Social Cartography as a path to transdisciplinarity within the socio-environmental aspects of the NEXUS+ approach: a case study in the Jacaré-Curituba Settlement, Brazil

A Cartografia Social como caminho para a transdisciplinaridade dentro do aspecto socioambiental da abordagem NEXUS+: um estudo de caso no Assentamento Jacaré-Curituba, Brasil

Nelson Bernal Davalos [1]

Elton S. Oliveira [2]

Roseli Santos [3]

Guadalupe Satyr [4]

Wesly Jean [5]

Paula Rodrigues Alves Brown [6]

Juliana Dalboni [7]

Daniela Nogueira [8]

[1] *PhD in Sustainable Development, Researcher, INCT-Odisseia project, Center for Sustainable Development, UnB, Brasília, DF, Brazil*
E-mail: neleduberdav@gmail.com

[2] *PhD in Applied Geosciences, Researcher, INCT-Odisseia project, Professor, Center for Humanities, Federal University of Western Bahia, Barreiras, BA, Brazil*
E-mail: cesoliveira@ufob.edu.br

[3] *Administrative technician, Community researcher, INCT-Odisseia project, Tiradentes University, Nossa Senhora da Glória, SE, Brazil*
E-mail: ros.ely2010@hotmail.com

[4] *PhD in Sustainable Development, Researcher, INCT-Odisseia project, Center for Sustainable Development, UnB, Brasília, DF, Brazil*
E-mail: guadalupesatiro@gmail.com

[5] *PhD in Mechanical Sciences, Researcher, INCT-Odisseia project, Center for Sustainable Development, UnB, Brasília, DF, Brazil*
E-mail: weslyjean999@gmail.com

[6] Specialist in Agroecology, Researcher, INCT-Odisseia project,
Center for Sustainable Development, UnB, Brasília, DF, Brazil
E-mail: pacastanho@gmail.com

[7] PhD in Sustainable Development, Researcher, INCT-Odisseia project,
Center for Sustainable Development, UnB, Brasília, DF, Brazil
E-mail: juliana.rocha@unb.br

[8] PhD in Sociology, Coordinator, Semiarid Project, INCT-Odisseia,
Center for Sustainable Development, UnB, Brasília, DF, Brazil
E-mail: danielanogueiracds@gmail.com

doi:10.18472/SustDeb.v15n3.2024.53909

Received: 14/05/2024
Accepted: 12/12/2024

ARTICLE-VARIA

ABSTRACT

This article presents the results of the implementation of a “social cartography” in the INCT-Odisseia research project, in the study area of the Jacaré-Curituba agrarian reform settlement, located in the interior of the State of Sergipe, Brazil. The incorporation of social cartography as a methodological instrument in the research allowed the identification of attributes in the study area, organised using two approaches: “Analytic Hierarchy Process" (AHP) and Nexus+ (food, water, energy and socio-ecological security). Through these, it was possible to delimit the study area into agro-villages and identify more than 720 attributes or reference points, ranging from human activities to local infrastructure. The attributes were identified through action research techniques, participatory observation and collaborative research, using geographic information applications and satellite images. It was possible to generate relevant information about the study area in terms of potential, infrastructure, crops, and production, in addition to generating maps of the vulnerability situation linked to Nexus+ security (energy and water), which should be replicated since it allows highlighting the social, economic, environmental and infrastructure characteristics of a given area.

Keywords: Social Cartography; Analytic Hierarchy Process; Jacaré-Curituba Settlement; NEXUS+; Climate change; Social vulnerability.

RESUMO

Neste artigo apresentam-se resultados da implementação de uma “cartografia social” no projeto de pesquisa INCT-Odisseia, cuja área de estudo é o assentamento de reforma agrária Jacaré-Curituba, localizado no interior do estado de Sergipe, Brasil. A incorporação da cartografia social como instrumento metodológico na pesquisa permitiu identificar atributos na área de estudo, organizados mediante duas abordagens: “Analytic Hierarchy Process" (AHP) e Nexus+ (segurança alimentar, hídrica, energética e socioecológica). Por meio dessas abordagens, foi possível delimitar a área de estudo em agrovilas e identificar mais de 720 atributos ou pontos de referência, que vão desde atividades antrópicas à infraestrutura local. A identificação dos atributos foi realizada mediante técnicas de investigação-ação, observação participativa e pesquisa colaborativa, usando aplicativos de informação geográfica e imagens de satélite. Foi possível gerar informações relevantes da área de estudo em função das potencialidades, infraestrutura, culturas, produção, além de gerar mapas da situação de vulnerabilidade vinculadas às seguranças do Nexus+ (energética e hídrica), recomendando ser replicado, já que permite evidenciar as características sociais, econômicas, ambientais e de infraestrutura de uma determinada área.

Palavras-chave: *Cartografia Social. Processo de Hierarquia Analítica. Assentamento Jacaré-Curituba. NEXO+. Mudanças Climáticas. Vulnerabilidade Social.*

1 INTRODUCTION

Since 1990, several mapping initiatives have emerged proposing to involve local populations in the map production processes. Due to the diversity of approaches, purposes, interpretation and connection with the population involved, mapping initiatives vary considerably in their methodologies and terminologies (Acselrad *et al*., 2008; Chapin *et al*., 2005).

According to Herlihi and Knapp (2003), participatory mapping is the process by which the spatial and environmental knowledge of local populations is recognised and inserted into more conventional models of knowledge. Representations of the territory thus begin to outline the real exposure of an area, showing its characteristics and describing or defining it and, symbolically, establishing or possessing it (Bargas; Cardoso, 2015).

Also recognised by some authors as a social cartography methodology, participatory mapping is a form of collective knowledge construction; it represents the encounter with others to be able to approach the territory based on the experience of residents and the space they live in, allowing the creation of maps full of stories, feelings, governance and social relations of everyday life (Diez, 2018). This technique has been consolidated over the last few years as an instrument for fighting socio-environmental issues, through the recognition and construction of knowledge of territories, and is increasingly used by local populations and traditional communities (Diez, 2018; Jean *et al*., 2021).

This is why this technique was implemented in the INCT-Odisseia Sitio Catinga project. This project, which stands for National Institute of Science and Technology (INCT) - Observatory of Socio-Environmental Dynamics (Odisseia), see https://odisseia.unb.br/, seeks to understand how socio-environmental dynamics occur in the different biomes of Brazil, analyzing the complexities inherent in the access and distribution of natural resources in socio-environmental systems. It prioritises the most vulnerable populations, in rural and urban areas, in three Brazilian biomes: Amazon, Cerrado and Caatinga. As a theoretical-analytical tool, it uses the Nexus+ approach (Araújo *et al*., 2019), which enables the understanding of the vulnerabilities and adaptive capacities of socio-environmental systems, through integrated analyses of Security: Food, Water, Energy and Socio-Environmental.

The first element observed for the implementation of this methodological technique within the project was the diversity of information and data that participatory, social, ethnic or cartographic mapping makes it possible to obtain, recovering key information from the study area to understand more precisely aspects of the territory, its natural resources, in addition to existing social and environmental conflicts. In addition, it allows us to understand the social and environmental dynamics of the AJC based on the perception of local actors and residents, in terms of issues related to land, water, food, energy and the environment.

Therefore, the main objective of this article is to show the scientific community the advantages of applying social cartography, as well as the procedures incorporated and the results achieved in a project with a strongly socio-environmental and transdisciplinary approach; understanding that maps are cartographic products resulting from an abstraction of the real world, elaborated by a series of people from some point of view, objective or by simple self-belonging to the place.

2 PARTICIPATORY MAPPING AND SOCIAL CARTOGRAPHY

Over time, there has been a major movement in social cartography worldwide, in South America and Central America. Countries such as Brazil, Colombia, Ecuador and Mexico have stood out in the

process of consolidating this methodology, as they have important professionals who have contributed significantly to the cartographic process.

Different nomenclatures of social cartography have been established to date, however, they can be grouped into two large sets: 1) Nomenclatures used in the North; and 2) Nomenclatures used in South America and the rest of the world.

In the first case, the most frequently used nomenclatures are: traditional land use study, land use and traditional knowledge studies, land occupation and use studies, aboriginal land occupation and use studies, subsistence mapping and resource use mapping (Diez, 2018; Jean *et al*., 2021). In the second case, some authors indicate that the following terminologies prevail: participatory mapping, participatory land use mapping, participatory natural resource mapping, community mapping, mapping of localised communities, ethnocartography, self-demarcation and delimitation of the ancestral domain (Chapin, 2005).

According to Acselrad and Coli (2008), these terminologies are associated with the various territorial, land, armed conflict, ethnic and political contexts from which various mapping initiatives were carried out. Until 2005, for example, ethnocartography sought to highlight problems not addressed by common methodological techniques, since in some cases this was linked to responding to needs, mimicking power relations. For this reason, cartography was not known within the scope of the Society and little discussed within the Brazilian Cartography Society, being discussed only among indigenous peoples, anthropologists and environmentalists.

According to Chapin, Lamb and Threlkeld (2005), participatory mapping in Brazil emerged in the 1990s, but incipiently, and only in 2001 did it adopt a more technical character. In these experiences, mapping also acquired different terminologies, including: ethnoecological surveys, ethnoenvironmental mapping of indigenous peoples, mapping of traditional uses of natural resources and forms of occupation of the territory, participatory community mapping, cultural mapping, participatory macrozoning, ethnozoning, ethnomapping, ethnoenvironmental diagnosis, social cartography, among others. For Corrêa (2007), these variations in the terms used reflect the different methodological strategies used.

In essence, participatory mapping promotes the spatial and environmental recognition of local populations by promoting the insertion of conventional knowledge models. It is claimed that its methodological roots are linked to participatory observation techniques and research methodologies. In this sense, participatory research methods combined with geotechnology, Geographic Information Systems (GIS) and remote sensing were adopted to produce maps, generating a new horizon for the production and use of such spatial representation instruments (Herlihi, 2003).

This participatory mapping directly involves community members in collecting data on land use and the boundaries of their domains. The technologies used vary according to the projects implemented; however, the notion of participatory mapping arises from marginalised communities and social groups, allowing the identification of references and key points within a given territory (Acselrad, 2008). In the participatory mapping process, some initiatives focus their attention on identifying activities linked to economic production, ecological-economic zoning, planning, territorial planning, conflict and risk; incorporating actors and sectors of society in planning actions and in the local decision-making process (Ataide, 2011; Dalton, 2018).

Social cartography incorporates new elements of cartographic practices. In this process, the construction of maps is carried out considering the various fields of possibilities existing in the studied locations, resulting from a relationship between researchers and social agents, in which cartographic practice is questioned and legitimised by academia (Santos, 2016; Silva, 2018). In this sense, it is worth rethinking the incorporation of these new elements into the collection of information and the process of consolidating social cartography, since this process involves researchers from different backgrounds

and has, as a fundamental element, the participation of social agents during the elaboration of maps or representations of territories, in which participatory research methods combined with geotechnologies, art, drawing, among others, enable the delimitation, description and representation of areas (Santos, 2016; Silva, 2018).

In the process of social cartography, not only the uses of mapping results are problematised, in which territorial appropriation is highlighted, but also the ethical stance of researchers regarding the traditional knowledge of the populations studied (Vaian, 2008). Almeida (2013) states that the process of creating maps under this approach is considered a methodological procedure and not a methodology (Santos, 2016).

In Brazil, social cartography has gained visibility mainly in the Amazon, being used as an instrument of struggle by traditional forest communities (Acselrad, 2008; Jean, 2021) and enabling the spatialisation of various attributes present in the territory, listing existing conflicts and showing the local reality. According to Mendes (2005), this process has contributed significantly to the social, political and territorial struggle of these communities, making its implementation quite useful.

Authors from South America, specifically from Ecuador, Colombia and Brazil, have recently incorporated new types of representation into this technique, which are very important for the current debate. Authors such as Alfredo Wagner, Mike McCall, or working groups such as ESTEPA from Colombia; Geobrujas and Unam-Ciga from Mexico, Geografia Crítica from Ecuador and Costa Rica, among others, indicate that other ways of representing territory exist and that they need to be considered within social cartography to move away from the two-dimensionality of cartography.

According to McCall and Barragan (2023), for example, it is indicated that cartographic creation goes beyond common maps, with bodily representations (Barnsley, 2006), or spatial representations, such as the dance, for example, of the Australian aborigines, or recreations of space through hairstyles, as can be seen in images from the National Museum of Bogotá where images of women from the black community are presented. On the other hand, it is indicated that the introduction of a three-dimensional talking ceramic artefact, for example, narrates the perspective of the territory in a particular way, making it possible to share a process of co-creation, a multiplicity of emotions, feelings and thoughts that often come to the surface through a warm and passive silence, accompanied by the modelling of clay and the rhythm of resonant drums.

Ancestral sounds that evoke memories and feelings, and call for introspection from participants, generating poetic and reflective spaces that increasingly bring us closer to the narratives of the territorialities experienced by each of the participants (Escobar, 2014; Hurtado, 2013). Therefore, we consider it essential to address these new techniques within socio-environmental research, since in essence, we enter into a dialogue of physical-cultural representation, interconnected with the local environment.

In Brazil, the New Social Cartography of the Amazon Project (PNCSA) is a national and international reference for the application of this technique. The project aims to provide an opportunity for self-cartography by traditional peoples and communities in the Amazon. Through the material produced, it seeks to aggregate greater knowledge about the process of occupation of this region, and above all, to provide greater emphasis and a new instrument for strengthening the social movements that exist there.

It is indicated that such social movements consist of manifestations of collective identities, referring to peculiar and territorialised social situations (Lima, 2018). Territorialities are socially constructed by the various social agents. Here, cartography appears as an element of combat and the PNCSA seeks to materialise the manifestation of the self-cartography of peoples and communities through the use of some tools. Teaching GPS and mapping techniques, in addition to talking to the agents and collecting testimonies about the social history and problems of the community, the social agents produce sketches, mapping their region and indicating which elements are relevant to its composition.

These illustrations comprise drawings, sketches and reproductions of symbols and objects (cars, houses, boats, work tools, animals, plants, etc.) that are transformed, based on the work of the team of researchers and the community, into icons to compose the map legends.

3 STUDY AREA AND METHOD

In the Caatinga biome, there is the settlement "Jacaré Curituba" (AJC), located between the municipalities of Canindé do São Francisco and Poço Redondo in the State of Sergipe (See Figure 1). Within the scope of INCT Odisseia, this region is called Sítio São Francisco. According to Codevasf (2018), until that year, more than 800 families lived in AJC. The choice to work in this area was due to different factors, among them: because it is considered one of the largest settlements in South America, for its socioeconomic and productive dynamics, as well as its environmental characteristics.

The application of social cartography began with the establishment of action research techniques, participatory observation and collaborative research, which together allowed the co-construction of knowledge. The linking of social actors to the co-construction process occurred through the incorporation of three community researchers into the project – understood as social agents and legitimate holders of local knowledge – allowing the collection of primary data and validation of secondary data.

Initially, a review of geospatial data was carried out using satellite images (Cbers 4A, WPM Camera - PAN with a spatial resolution of 2 meters) and maps provided by different public and private entities. At the same time, an approach to the local population was promoted through conversations, seeking to understand the studied area.

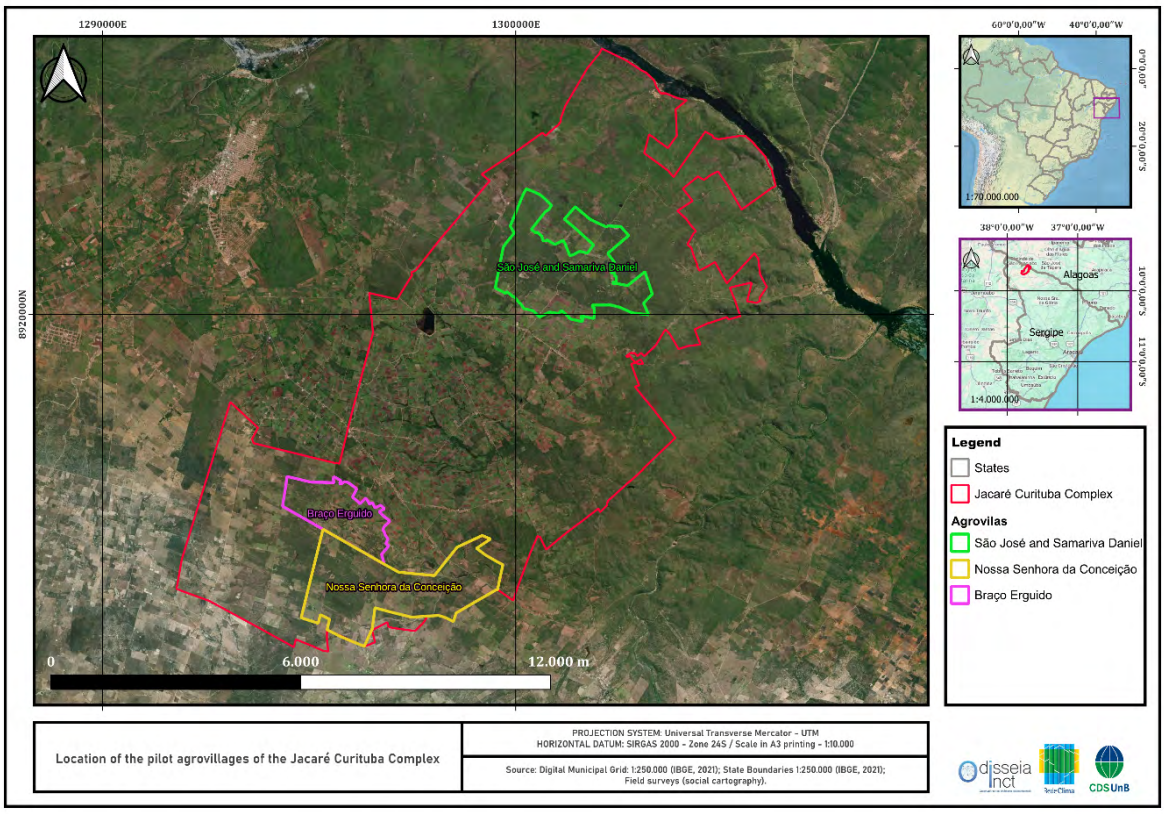

Figure 1 – Map of the settlement with the agro-villages identified

Source: Authors.

Subsequently, using the Tracklia application, which allows mapping to be developed through a webmap system, the delimitation of the four pilot areas of the study area was promoted, these being the agro-villages: São José, Braço Erguido, Samariva Daniel and Nossa Senhora da Conceição (See Figure 1). Once this was done, several attributes present in the territory were identified, which were established through a point survey guide, based on the aforementioned safety features of the Nexus+ approach (See Table 1).

Table 1 – Attributes to be identified in the settlement and pilot areas

Points Identified in relation to the NEXUS+ approach				
Socioecological/land	***Water***	***To feed***	***Energy***	***Socioecological***
Settlement and Agrovillage boundaries	Water supply network	Family farms	Local electrical network	Living areas
Lot dimensions	Sewage network	Production areas	Renewable energy sources	Degraded areas
Identification of agro-villages and boundaries	Irrigated or irrigated area	Types of production by area	Power distribution plants	Meeting locations
Delimitation of agro-village areas	Areas at risk of contamination in rivers, reservoirs, etc.	Fishing Areas	Public lighting	Areas at risk due to the use of pesticides
Dryland areas	Areas of conflict over the use of water for irrigation	Agroecological production	Sub-power distribution plants	Areas of conflict due to the use of pesticides
Irrigation areas	Water supply points	Livestock raising areas and animal identification	Energy transformers in agrovillages	Areas contaminated by organic and solid waste
Invasions	Location of water pumps		Power transformers in pump houses	Conservation area
Land conflict	Reservoirs, water cisterns, tanks, others.			Family recreation
Irregular Lots	Wells			
	Rivers			Conventions or socialisation
	Springs			Areas of water contamination
				Extractivism

Source: Prepared by the authors.

The implementation of social cartography in the project went through five stages: 1) Analysis of secondary data from the study area; 2) Identification of the application, training and preparation of the cartographic guide; 3) Delimitation of the agro-villages and identification of the attributes of the study area; 4) Spatialisation of information; 5) Validation of data in the field and feedback.

Stage five (5), data validation and feedback, was the most important, since the local population, with the support of researchers from Brasília and also local researchers, verified and validated the attributes identified in the settlement, adjusting the location and including information (see Figure 2). This stage was proposed to guarantee the quality of the data and establish the co-construction of knowledge, jointly providing an overview of the settlement close to the current reality.

To this end, four participatory workshops were organised in the study area, where maps corresponding to each agro-village (4) were presented, plus one for the settlement (1). At the time, the participation of rural workers, peasants, traders, housewives, individual community entrepreneurs, local technicians, members of associations and educational centres and support entities or cooperatives was encouraged, which together made it possible to establish a comprehensive understanding of the local social and environmental problems, as well as identify possible suggested alternative solutions. In total, 57 people participated in the different workshops held and attended in response to an invitation extended to each of the families in the agro-villages studied. It is worth mentioning that to comply with the ethical considerations of the research, for all activities carried out, including recording speeches, images and social dynamics, terms of authorisation for the use of information and images were signed by each participant.

Figure 2 – Workshops for validating information on social cartography

Source: Authors (March 2021).

The workshops, as mentioned, made it possible to validate the mapping and add new elements to the data collected through a new participatory process, reaching the record of 720 pieces of information, which, due to their characteristics and robustness, required organisation and consideration.

These were organised by class, facilitating a hierarchy based on environmental, natural resources, infrastructure, physical and productive aspects. Additionally, the distribution of the dwellings was mapped based on 10 criteria, to understand the situation of each one in relation to occupation (See Table 2). The choice of criteria was the result of co-construction since their definition was consolidated together with the residents and community researchers.

Table 2 – Main attributes identified by social mapping

Class 1	Class 2	Class 3	Amount of points
Rural anthropology	Rural residence	Lot Residence / Association Lot / Residence	28
	Rural lot	Dryland or irrigated lot	17
	Fishing	Handmade	2
	Agrovilla	Name of the agrovillage	11
	Conflicts	Invasion	1
	Social spaces	Church / Football field / Football pitch / Meeting hall / Community centre / Office / Meeting name / Meeting points	30
	Business	Services (tyre shop and bars)	11
	Infrastructure	School / Roads / Silage / Pumping house / Cooling tank / Health post / Power substation / Milking / Wind energy / Solar energy / Factory / Confinement / Milk collection	96
Non-agricultural anthropogenic	Degraded areas	Garbage / Sewage / Burning / Salinisation / Deforestation	30
	Mining Area		0
Agricultural anthropology	Temporary culture	"Vegetables, Okra, Corn, Beans, Sorghum, Passion fruit, Cassava, String beans, Pepper, Cassava, Sweet potato, Watermelon, Allspice, Passion fruit, Pumpkin."	147
	Permanent culture	Acerola, Acerola and grass, Banana, Banana tree, Cashew, Coconut tree, Guava, Orange, Lemon, Cassava, Mango, Passion fruit, Corn, Palm, Okra, Tomato, Grape.	161
	Pasture	Cattle and sheep / Dryland plot / Pasture plot	18
	Fish farming	Breeding tanks / No fish at the time of the survey	2
	Plowed land	Farm in preparation	1
	Livestock	Creation name	48
Water	Water mass	Dam / Weir	15
	watercourse	Stream	15
	Wet area	flooded area	4
	Infrastructure	Cistern / Water tank / Well / Water collection	37

Source:Authors.

Table 3 – Main attributes identified by social mapping

Criterion	Situation	Description
A	Closed house	The house has no occupants, but neighbours report that the family lives on the Lot.
B	Rented	The house is rented to relatives, people from the settlement or from outside.
C	Own RB	The house is occupied by first-generation beneficiaries.
D	Granted	The House was left to a family member or friend who is not in an RB situation.
E	Borrowed	House borrowed to live in.
F	Take care	House left in someone's care in exchange for maintenance and feeding of animals.

Criterion	Situation	Description
G	Occupied by the son of a settler	House inherited by beneficiaries from first-degree relatives
H	In court	House in litigation process
I	With a resident who only has a house in the agrovillage	House with a resident who only lives there and does not have a lot.
J	Others	Describe

Source:Authors.

In parallel and under the umbrella of the Nexus+ approach, we incorporated the Analytic method into social cartography. Hierarchy Process (AHP).

The AHP method, proposed by Saaty (1991), is efficient in analyzing landscape elements taking into account the influence that each variable has on the phenomena to be analyzed (Miara; Oka-Fiori, 2007). Thus, AHP allows us to understand the problem in an organised and hierarchical way (Marins *et al*., 2009). However, its structuring and attribution of weights for the variables used depends on the understanding and comparison between them, thus forming a relationship matrix.

This definition of priorities is based on the researcher's ability to perceive the phenomenon and the situations observed (Marins *et al*., 2009). In this sense, Saaty (1991) proposed the scale shown in Table 4, with values ranging from 1 to 9, where 1 indicates that the elements are of equal importance and 9 represents extreme importance of one element over the other, with intermediate values between them.

Table 4 – Parameter definition using AHP

Intensity	Definition	Explanation
1	Same importance	Two elements contribute equally to the objective.
3	Little importance of one over the other	Experience and judgment slightly favour one activity over the other.
5	Great or essential importance	Experience and judgment strongly favour one activity over another.
7	Very great or demonstrated importance	One activity is strongly favored over the other and its dominance is demonstrated in practice.
9	Absolute importance	The evidence in favour of one element over another is of the highest order of affirmation.
2, 4, 6, 8	Intermediate values between adjacent values	When looking for a compromise condition between two definitions.

Source:Saaty (1991).

From this, priority parameters are defined in the study and the cumulative weights associated with each one to determine the relative importance of each alternative in terms of each criterion.

4 RESULTS AND DISCUSSION

Field researchers used Tracklia to identify 720 attributes in the settlement (see Table 2). These include specific areas in agrovillages and lots, as well as local infrastructure, such as housing, production, access to natural resources and basic services, commerce and recreation.

Spatialising the information observed in the four agro-villages, it is observed that there are a total of 173 houses, distributed as follows: São José 27; Samariva Daniel 37; Braço Erguido 70 and Nossa Senhora da Conceição 39. Regarding the situation of each one, this differs by agro-village, showing an interesting dynamic in relation to occupation, transfer, presence of owners and leasing, mainly in Samariva Daniel and Nossa Senhora da Conceição.

Once all the attributes in the settlement and agro-village were identified, they were spatialised and plotted on a map (See Figure 3). As can be seen, there is a greater concentration of activities and infrastructure in the centre of the settlement, an area that in fact concentrates the largest number of homes, productive lots and local activities. One of the most important aspects identified was the distribution of productive activities in the area, which, linked to the perimeter, whether irrigated or dryland, shaped the size of the lots, animal breeding and production of derivatives, as well as the concentration of infrastructure for basic services and water supply.

Other data of interest that were possible to obtain and describe on the map were: reserve areas, irrigated areas, burning areas, productive areas, local practices, socialisation areas, as well as problems in the study area, including: soil salinity, problems for production and trade, conflict over the use of pesticides and water use, and poor water quality and supply. Regarding salinisation, a significant number of affected areas were observed at the settlement level, including some of the agro-villages studied, Samariva Daniel, São José and Nossa Senhora da Conceição. Regarding the problem of marketing, collection points for dairy and agricultural products were identified, and with this, the difficulties that families face in reaching their destinations, due to accessibility and the condition of the roads.

Regarding production, we observed that this issue is mainly linked to the areas (rainfed and irrigated) and the amount of water accessed, an aspect that, due to water pressure, gives rise to internal conflicts in some agro-villages. Regarding this aspect, points that indicate low water quality in the settlement's agro-villages were spatialised, as well as those that have access to drinking water, of which there are only three: Zumbi 2, Pereira and Santa Luiza.

All of these collected data were systematised based on the Nexus+ approach (securities: water, food, energy and socio-ecological – land), defining priority and transversality for each attribute (See Table 5). After this systematisation process, it was observed that a large number of attributes were considered transversal, that is, they form part of more than one security. Considering this aspect, it became necessary to organise them in a better way, placing priorities and weights per attribute, incorporating the *Analytic into the social cartography Hierarchy Process* (AHP).

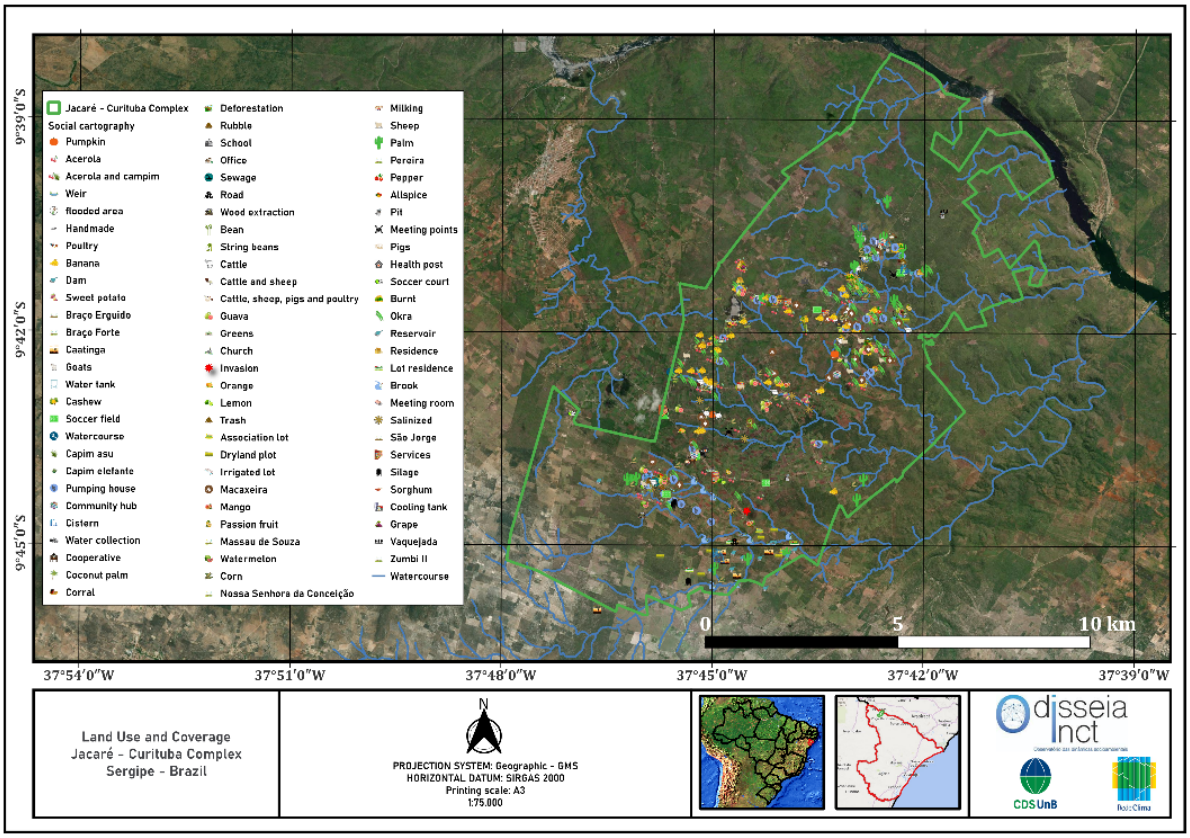

Figure 3 – Description of the settlement with all attributes identified

Source: Community researchers, local population and authors of the article.

Table 5 – Organisation of attributes by Nexus+ security, priority and transversality (P. Priority; T. Transversal)

Class 1	*Class 2*	*Class 3*	*Cycle*	*Utility of Geospatial Data*	*To feed P or T*	*Water P or T*	*Land P or T*	Energetics P or T	Socioecological P or T
Rural anthropology	Rural residence	Lot Residence / Association Lot / Residence	Average time for crop cycle, considering the harvest phase in irrigated areas	Describes how each piece of data can be applied to the study and its relationship with the safety analyzed in a primary and transversal way.	Priority security for the variable. Mark using a "P".	Priority security for the variable. Mark using a "P".	Priority security for the variable. Mark using a "P".	Priority security for the variable. Mark using a "P".	Cross-sectoral security variable. It can be used, but it does not have top priority. Mark using a "T".
	Rural lot	Dryland or irrigated lot							
	Fishing	Handmade							
	Agrovilla	Name of the agrovillage							
	Conflicts	Invasion							
		Social spaces							
		Business							
		Infrastructure							
		Degraded areas							
		Mining Area							
Non-agricultural anthropogenic	Degraded areas	Garbage / Sewage / Burning / Salinisation / Deforestation							
	Mining Area	No							

Class 1	*Class 2*	*Class 3*	*Cycle*	*Utility of Geospatial Data*	*To feed P or T*	*Water P or T*	*Land P or T*	Energetics P or T	Socioecological P or T
Agricultural anthropology	Temporary culture	"Hortaliças, Okra, Corn, Beans, Sorghum, Passion fruit, Cassava, String beans, Pepper, Cassava, Sweet potato, Watermelon, Allspice, Passion fruit, Pumpkin."	Average time for crop cycle, considering the harvest phase in irrigated areas	Describe how each piece of data can be applied to the study and its relationship with the safety analyzed in a primary and transversal way.	Priority security for the variable. Mark using a "P".	Priority security for the variable. Mark using a "P".	Priority security for the variable. Mark using a "P".	Priority security for the variable. Mark using a "P".	Cross-sectoral security variable. It can be used, but it does not have top priority. Mark using a "T".
	Permanent culture	Acerola, Acerola and grass, Banana, Banana tree, Cashew, Coconut tree, Guava, Orange, Lemon, Cassava, Mango, Passion fruit, Corn, Palm, Okra, Tomato, Grape.							
	Infrastructure	Corral							
	Pasture	Cattle and sheep / Dryland plot / Pasture plot							
	Fish farming	Breeding tanks							
	Plowed land	Farm in preparation							
	Livestock	Creation name							
	Forestry	Timber extraction							
Natural vegetation	Caatinga	Delimitation of the area							
Water	Water mass	Dam / Weir							
	watercourse	Stream							
	Wet area	flooded area							
	Infrastructure	Cistern / Water tank / Well / Water collection							

Source:Saaty (1991).

4.1 THE APPLICATION OF AHP WITHIN SOCIAL CARTOGRAPHY AND RESULTS

The use of AHP in line with social cartography allowed securities to be assessed qualitatively and quantitatively, thereby reducing the subjective nature of the weighting of the variables used. The information, together with secondary data acquired, allowed the creation of an analysis routine with a specific data set for each of the securities.

Given that the project is underway, some security analyses present preliminary data or cutouts. Therefore, what has been developed in some security vulnerability analyses, as well as some results, is shown here. In this sense, one of the security areas that is already at a more advanced stage in the analyses is energy and water. Below, we show the water security flowchart that guided the steps and data analyzed (see Figure 4).

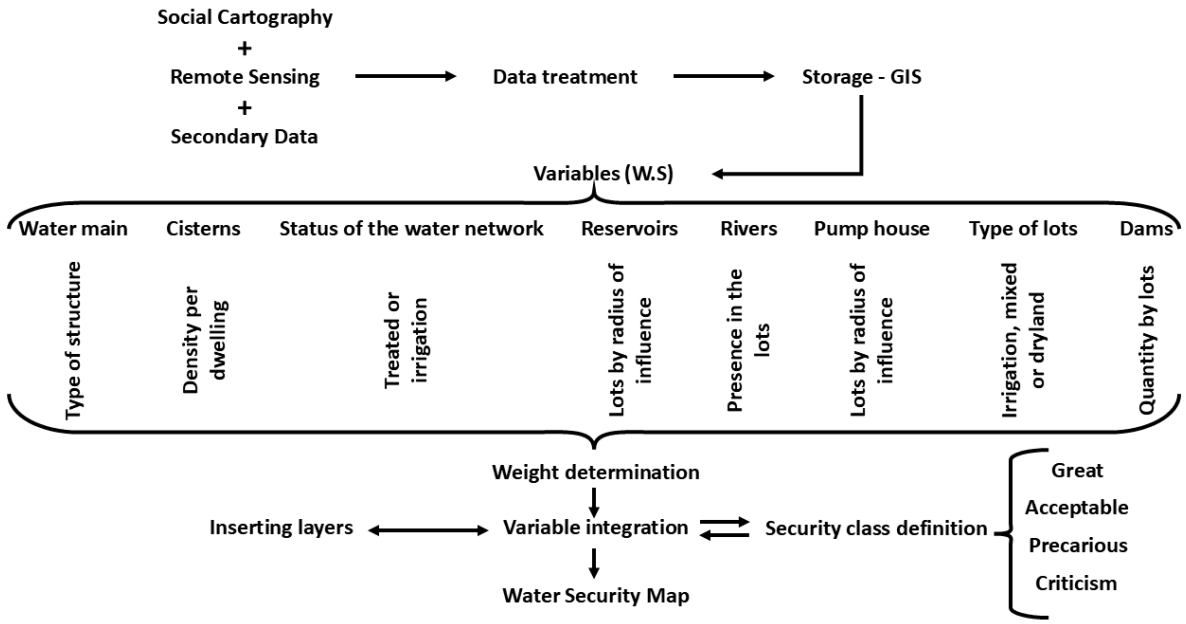

Figure 4 – Flowchart of steps and data used in water security

Source: Authors.

In this process, the use of secondary data: water network; information from remote sensing: dams, rivers and reservoirs; in addition to information collected by social mapping: cisterns, network status, pump house and types of lots; allowed the process to begin to measure the stage of water security in the area of the pilot agrovillages, all of this, through the weighting of the weights of each of the data layers used (See figure 5).

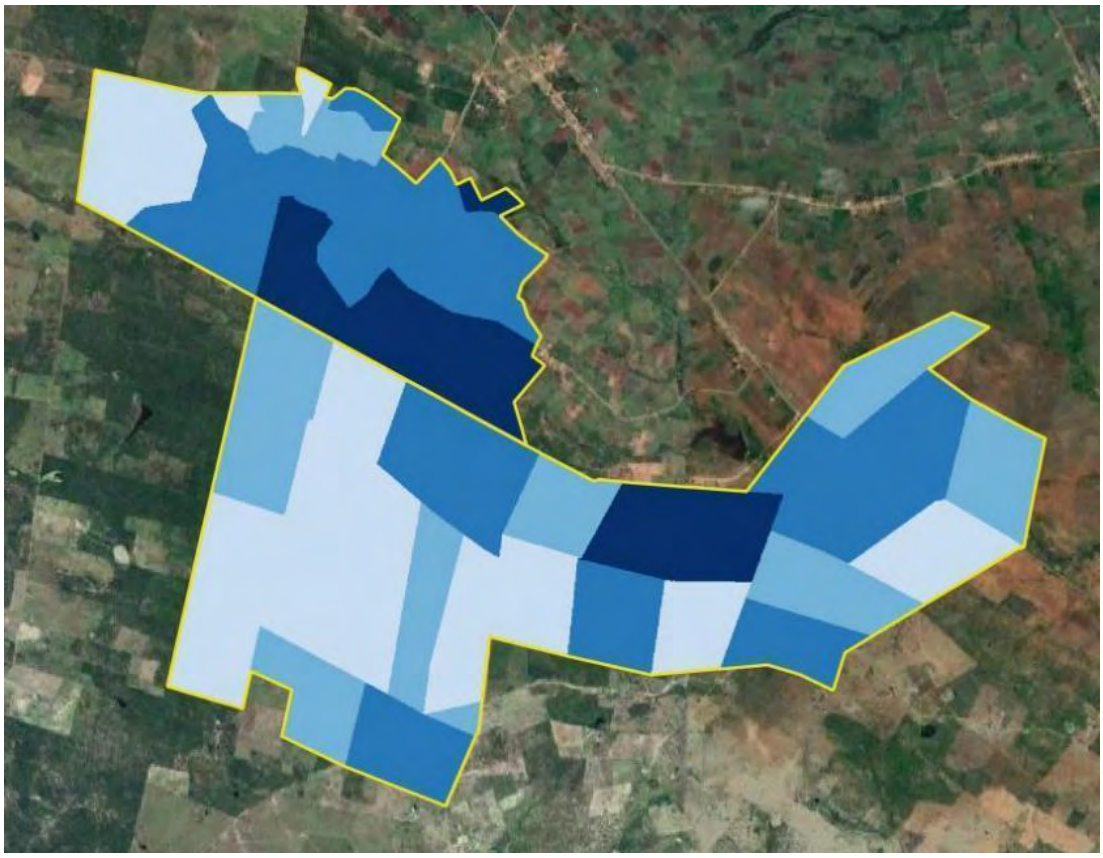

Figure 5 – Preliminary spatialisation of water security in the Braço Erguido and Nossa Senhora da Conceição agro-villages

Description: Intense blue, greater security, light blue, less security.

Source: Authors.

Within the energy security and a comparison of the security levels between the 4 pilot agrovillages of this study was carried out, the study revealed that only the Braço Erguido agrovillage presents a very high or acceptable level of energy security for most of the lots (Jean *et al*., 2024). The lots in the other three agrovillages (São José, Samariva Daniel and Nossa Senhora da Conceição) generally present low or very low levels of energy security, which may indicate a trend to be observed throughout the settlement. It is also important to note that more than 66% of the 109 families studied consider access to energy to be precarious in their settlement, which reinforces the viability of the trend of the results described in this work (Jean *et al*., 2024). The cost of local energy is considered high by local standards, as emphasised above, which also reinforces the issue of energy insecurity (Jean *et al*., 2024).

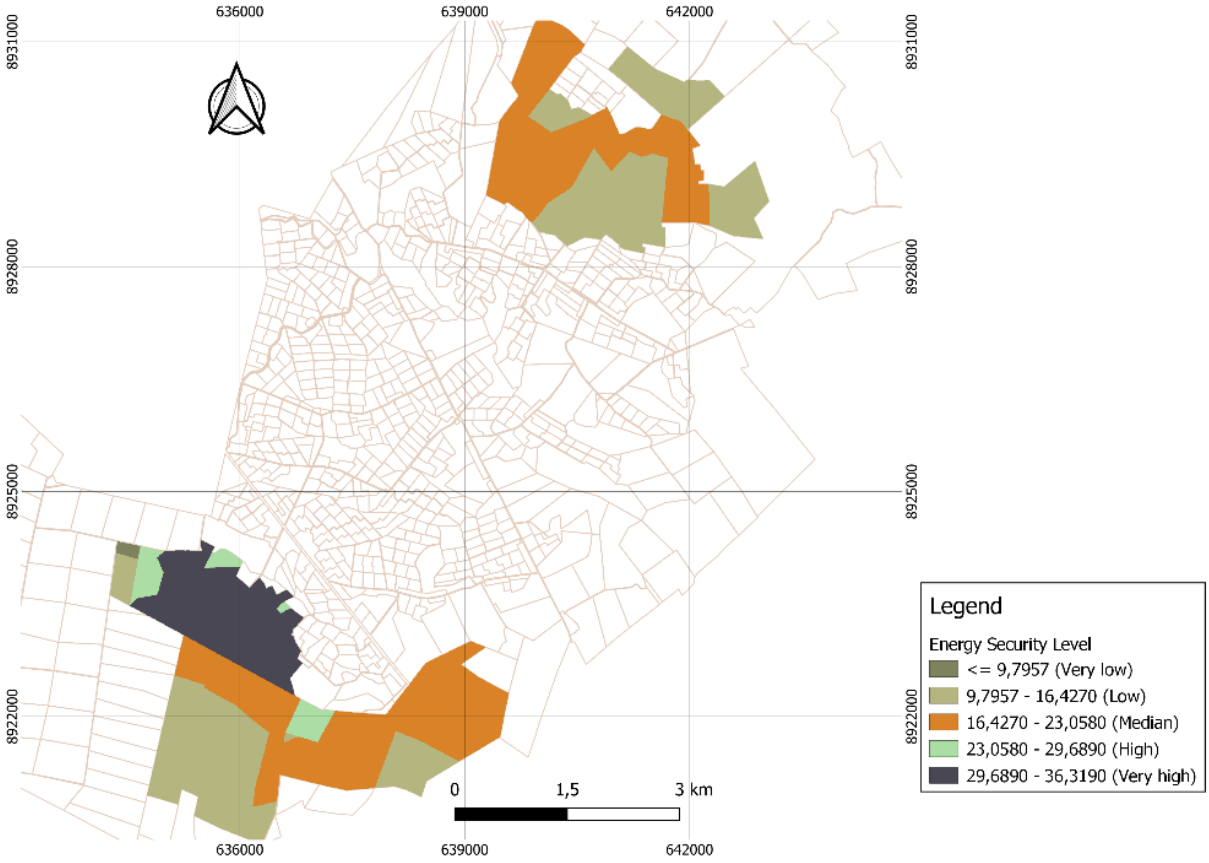

Figure 6 – Comparison of energy security assessments among the four (4) agricultural villages

Source: Authors.

In recent years, some studies involving the incorporation of social cartography techniques linked to the NEXUS approach have already been carried out, however, these were applied to highlight and encourage the cohesive use of natural resources, subsidising the improvement of the quality of life of residents, prioritising the idea of food sovereignty, access to treated water and a stable energy source, guiding the preservation of the environment in which they are inserted (Gorayeb, 2023).

Tavares (2023) proposes to fill knowledge gaps relevant to the nexus in Eastern Amazonia and to describe methodological procedures to enrich human and socio-environmental geography. The authors apply qualitative and quantitative methodologies (SWOT Matrix and Q Method) to determine "bottom-up" understandings of the water-energy-food nexus of rural and riverside communities in Northeast Pará. They empirically identify four subjectivities that show how communities understand the nexus: Factor 1: Income and water; Factor 2: Energy priority in the nexus; Factor 3: Food is the priority; and Factor 4: Water-energy-food connection.

Zara (2020), on the other hand, explores the social, cultural, and political implications of relationships and understandings of the water-energy-food nexus, showing how young people express a range of sociopolitical sensibilities that articulate with food and expand nexus thinking in several interconnected ways. First, by exposing the multi-scalar and multi-temporal processes underlying their everyday "nexus." Second, by destabilising the water-energy-food nexus to include ever-new elements that emerge from lived experiences of accessing resources. Third, by showing the embeddedness of resources in the cultures, policies, and social fabric of communities. Fourth, by uncovering the functioning of social difference in the articulation of dis /connections of the nexus. It is through these encounters with young people in Brazil that we propose a (re)politicisation and critical transfiguration of the nexus thinking.

Bottom-up research methodology can be based on the SWOT matrix and participatory mapping, or by exploring the social, cultural and political implications of a specific sector of society, as is the case of young people in Zara's (2020) research. The authors observed rhythms, experiences, sociopolitical feelings, multi-scalar and multi-temporal processes on a topic and in a specific area, but they did not measure a problem in terms of vulnerability, as is done here, demonstrating its need for analysis and specificities.

5 CONCLUSIONS

The Nexus+ approach requires both academia and other stakeholders to make a joint effort to coordinate particular interests towards the common interest of contributing to the construction of a more resilient society, including social and institutional participation (Araújo, 2019). Its implementation in social cartography and the incorporation of the AHP methodology have demonstrated that a transdisciplinary approach makes it possible to better address complex socio-environmental problems.

This approach showed that a new ontological, epistemological and methodological understanding of scientific knowledge is possible, making its implementation valid for understanding complex issues. Therefore, it is suggested that it be replicable in research projects that promote solutions to socio-environmental problems based on the Nexus+ approach. Another key element in this process was the promotion and establishment of the co-construction of knowledge, involving researchers from different areas and regions, which enabled an even more refined process of data collection, systematisation and analysis.

On the other hand, it was observed that the use of geographic information data and webmap applications is viable, since it helps in the identification of attributes, as well as in the understanding of changes in the territory, understanding the social and environmental reality of the region, as well as the problems, needs and demands of the population in relation to aspects linked to water, energy, food, territory and environment. The mapped knowledge was only possible through the participants, the authors of the present work, who guided and consolidated the process through the intermediation between local empirical knowledge and methodological techniques, making co-construction in the research process viable.

Among the most important data, it was observed that there are several points in the study area with problems of salinisation, conflict over the use of pesticides and water use, and low water quality and supply, requiring the internal organisation of the community to solve these problems. On the other hand, the methodology supported the identification of land use and occupation, mapping the types of production and crops established, as well as the number of areas occupied by the mentioned activities.

The study showed that production in dryland and irrigated areas generates disparities in terms of harvesting and income generation, leading to greater vulnerability in some regions, but mainly in terms of food security. This is an example of a result that the implementation of social mapping made it possible to achieve. However, the analysis of vulnerability by security and the agro-villages studied projected on the vulnerability maps allows us to observe the real situation in each area in relation to the aforementioned security, motivating social actors and community researchers to demand concrete actions from decision-makers .

The study had some limitations, including the use of other techniques for representing space, such as dance, painting, and crafts, among others, since they represent aspects that could have been better utilised in a very vivid and non-two-dimensional way, bringing new information to the study. The objective here was not to deal with this type of analysis, but it is recommended that these techniques be incorporated into social cartography and applied in Brazil.

Finally, we hope that the records and data produced thus far will serve as a basis for the generation of appropriate and effective public policies, motivating decision-makers to develop them by listening to the beneficiary population.

ACKNOWLEDGEMENTS

This work was supported by INCT/Odisseia-Observatory of socio-environmental dynamics: sustainability and adaptation to climate, environmental and demographic changes under the National Institutes of Science and Technology Program (Call INCT – MCTI/CNPq/CAPES/FAPs n.16/2014), with financial support from the Coordination for the Improvement of Higher Education Personnel (Capes): Grant 23038.000776/2017-54; National Council for Scientific and Technological Development (CNPq): Grant 465483/2014-3; Research Support Foundation of the Federal District (FAP-DF): Grant 193.001.264/2017.

REFERENCES

ACSELRAD, H., COLI, L. Disputas territoriais e disputas cartográficas. In: **Cartografias sociais e território**. ACSELRAD, H. (org.). Rio de Janeiro: Universidade Federal do Rio de Janeiro, Instituto de Pesquisa e Planejamento Urbano e Regional, 2008, n. 1, 168 p. (Coleção Território, ambiente e conflitos sociais).

ALMEIDA, A. Nova cartografia social: territorialidades específicas e politização da consciência das fronteiras. In: **Povos e Comunidades Tradicionais**. Manaus: PNCSA/UEA, 2013. p.157-173.

ARAÚJO, M.; OMETTO, J.; RODRIGUES FILHO, S.; BURSZTYN, M.; LINDOSO, D.; LITRE, G.; GAIVIZZO, L.; FERREIRA, J.; REIS, R.; ASSAD, E. **The socio-ecological Nexus+ approach used by the Brazilian Research Network on Global Climate Change, Current Opinion in Environmental Sustainability**, v. 39, p. 62-70, 2019. ISSN 1877-3435. Available at: https://doi.org/10.1016/j.cosust.2019.08.005.

ATAIDE, M. A **Etnocartografia no Brasil – 10 Anos Depois**. Equipe de Conservação da Amazônia – ACT Brasil. XXV CONGRESSO BRASILEIRO DE CARTOGRAFIA - Curitiba-PR - Brasil, 21 a 24 de agosto de 2011.

BARGAS, J. R.; CARDOSO, L. F. **Cartografia social e organização política das comunidades remanescentes de quilombos de Salvaterra, Marajó, Pará, Brasil**. Bol. Mus. Para. Emílio Goeldi. Ciênc. Hum., Belém, v. 10, n. 2, p. 469-488 maio-ago. 2015.

BARNSLEY, J. **El cuerpo como territorio de la rebeldía**. 2. ed. Caracas: Unearte. 231 p. 2006. Available at: https://mediacionartistica.files.wordpress.com/2017/08/el_cuerpo_como_territorio_de_la_rebeldia.pdf. Access at: 9 jun. 2022.

CHAPIN, M. *et al*. Mapping Indigenous Lands. **Annu. Rev. Anthropol**., v. 34, p. 619–638. 2005.

CODEVASF. **Projeto Público de Irrigação Jacaré-Curituba**. Available at: https://www.codevasf.gov.br/linhas-de-negocios/agricultura-irrigada/projetos-de-irrigacao/em-producao/jacare-curituba. Access at: 5 abr. 2023.

DALTON, C. M.; STALLMANN, T. **Counter-mapping data science**. The Canadian Geographer/Le Géographe Canadien, v. 62, n. 1, p. 93-101, 2018. Available at: https://www.countercartographies.org/wpcontent/files/Dalton_countermapping_data_science.pdf

DIEZ. J. **Cartografía social**: teoría y método estrategias para una eficaz transformación comunitária. Editorial Biblos, 15 de mai. de 2018. 102 p Available at: http://dx.doi.org/10.18764/2446-6549/interespaco.v2n6p273-293

ESCOBAR, A. **Sentipensar con la tierra**: nuevas lecturas sobre desarrollo, territorio y diferencia. Cartilla, Universidad Nacional de Colombia. 2014.

FOX, J. *et al*. O poder de mapear: efeitos paradoxais das tecnologias de informação espacial. In: **Cartografias sociais e território**. ACSELRAD, H. (or.). Rio de Janeiro: Universidade Federal do Rio de Janeiro, Instituto de Pesquisa e Planejamento Urbano e Regional, 2008, n. 1,168 p. (Coleção Território, ambiente e conflitos sociais).

GORAYEB, A. *et al*. Participatory Mapping of the Water Food-Energy Nexus in the Brazilian Semiarid Region to meet the SDGs. **Abstracts of the ICA**, v. 6, p. 1-2, 2023. Available at: https://ica-abs.copernicus.org/articles/6/75/2023/ica-abs-6-75-2023.pdf

HERLIHI, P. H.; KNAPP, G. (eds.). Maps of, by and for the Peoples of Latin America. Human Organization. **Journal of the Society for Applied Anthropology**, v. 62, n. 4, Winter 2003.

HURTADO, Y. **Diálogo de saberes artísticos**. Vivencia teórico-práctica. p. 139-154, 2013.

JEAN, W. *et al*. A GIS for Rural Electrification Strategies in the Brazilian Amazon. **Papers in Applied Geography**, v. 7, n. 3, p. 239-255, 2021. DOI: 10.1080/23754931.2020.1870539

JEAN, W. *et al*. Linking Energy Transition to Income Generation for Vulnerable Populations in Brazil: a win-win strategy. **Sustainability**, n. 16, 7527, 2024. Available at: https://doi.org/10.3390/su16177527

JEAN, W. *et al*. Energy security assessment in rural communities in Brazil: a contribution to public policies. 2024. Em revisão. **Revista Energy nexus**. Submetida em agosto 2024.

LIMA, R. **Preservação digital e "divulgação" científica na Amazônia**. Manaus: UFAM /Dissertação, 2018. Available at: http://tede.ufam.edu.br/handle/tede/6049. Access at: 27 out. 2024.

LINDOSO, D. P. *et al*. **Uma Odisseia no campo socioambiental da pesquisa transdisciplinar**. Bases epistemológicas para a coconstrução do conhecimento do projeto INCT-Odisseia, estudo de caso do Baixo São Francisco. Brasília: Capes/CNPQ/FAPDF, 2021. Available at: https://odisseia.unb.br/wp-content/uploads/2020/10/Working-Paper-1.pdf.

MARINS, C. *et al*. **O uso do método de Análise Hierárquica (AHP) na tomada de decisões Gerenciais**: um estudo de caso. XLI SBPO – Pesquisa Operacional na Gestão do Conhecimento, 2009. p. 1778.

MENDES, J. S. *et al*. Impactos Socioambientais em Comunidades Atingidas pelos Empreendimentos de Energia Eólica: o caso de Xavier, Camocim, Ceará. In: GORAYEB, A.; MEIRELES, A. J. A.; SILVA, E. V. (Org.). **Cartografia Social e Cidadania**: experiências de mapeamento participativo dos territórios de comunidades urbanas e tradicionais. Fortaleza. Expressão Gráfica, 2005, p. 135-166.

MIARA, M. A.; OKA-FIORI, C. Análise por múltiplos critérios para a definição de níveis de fragilidade ambiental – um estudo de caso: bacia hidrográfica do Rio Cará-Cará, Ponta Grossa-PR. **R. RA´E GA**, n. 13, 2007.

SAATY, T. L. **Método de análise hierárquica**. São Paulo: McGraw-Hill. 1991.

SANTOS, D. Cartografia social: o estudo da cartografia social como perspectiva contemporânea da Geografia. **InterEspaço**, Grajaú/MA, v. 2, n. 6 p. 273-293, 2016.

SILVA, L.; GOMES, M.; FREITAS, V. B. A Cartografia Social como Processo Organizativo de Visibilidade e Mobilização Social: relato da experiência com moradores em áreas sujeitas a inundação na cidade de Guarapuava-PR, entre 2015 e 2016. **Geografia**, Londrina-PR, v. 27, n. 2. p. 225–245, agosto. 2018.

TAVARES, G. *et al*. Análise bottom-up do nexus agua, energía-alimento na Amazônia oriental. **Revista de Geografia**, Recife-PE, v. 40, p. 225-254, 2023. Available at: https://periodicos.ufpe.br/revistas/index.php/revistageografia/article/view/25756

ZARA, C. *et al*. Geographies of food beyond food: transfiguring nexus-thinking through encounters with young people in Brazil. **Social & Cultural Geography**, 2020. DOI: 10.1080/14649365.2020.1809010