homes) and the threat of greater restrictions on fishing (previously legalized species), which interfere with the viability of traditional activities.

Bureaucracy contributes to the need to seek outside employment or resort to illegal practices to secure a living, such as fishing during prohibited seasons or fishing for prohibited species. In this context, the construction of the dam makes it difficult to carry out meaningful and sustainable work for the local community and highlights the disconnect between bureaucracy and the real needs of the community.

Bureaucracy 🔄 Economic Dependence (normative and determinative)

The relationship between bureaucracy and economic dependence presents a feedback loop in the community studied. Initially, the implementation of a hydroelectric plant, a bureaucratic undertaking, resulted in economic dependence for local residents. Fishing was previously the main means of livelihood for the residents, and they were able to have a quality life and be economically independent. After the arrival of the hydroelectric plant and the change in the abundance of fish in the river, this financial independence was no longer a reality, and the fishermen needed to seek other sources of income, and even then they faced financial difficulties.

The restrictions imposed by ICMBio on the existence of guest houses and tourism prohibit residents from seeking alternative means of subsistence, such as community tourism, which is a sustainable alternative. This makes them economically dependent on the organizations that introduced this burden; they are dependent on aid, government benefits (when they receive them) and charity, among others.

The community's dependence on tourism is largely enabled by caretakers, which is the case for many residents, especially fishermen. The properties live somewhere else but still have their houses on the islands, that are used by tourists from the tourist fishing, and the caretakers are responsible for keeping the place organized and clean, receiving a monthly allowance that guarantees them housing, a steady salary and financial security. Some also have access to electricity and treated water, as the house they look after has these "privileges" that some other residents do not have.

If the option of tourism should be taken away from them, the holiday homes destroyed and they can no longer work in this sector, the impact on the community's economy will be much greater, causing the quality of life to decline, extreme poverty or an even greater rural exodus.

This dependence results in difficulties, such as a shortage of electricity, since only those with good financial means can access it through their own initiative. It also results in the

lack of fish (essential for food and subsistence), the lack of treated water, difficulties accessing health and education, and the limitation of other basic needs for a self-sustainable community. Bureaucracy, together with the lack of adequate public policies, contributes to economic vulnerability, which forces residents to resort to alternative strategies to ensure their subsistence, without facing legal challenges and compromising their quality of life.

Caneso *et al.* (2008) also came to similar conclusions. When he assessed, through questionnaires with residents, the impact of hydroelectric plants on the Paraná River villages, he found that the main problems were fish mortality, deforestation and the search for tourism as a supplementary source of income.

Bureaucracy → Health and Environment (regulatory)

The installation of the hydroelectric dam had significant impacts on the river's ecosystem. The flooding of an area of approximately 225 thousand hectares destroyed important ecosystems in Mato Grosso do Sul, floodplains with characteristics comparable to the Pantanal, which were home to endangered species such as the jaguar and the nhambu-guaçu (Costa *et al*, 2018). These data confirm what was mentioned in several interviews, which is the disappearance of several species that were previously common on the islands.

The installation of the dam also affected the water level, which consequently affected the variety and quantity of fish. In addition, the use of chemicals to combat the golden mussel impacted the ichthyofauna, which further increased environmental challenges. These changes resulted not only in a shortage of fish, but also in difficulties in crossing the river due to the low volume of water.

The initial purpose of the dam, as stated by journalist Rogério Mascia Silveira (2007), was to control flood and drought regimes, and thus contribute to society by avoiding water shortages during dry periods and floods during periods of heavy rain. However, according to the interviewees, these activities had more negative than positive effects.

The presence of the golden mussel, an invasive species in the Paraná River, has negatively impacted both the river's ecosystem and the hydroelectric plant's activities. The accelerated growth of this species, which becomes encrusted in the turbines, causes huge losses for energy generation. Therefore, some forms of control of this invasive species are carried out, including the use of chemical compounds that can contaminate the river and the fish (Gazeta do Povo, 2006). However, the death of the fish is not only related to these chemical compounds, since several studies point to the new hydroelectric plant facilities (Jusbrasil, 2008) and the flow regimes of the water contained in the dam as the main causes.

Furthermore, the dependence on state bureaucracy for health issues makes it harder to have local medical facilities and health agents present on the island who meet the specific needs of the community.

Work ← Economic Dependence (determinative)

The relationship between work and economic dependence in the community is highlighted in the interviews, revealing the transformation of work, once a vocation and service to the family and community, into employment to ensure survival. The need to seek sources of income, such as other temporary work on farms, highlights economic instability. Furthermore, the dependence on fish as the main source of income is a cause for concern, as the decline in the fish population in the river jeopardizes subsistence.

The community seeks alternatives, such as tourism, to supplement its income, but faces challenges imposed by environmental agencies (ICMBio). The search for financial independence is just and fair and the result of the hard work of the inhabitants, who face not only the challenges of nature, but also bureaucratic barriers that limit their subsistence options.

Work ⇦➔ Education (normative and determinative)

The dynamics between work and education in the community reveal a relationship permeated by challenges. Work, often transformed into paid employment, has become a necessity to ensure survival, diverting attention from the search for education. Economic dependence causes vocation and service to the community to give way to the immediate need for subsistence wages.

However, some residents seek to redefine education as an agent of transformation; they aim to train themselves for local professions and so reconcile the practical demands of work and education to promote autonomy and sustainability in the community. This is highlighted by the missionary: “Because the idea is also for them to seek courses that they can apply there”. These efforts, however, face resistance from a utilitarian mentality that devalues education in comparison to work. The crucial challenge lies in reconciling these spheres, recognizing the importance of both in building a sustainable future for the community.

Economic Dependence ⇦➔ Social Structure (normative and determinative)

Based on the data provided about the relationship between Economic Dependence and Social Structure, it can be observed that economic dependence has a negative impact on social structure, resulting in a considerable rural exodus. The desire to seek employment and livelihood opportunities in urban centers is evidenced by testimonies that highlight the departure of children to study and work in distant cities. This migratory flow, predominantly among the youngest, results not only in a geographical change, but also in transforming the community into an elderly community. This compromises the prospects for a productive and active future for the community.

On the other hand, social structure plays a beneficial role in mitigating economic dependence. Community unity is evident in the way residents help each other and minimizes economic dependence in different ways by building houses, sharing resources and growing food for their own consumption.

3.3 Health and Environment: A fundamental factor for the local community

Work ← Health and Environment (determinative)

The relationship between Work, Health and Environment highlights the complex interconnection of these factors in the lives of the islanders. Fishing, which is crucial for subsistence, is facing challenges due to changes in the river ecosystem. The abundance of fish that once sustained communities is now limited to a short period of two months after the opening of fishing. As one fisherman reported: “The income is only good at the beginning, when the fishing opens. Then after about two months it starts to decrease, and right now (October) there is nothing.”

The drastic decrease in water volume downstream, associated with dam activities, results in a shortage of fish (Pamplona, 2021; Lopes *et al.*, 2021). Faced with this challenging scenario, many islanders seek to diversify their sources of income, engaging in activities such as raising chickens and producing food. However, they must face restrictions imposed by ICMBio in regard to tourism, and this prohibits the search for alternative sources of livelihood. Fishing, which previously provided financial stability, faces a crisis that interferes with the subsistence and quality of life of the island's inhabitants.

Economic Dependence ← Health and Environment (determinative)

The relationship between economic dependence, the environment and health on the islands reveals a cycle that negatively impacts the lives of residents. Dependence on fishing, once a source of livelihood in the region, has become a growing challenge due to environmental degradation.

The absence of fish in the river, a constant reality according to residents, not only compromises the community's financial income, but also leads to a search for alternative sources of income, such as daily wages in other activities, as a way of adapting to this crisis.

The environmental impact of industrialization resulting in water pollution and the introduction of harmful substances, directly contributes to the deterioration of the river ecosystem. Reports of contaminated water and changes in aquatic fauna point to a constant threat to the health of islanders, who are sometimes forced to seek water from outside the community to avoid health problems.

The difficulty in accessing emergency medical care due to the unfavorable river crossing conditions reveals another facet of this problem. The health of residents is compromised not only by the lack of medical resources, but also by the challenging logistics of obtaining care. The scarcity of financial resources, exacerbated by the fishing crisis, becomes an additional obstacle to accessing adequate health care.

Economic dependence on local activities such as fishing creates a vicious cycle where environmental degradation harms the economy, and the weakened economy prevents investment in sustainable practices or in improving local health and infrastructure. This scenario highlights the urgent need for integrated measures that address environmental, economic and health issues.

Social Structure ⇨ Health and Environment (normative)

The interconnection between social structure and environmental health is a crucial factor in the lives of the islanders, resulting in a beneficial relationship. The residents' concern for preserving the environment around them is evident in their daily actions and in the way they interact with nature.

Harmony with Local Fauna: The community expresses a remarkable commitment to local fauna, fostering an environment where native animals such as agoutis (small rodents) and lizards (reptiles) coexist peacefully. This harmony reflects not only respect for biodiversity, but also the satisfaction of the inhabitants in witnessing the return of previously absent species.

Reforestation and Vegetation Succession: The arrival of the inhabitants to the island marked a chapter in reforestation, transforming areas previously dominated by deforested fields into vibrant green spaces. The community not only planted trees, but also dedicated itself to preserving the vegetation, resulting in a significant improvement in environmental quality.

Sustainable Permaculture Methods: Church leadership has adopted innovative practices, such as permaculture, to address environmental challenges.

Quality of Life and Environment: The movement of some people from large cities to the island has resulted not only in an improvement in the quality of life, but also in health benefits. The daily connection with nature, the fresh air and the absence of urban stress are factors that have contributed to improvements in the physical and mental health of residents.

Environmental and Legal Awareness: The islanders demonstrate a clear understanding of environmental laws, recognizing the importance of preserving the riverbank as a protected area. Furthermore, the suggestion of prohibiting fishing of certain species highlights the commitment to conserving natural resources.

Impact on the Local Economy: Diversification of crops, including fruits and crops specifically for wildlife, not only contributes to local food security, but also attracts visitors from the city looking for more affordable and natural products.

Reflections on Sustainable Development: The transformation of the islands, driven by the arrival of the village community, is also an example of sustainable development. The cooperation between the social structure and environmental awareness highlights the promising alliance between society and the environment.

These testimonies of island life not only describe a deep connection between social structure and environmental health, but also highlight the active role of the community in promoting sustainable practices.

3.4 Beneficial links under threat

In addition to the links presented below, the beneficial links for community life also include the impacts exerted by “Education” on “Work”, by “Social Structure” on “Economic Dependence” and by “Social Structure” on “Health and the Environment ”, as presented in the previous paragraphs.

Social Structure ⇦ Christian Faith (determinative)

In the island community, the presence of the Christian faith is revealed as a force shaping the social and community structure. The interviews show that the faith in the lives of the islanders is a dynamic that influences daily life.

In this context, Christian faith is not restricted to worship and religious ceremonies; it manifests itself in practical and concrete ways in the provision of essential services to the community. The construction of septic tanks, mentioned in interviews, exemplifies how the church, through its practical actions, not only strengthens social obligations, but also acts as a transformative force in solving problems faced by the islanders.

The building of bonds, identification of specific needs and interventions in challenging times can be observed in the work of the church on the island. In this way, the Christian faith on the island permeates and directly influences the social structure of families and communities. The church not only strengthens community cohesion, but also responds to the practical needs of the population.

Education ⇦ Christian Faith (determinative)

The relationship between Education and Christian Faith on the island is notable for the active pursuit of educational opportunities, especially through the local church. In addition to providing access to higher education, they seek to apply this knowledge in the community itself, avoiding the need to migrate to urban areas. The intention is clear: when seeking academic training, young people are encouraged to choose courses that can be directly applied on the island such as Agronomy, Pedagogy, Bachelor of Arts in Language, Medicine and Bachelor of

Law, among others. In this context, Education and Christian Faith intertwine as catalysts for integral growth, highlighting the search for education that benefits the community.

Due to the strong detrimental influences faced by the factors that give rise to beneficial bonds, these relationships are now under significant threat.

4. FINAL CONSIDERATIONS

This study enabled the creation of a multimodal systemic model that portrays the dynamics of life in the riverside community of the Paraná River, highlighting the relevance of incorporating factors related to the biotic modality to sustain social viability.

Through the analysis of intermodal links, it was found that the biotic modality, related to the Health and Environmental factor, maintains direct and indirect connections with the other modalities of the community. In this context, it has been observed that this factor is negatively impacted by bureaucracy and it is influenced by utilitarian ethics, and by large enterprises, which generate various impacts on local ecosystems. Consequently, these environmental disturbances have a negative impact on the work and economy of the community, also shaking social structure and education, and interfering with the health of local development.

On the other hand, the Christian faith plays a positive role in this system, exerting a direct influence on education and social structure. These aspects, in turn, have a positive impact on work, the economy and the environment. However, due to the predominance of harmful links, which strengthen feedbacks, the beneficial impact is still fragile and subject to great threats.

The conclusion reached is that restoring the normality of the biotic environment could contribute significantly to resolving the adversities faced by the community. However, this restoration is intrinsically linked to the sustainable functioning of the other factors that affect local sustainability.

The application of MMST, however, is not limited to carrying out an analysis by identifying factors and their links; this stage is only the beginning for the method to be implemented and generate significant changes in the community in question. Thus, this project will be continued in a second stage that will involve the search for a model of action in the community, so that the negative impacts between the factors can be reduced and the positive impacts accentuated.

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