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ABSTRACT

The Legal Amazon, covering 61% of the Brazilian territory, faces significant challenges due to economic, social and environmental inequalities, requiring specific regional strategies to face the uncertainties arising from the climate emergency. The great shock of the Covid-19 pandemic has introduced a new scenario for research in the region. In the Portal Territory of the Amazon, broadening the understanding of the resilience of family farming required the construction of new theoretical and methodological approaches. The Territorial Health approach proposed in this article is characterized as a strategy for broadening the understanding of vulnerability in the agricultural frontier of the Mato Grosso Amazon, based on the OneHealth and EcoHealth approaches. The data was categorized into environmental, economic, educational, land use, and public policy dimensions and analyzed using two multivariate statistical techniques: principal component analysis (PCA) and cluster analysis. The results show the contradictions of an agricultural occupation model that has failed to consider human health and the environment as a development strategy. They also demonstrate the fragility of the data for constructing an ecosystem approach that explains the distinctions between municipalities in terms of more or less ecosystem health. Ultimately, the exercise of building the Territorial Health approach highlights essential aspects for the construction of public policies adapted to the context of the agricultural Amazon.

Keywords: Amazon Portal. Ecosystem Health. Socio-ecological Resilience

RESUMO

A Amazônia Legal, cobrindo 61% do território brasileiro, enfrenta desafios significativos devido a desigualdades econômicas, sociais e ambientais, exigindo estratégias regionais específicas para enfrentar as incertezas decorrentes da emergência climática. O grande choque da pandemia de Covid-19 introduziu um novo cenário para as pesquisas na região. No Território Portal da Amazônia, a ampliação da compreensão da resiliência da agricultura familiar demandou a construção de novos enfoques teórico-metodológicos. A abordagem da Saúde Territorial, proposta neste artigo, caracteriza-se como uma estratégia de ampliação da compreensão da vulnerabilidade na fronteira agrícola da Amazônia mato-grossense, baseada nos enfoques de OneHealth e EcoHealth. Os dados foram categorizados nas dimensões ambiental, econômica, de educação; ocupação do solo e de política pública e foram analisados utilizando duas técnicas estatísticas multivariadas: análise de componentes principais (PCA) e análise de clusters. Os resultados demonstram as contradições de um modelo de ocupação agrícola que não considerou a saúde humana e do ambiente, como estratégia de desenvolvimento. Demonstram, igualmente, a fragilidade dos dados para a construção de uma abordagem ecossistêmica que explique as distinções entre os municípios em termos de mais ou menos saúde ecossistêmica. Em última análise, o exercício da construção da abordagem da Saúde Territorial evidencia aspectos essenciais para a construção de políticas públicas adaptadas ao contexto da Amazônia agrícola.

Palavras-chaves: Portal da Amazônia. Saúde Ecossistêmica. Resiliência Socioecológica.

INTRODUCTION

The Brazilian Legal Amazon (LA) covers almost 61% of the total area of the country, across nine states and 5.2 million km^{2,} and has been established by several legal provisions since 1953 to plan actions and promote socioeconomic strategies for the region (Amaral; Silva et al., 2020). Although rich in biodiversity and other natural resources, numerous problems of economic, social, and environmental development nature characterize this extensive region (Oliveira et al., 2019), which supported a conception of State focused on regionalization for the development of specific projects. Historically, the LA occupation processes were characterized by strategies, programs, and projects aimed at regional development (Vale et al., 2018; Gumiero, 2020).

Socioeconomic heterogeneity and inequalities have been pointed out in many studies on the Legal Amazon (Vieira et al., 2008; Vale et al, 2018; Carvalho, 2018; Souza; Lima, 2023). According to Garnelo (2019), in the region there is

> A heterogeneous and multifaceted socio-environmental scenario [...] and social, economic, and sanitary indicators are also very disparate, associating accelerated demographic and economic growth with a massive concentration of income and living conditions that are largely unfavorable to the majority of the population (Garnelo, 2019, p. 1).

Viana et al. (2016) carried out an analysis based on indicators for assessing the development in the region between 2000 and 2010 and pointed to the "persistence of immense inequalities in social and economic indicators", highlighting economic growth and environmental degradation unequally between municipalities. Oliveira et al. (2019) also analyzed a set of sustainability indicators and concluded that "environmental indicators show opposite signs because the most economically developed municipalities have an unmatching environmental preservation agenda" in the region. These authors conclude, by assessing the public policies of regional development, that the economic, social, and environmental development problems are linked to the application of policies that do not consider or fully respect the context in which they are inserted. For them, there is a strong division between municipalities, considering those more to the north, compared to those located more to the south, with strong ties with agribusiness.

How then can we think of development strategies and policies for such a heterogeneous region? According to Oliveira et al (2019), decentralization can contribute to local development since it is related to the initiatives and capabilities of local and municipal populations and their political and administrative bodies. Thus, data analysis and the definition of strategies aimed at actual regional development should take into account the differences between municipalities and their intrinsic characteristics on multiple topics and dimensions.

The State of Mato Grosso became part of the LA in 1977, with the approval of Complementary Law No. 31, of October 11, 1977 (SUDAM, 2021). Buschbacher et al (2021) highlight the inequality between municipalities in the state based on their colonization processes. The economy of municipalities in the south is based on modernized commodity-based agricultural production (with high per capita income and high HDI), while those in the north and northwest are characterized by high migration rates, stagnant economies, and high levels of poverty.

Also in the *Portal da Amazônia* territory in the extreme northern portion of the state, a region of agricultural borders with 16 municipalities located in the so-called "Arch of Deforestation", the process of agricultural occupation was responsible for economic, socio-cultural, and environmental consequences that reach populations quite unevenly. We have studied family farming in this region, based on a collaborative research network focusing on assessing its resilience, and the strategies that can strengthen it since 2016 (Olival et al., 2021).

Recently, the Covid-19 pandemic has brought on a new scenario of analysis to think about several topics, including studies on resilience. In this new scenario (Post-Covid-19), we understand that the discussion and establishment of strategies for the regional development of the *Portal da Amazônia* relates to the strengthening of family agriculture and should take into account the heterogeneity present in its 16 municipalities. For this purpose, this work presents the elaboration/development of a new theoretical-methodological approach, proposing a territorial outline for impact analysis and possible strategies to strengthen FA resilience in the municipalities of the *Portal da Amazônia*, in all their heterogeneity.

Stimulated by the pandemic and previous studies, in which we investigated the socio-ecological system (SSE) of Family Agriculture, we started from a conception of SSE (focusing on agricultural property, productive system, family system) to advance in two directions: 1) The construction of an SSE approach with territorial dimension, which allows understanding the FA state/degree of resilience/vulnerability in the different municipalities of the *Portal da Amazônia*; 2) The construction of a theoretical-methodological structure (which we call the "health of the territory") that aims to expand the understanding of the AF resilience/vulnerability based on approaches related to ecosystem health, from EcoHealth and resilience approaches.

Based on that, we categorize municipalities into levels of vulnerability to develop strategies for mitigating future shocks and for regional development from what we define as "territory health".

FAMILY FARMING AND RESILIENCE IN THE *PORTAL DA AMAZÔNIA*

The dynamics of rural areas in Brazil have been characterized by strong economic, social, and cultural heterogeneity, with a strong presence of socioeconomic transformations in the Amazon Biome, where the expansion of the agricultural border has had a strong impact on rural properties and families (Bezerra et al., 2022), which is also true for the *Portal da Amazônia*.

For Buschbacher et al. (2021), in this region:

> The environmental impacts, which extrapolate the local, regional, or national dimension, associated with the questioning of the balance between economic and social benefits arising from this occupation process, are some of the elements that currently bring new perspectives for the development of the agricultural border (Buschbacher et al., 2021, p. 16)

The constant transformations of this border region caused an accelerated dynamic of irregular occupation of rural space, the impoverishment of a large part of the rural population, with deforestation and contamination of natural ecosystems (Weihs; Sayago; Tourrand, 2017), significantly affecting family agriculture (Weihs; Olival, 2021).

Currently, 32% of the population in this region lives in rural areas (Gervazia et al., 2023), and family farming represents more than 70% of rural settlements in the territory (IBGE, 2017). From 2016 to 2020, we studied Family Farming in the territory, from the approach of resilience of complex socio-ecological systems, whose process is described herein, succinctly. Resilience is defined as the ability to maintain functions, structures, and responses when going through natural or social changes (Walker, 2004). It is an important conceptual tool to understand and promote basic and long-term changes in rural communities (Darnhofer et al.; 2014), using shocks and disturbances as a stimulus to renewal and innovation, encompassing learning and diversity. Thinking about resilience means, therefore, building flexibility and adaptability (Resilience Alliance, 2010) to different shocks. In methodological terms, to investigate resilience it is necessary to define a scale of analysis and the elements that characterize the system and its central attributes, whose maintenance characterizes its capacity for adaptation (Buschbacher et al., 2016). The theory of resilience brings the perspective that socio-ecological systems are complex, dynamic, unpredictable, and nonlinear, which makes it necessary to prepare for various future possibilities, that is, to increase the adaptive capacity – or the general resilience – of these systems for future shocks (Buschbacher, 2014).

Socio-ecological systems are complex, integrated, and adaptive systems in which human beings are part of nature and are characterized by the interaction of cultural, political, social, economic, ecological, and technological components, which is why we understand the FA as an SSE for our analyzes (Oliveira et al., 2021). The trajectory of the FA in the *Portal da Amazônia* is marked by shocks related to very relevant socioeconomic and environmental aspects and the adaptations to these multiple shocks, which determined their ways of life (Weihs; Olival, 2021).

For five years, focusing on the stages of resilience analysis, i.e., resilience of what, against what, and the strategies to adapt to impacts (Olival et al., 2021; Oliveira et al., 2021), we studied and characterized the FA in the *Portal da Amazônia* into four dimensions of analysis: Types of landscape

occupation and use of resources; economic and market relations; social interactions; governance; and institutions. We made a diagnosis on the diversity of Family Agriculture ("resilience of what"), about the elements that presented themselves historically and procedurally as risks to this form of production ("resilience against what"), and about the strategies, adaptations, arrangements, and lessons that strengthened their resilience, in the face of different impacts, throughout their trajectory. We discovered an intricate network of factors that influence the livelihoods of family farmers in the Mato Grosso Amazon – and on the Portal.

Based on the results obtained previously, we understand that the promotion of resilience is linked and can only be achieved by improving the quality of life of rural populations in the region of the study, based on greater autonomy for families in rural properties (with generation of work and income, diversification, and promotion of greater efficiency in agricultural production, access to local markets, better access to public policies, improvements in education, valuation of local ways of life, promotion of health and well-being, and promotion of food security in communities).

THE HEALTH APPROACH AS A PERSPECTIVE OF ANALYSIS

Since the Covid-19 pandemic, the theoretical framework that we used became insufficient for understanding and analyzing the resilience of Family Agriculture (FA), in a completely new context. The scenario imposed by the pandemic made us understand the need to incorporate theoretical and methodological assumptions related to health, which led us to include in our approach the references to "One Health" and "Eco Health" (Jorwal et al., 2020; Lerner; Berg, 2017; Harrison et al., 2019). Eco Health and One Health are complementary approaches related to Health that assume that humans and other animals share the same planet and the same environmental challenges.

The One Health concept was conceived as an "all-inclusive" approach, incorporating the direct impact of environmental epidemiology into human and animal health (Jorwal et al., 2020). This approach refers to improving health and well-being through risk prevention and the mitigation of the effects of crises that originate in the interface between humans, animals, and their various environments. Lately, the need to broaden the concept to cover not only human and

animal health, but also biodiversity, ecology, climate change, agricultural systems, and various social sciences has been highlighted (Lerner; Berg, 2017). The EcoHealth approach is described as involving the health of human beings, animals, and ecosystems, also including environmental sustainability and socioeconomic stability in this framework. EcoHealth aims at "sustainable human and animal health and well-being through healthier ecosystems" (Lerner; Berg, 2017).

From a scientific point of view, the concept that there is an intrinsic relationship between the health of the people and the environment they inhabit has been accepted.

For Santos (2018):

> The social or physical contexts or environments in which people live and lead their daily lives are important to health. The characteristics of disadvantageous environments, through processes of obstruction of access, exposure, and interaction, impact the maintenance and promotion of health. Collective practices shaped by social structures and collective lifestyles of health are formed in spatial contexts (Santos, 2018, p. 558)

This relationship between the environment and people's health is clear when we are faced with the picture presented by Viana et al (2016), who used socioeconomic, environmental, and health indicators to assess the LA. The authors highlight vulnerabilities, with negative effects on environmental and sanitary characteristics in the region, where "economic growth and environmental degradation are combined with a rapid and precarious urbanization process and development projects aimed at the exploitation of natural resources". For the authors:

> […] the result is a complex picture of health problems, with the presence of infectious and parasitic diseases related to severe environmental changes and poor conditions of life, caused mainly by inequalities in social and economic indicators (Viana et al., 2016, p. 233).

The inequalities historically described for the *Portal da Amazônia* also present a paradox, with municipalities with better economic indices apparently being the worst from the perspective of their environmental and social performance.

TERRITORIAL HEALTH AS A WAY TO COMBINE DEVELOPMENT AND THE ENVIRONMENT

The notion of Territorial Health proposed herein stems from the understanding of space-territory, or built territory, considered, in turn, as a result of the interaction and mobilization of social players in a geographical space that has as basic characteristics multiplicity, lack of clarity regarding physical borders, and the possession of differentiation assets (Cazella et al., 2009). Unlike the given territory, which is limited to the political-administrative concept of a place that supports economic activities, the idea of a built territory is expanded and takes on the form of a dynamic social fabric marked by relationships of cooperation but also of conflict (Fernandes, 2004). The space-territory is a place of constant construction, life, culture, and development. The socioeconomic, political, cultural, and ecosystem dimensions do not represent isolated elements of the analysis, but rather a dynamic and changeable entanglement that develops in a given local context.

The territory is a result of the historical trajectory and socio-spatial dynamics (Saquet, 2009); it is both a product and a conditioner of human action. The territory is thus a precursor of the landscape and the relationship between man and the environment, including nature. In the case of sustainability, this society-nature relationship represents the core of the discussion.

The very idea of differentiating assets, or territorial assets (Pecqueur, 2006), seeks to broaden the discussion about the use of potential resources without restricting them to physical, material, or natural factors. The territory is a site of potential resources that, when identified and valued, become a source of differentiation (Makishi et al., 2019). More than material resources, these assets can be made up of cultures, traditions, ways of life, and production. Contrary to the economic logic, which sees nature as a resource or commodity, the argument defended here is that nature, like in ecosystem theories, should be seen as a component of the space-territorial context. The territorial approach has proven to be very useful in the discussion around development. In the territory, the interaction of players allows the construction of institutional architectures, that is, of a set of formal and informal rules, adapted to the specific context and that govern the forms of cooperation and negotiation necessary to identify and solve common problems. The institutions represent “the rules of the game” as described by North (1990). These rules structure, modify and restructure the political, economic, and social interaction of human beings.

The relationship between institutions and the sustainable use of resources was explored by Elinor Ostrom (1990) in her theory of governing the commons. In short, Ostrom argues that, contrary to what the so-called tragedy of the commons advocates, societies can, and often do, locally develop robust and lasting institutional arrangements to collectively manage their resources sustainably.

Common problems are understood as the need to maintain decent work and income generation, food security and promotion, the construction of identity and social inclusion, and the preservation of natural resources and landscapes. It is worth remembering that issues such as poverty, health, and ecosystem degradation are strongly linked. Becker (2013) offers good examples of how the wrong development policies of the past, migration processes, and the agrarian problem have resulted in the recent urbanization process (and its consequent problems) and increased pressure on the forest and climate ecosystem in the Brazilian Amazon.

In this sense, the Territorial Health mentioned here reflects the ability to promote and enhance territorial development and territoriality. The premise adopted is the same as that of EcoHealth studies, in which human health and well-being depend on the environment (Lebel, 2003). Thus, the health of the territory represents the set of spatially contextualized attributes that enable populations to develop their ways of life and types of production, in balance with the natural environment, allowing present and future generations a life worth living.

This understanding is close to the conception of healthy ecosystems advocated by Rapport (2007), being an essential condition for maintaining the conditions of well-being and health of people, communities, and livelihoods. In other words, Territorial Health proposes an effective ecosystem-based perspective for the society-environment relationship. This is because territorial dynamics cannot be removed from the debate involving waste generation, loss of biodiversity, or climate change. In addition, the notion of Territorial Health would contribute, as part of the environmental debate, to a better understanding of the conflicts between global conservation efforts and the resulting costs taken on by the local populations so present in the Amazon territories (Bauch et al., 2015).

On that topic, the construction proposed herein seeks to offer a less partial perspective on the classical dichotomy involving economic development and environmental conservation. Economic growth, often measured by Gross Domestic Product, cannot be marginalized in environmental

discussions. The contrary is also true. As already mentioned, this is an integrative proposal, more ecosystem-like. It is not a question of assessing the parameters separately but of observing the nuances of their relationships.

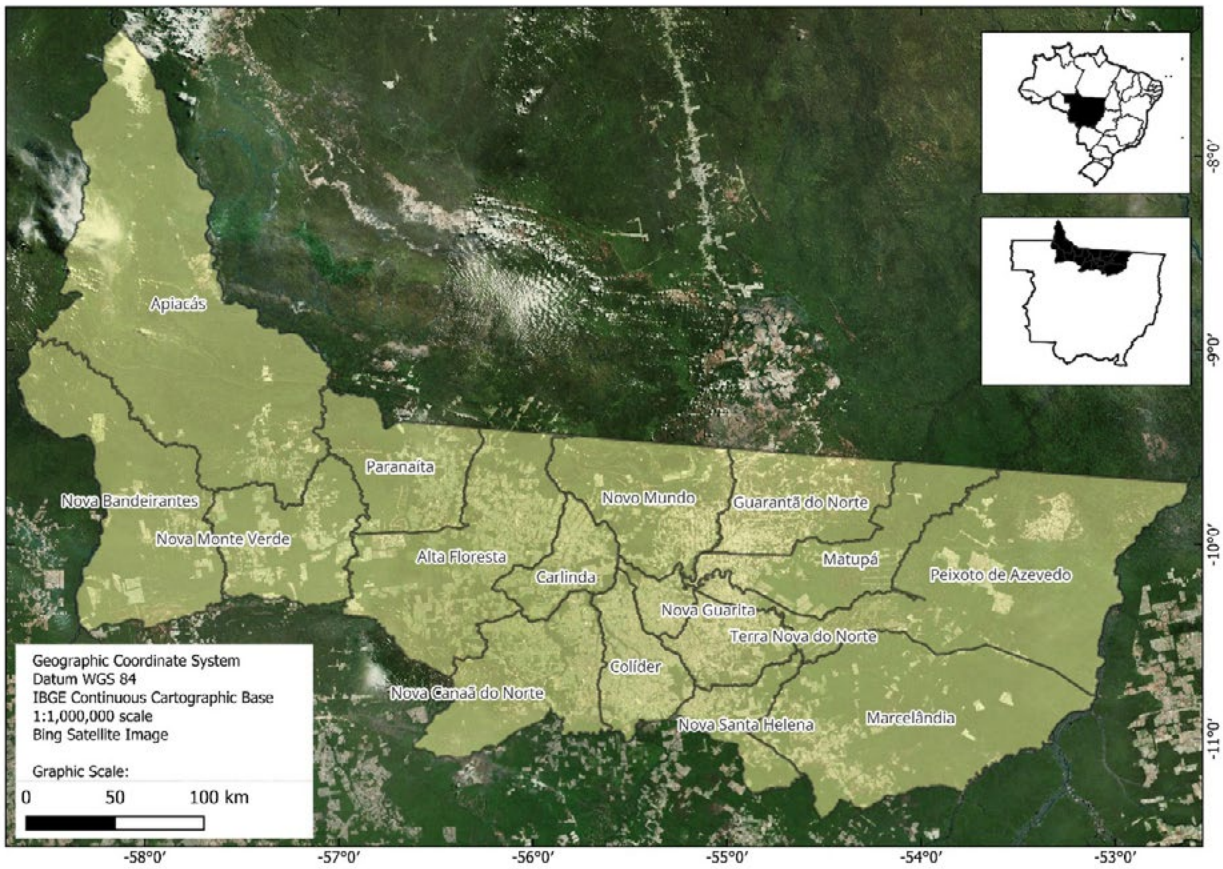
If territorial development can be understood as the construction of cooperation bonds between players (civil society, public authorities, and private sector), even if they have different interests, who find some convergence for their coexistence (Carrière; Cazella, 2006), Territorial Health can be taken as a latent means by which these relations are established, negotiated, and reaffirmed. This favorable – or not – atmosphere is, from the ecosystem and territorial perspective, the result of a historical and geographically inscribed society-environment relationship. Thus, Territorial Health reflects how this relationship occurs, whether in the different types of land occupation, in the use of natural resources for wealth production, or the impacts of human action on nature (biodiversity conservation, waste generation, and climate change).

Given this proposition, the State also plays an important role in maintaining this favorable environment, which goes far beyond the merely regulatory and supervisory role of the economic and social organization traditionally attributed to the public bureaucracy. In addition to conflict mediation and the guarantee of property rights, it is the role of the State to ensure that local arrangements are developed by acting in eventual coordination gaps. In order for development to take place, it is necessary to guarantee to the population the conditions to develop their individual and, in particular, collective strategies. This involves the individuals' education, citizenship, and political formation, the maintenance of basic living conditions, such as food and health care, and, when necessary, compensatory action, for example, in the generation and distribution of income.

METHODOLOGY

The study was carried out in the municipalities that comprise the so-called "*Portal da Amazônia* Territory", a region located in the extreme north of the State of Mato Grosso, composed of sixteen municipalities: Alta Floresta, Apiacás, Carlinda, Colíder, Guarantã do Norte, Matupá, Nova Bandeirante, Nova Canaã do Norte, Nova Guarita, Nova Monte Verde, Nova Santa Helena, Novo Mundo, Paranaíta, Peixoto de Azevedo, Terra Nova do Norte, and Marcelândia (Figure 1).

Figure 1 | Municipalities and Citizenship Territory of the Portal da Amazônia, Mato Grosso, Brazil.



Source: Prepared by the authors.

Based on the historical trajectory and the current reality (environmental, socio-cultural, political, and economic) of the *Portal da Amazônia*, and previous research experiences, we defined that, in theory, a healthy territory would ideally involve the following characteristics: Low rates of deforestation, conservation of native vegetation cover and preservation areas, low density of fires, a smaller area occupied by soybean monoculture (considering all local impacts linked to its expansion), lower occurrence of diseases in the cattle herds of the region (considering that dairy and beef cattle raising is one of the main economic activities associated with family farming in the region), greater economic dynamism, lower social inequality, low land concentration, access to basic health services and education for the people, food security linked to a greater presence of family farming, and greater diversification of production.

Based on this premise, that is, for a characterization of the territory based on the ecosystem health approach, we identified a set of independent variables that would interfere, in theory, with a dependent variable - the territory health - defined by us. Economic, collective health, education, food safety, and environmental quality variables were selected in different dimensions (Table 1). The criteria for the choice of variables were: (i) access to secondary databases in official channels; (ii) variables listed in the literature with the mentioned dimensions; and (iii) variables easy to understand.

Table 1 | Variables representative of economic, environmental, land occupation, and public policy dimensions.

Variable	Name	Dimension [1]	Source
Per capita Gross Domestic Product (GDP) (2019)	GDP	E	IBGE (2022)
Total percentage of people in families beneficiaries of the *Bolsa Família* Program/ *Auxílio Brasil* Program (2020)	Bolsa_Familia	PP	Ministry of Citizenship (2022)
Percentage of municipality area occupied by family farming settlements (2017)	Agr_Farm	E, OS	IBGE - Agricultural Census
Percentage of municipality area occupied by soybean plantations (2020)	Area_Soja	E, Am, OS	Projeto MapBiomas Coleção 7
Percentage of municipality area occupied by pasture (2020)	Area_Pasto	E, Am, OS	Projeto MapBiomas Coleção 7
Primary health care population coverage (2019)	Atencao_Basica	PP	Ministry of Health (2022)
Health professionals/ 100,000 inhabitants (2019)	Prof_Saúde	PP	Ministry of Health (2022)
Enrollments in rural schools/ No. of family farmers (2017)	Matriculas_Rurais	PP	INEP (2022)
Teachers in rural schools / No. family farmers (2017)	Professores_Rurais	PP	INEP (2022)
Number of rural schools/ No. family farmers (2017)	Escolas_Rurais	PP	INEP (2022)
Percentage of deforested area in the municipality (2020)	Deforestation	Am	Projeto MapBiomas Coleção 7 (2022)
Fires/1000Km² (2020)	Focos_Calor	Am	INPE (2022)

1. Am: environmental, E: economic; Ed: education; OS: soil occupation; PP: public policy.

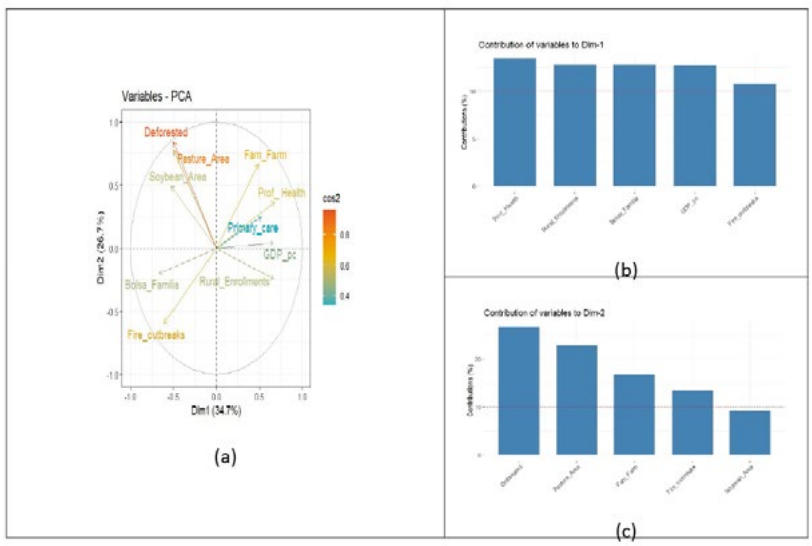
Considering an exploratory study of a quantitative nature, two multivariate statistical techniques were used: Principal Component Analysis (PCA) and Cluster Analysis. PCA was chosen because it helps reduce the number of variables to identify which actually present interaction behavior.

The data were first submitted to correlation analysis to verify coefficients greater than 80%. Only the variables related to the education dimension met this criterion, and the variable "Enrollments in rural schools/ No. of family farmers" was selected to remain in the analyses. The data were also normalized for the analyses due to the different scales. The analyses were performed in the R@ computer environment, using FactoMineR and factoextra statistical packages for PCA and for cluster analysis using the K means method (Husson et al, 2023; Kassambara; Mundt, 2022). The PCA is presented through graphs representing cosine^2 (COS ^{2}) with an indication of the weight of the variables for each dimension.

RESULTS AND DISCUSSION

Based on the results obtained by the main components technique, we verified that the first two dimensions explain 61.4% of the total data variance, with the first dimension explaining 34.7% and the second one, 26.7% (Figure 2).

Figure 2 | Biplot of the relationships between the first two main components (Dim 1 and Dim 2) and the variables represented through the color scale of the square cosine values (a). Graphs of the contribution percentage of variables in dimension 1 (b) and dimension 2 (c).

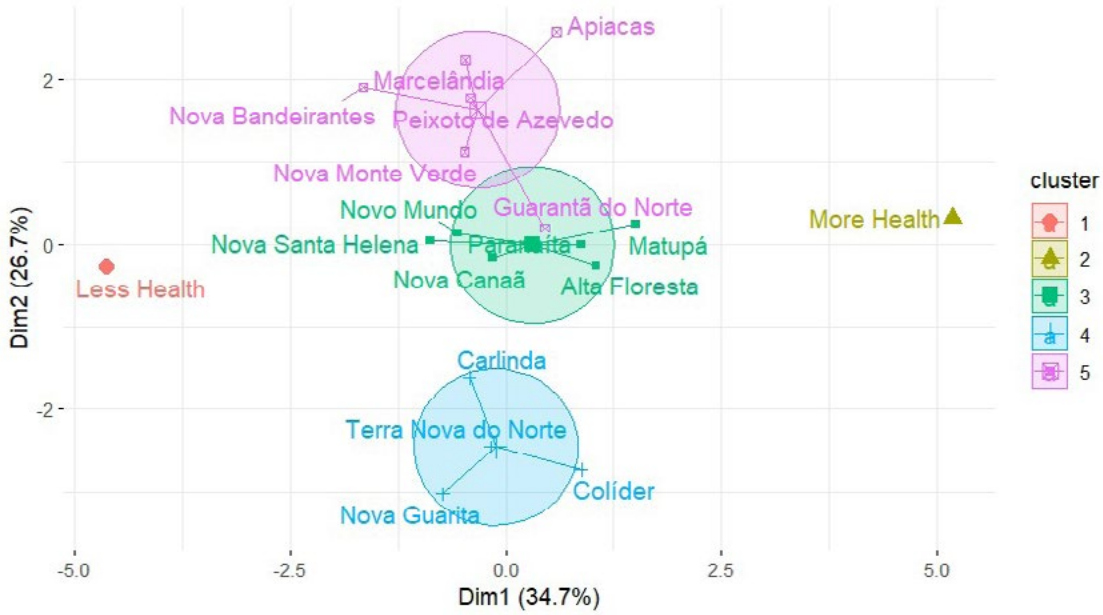


Source: Prepared by the authors.

In dimension 1, the most relevant variables for the model were those related to health, education, social vulnerability (*bolsa família*), GDP, and fires. In dimension 2, the variables that stand out, in decreasing order of importance are: percentage of deforested area, percentage of pasture area, percentage of area with family farmers, once again, fires, and, lastly, percentage of municipality area occupied by soybean.

Still based on the PCA biplot graph (Figure 3a) we can see that the GDP and *Bolsa Família* presented opposite correlations, which was expected, because the higher the GDP, theoretically, the lower the proportion of residents who need the *Bolsa Família*. In addition, the highest percentages of pasture and soybean areas showed a negative correlation with the number of enrollments in rural schools, which can be explained by the fact that these are activities that require little labor (mainly pasture for extensive cattle raising), leaving young people with no occupation, making them migrate to cities, thus reducing the demand for services in rural areas. For the grouping of municipalities, elaborated using the health indicators of the territory and carried out according to the PCA, we used the K Means procedure, opting for 5 groups (Figure 3) established based on our initial definition of territory health.

Figure 3 | Grouping of municipalities based on the K Means procedure of cluster analysis for the municipalities of the Portal da Amazônia, MT.

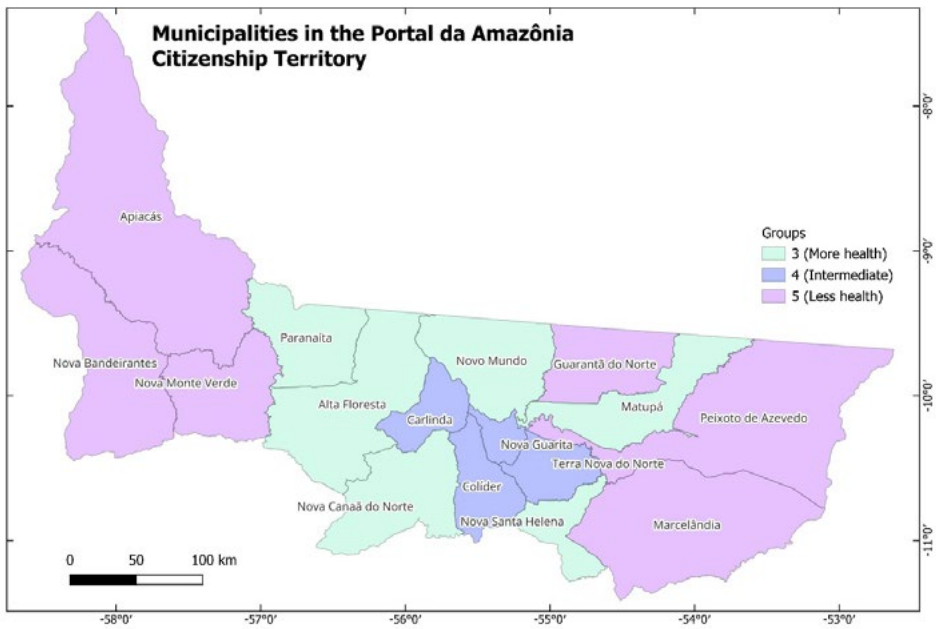


Source: Prepared by the authors.

Groups 1 and 2 are characterized by hypothetical municipalities entitled “less health” and “more health” respectively, which were isolated from the other municipalities of the *Portal da Amazônia*. Group 3 was characterized as the closest group to the “more health” model (Alta Floresta, Matupá, Nova Canaã do Norte, Nova Santa Helena, Novo Mundo, and Paranaíta); Group 4 was categorized as intermediate (Carlinda, Colíder, Nova Guarita, Terra Nova do Norte); and Group 5 is the closest to the “less health” model Apiacás, Guarantã do Norte, Marcelândia, Nova Bandeirantes, Nova Monte Verde, and Peixoto de Azevedo).

The three clusters of the municipalities of the *Portal da Amazônia* synthesize the stages of expansion of the agricultural border in this territory (Figure 4), from the point of view of the degree of consolidation of the agricultural border. This approach helps us to understand the categories of more or less health adopted in this study. To this end, the starting point is the understanding that the recently occupied areas (New Border) have as their main milestone the recent conversion of the Amazon forest into areas of pastures and crops. In family farming properties, this phenomenon is characterized by the implementation of subsistence agriculture, based mainly on the production of bovine milk. In agricultural estates, in turn, open areas are converted into pastures for the production of beef or grain.

Figure 4 | Spatial representation of health groupings of the territory of the municipalities of the territory of the *Portal da Amazônia* Citizenship Territory



Source: Prepared by the authors

In the municipalities where the border is in a more advanced stage of occupation (Consolidated Border), we can see the frank expansion of the production of agricultural commodities, such as soybeans and corn. It is also observed an advanced stage of consolidation of family agriculture in rural settlements, created through government policies or spontaneous occupation. These are municipalities that offer, roughly, better access to infrastructure such as basic services like health and education (Rodrigues; Buschbacher, 2021; Rodrigues, 2017).

In the Consolidated Border, accumulated deforestation is high, due to the long trajectory of forest opening, as observed in group 4 (Carlinda, Colíder, Nova Guarita, Terra Nova do Norte), categorized as intermediate in terms of Territory Health. These municipalities are smaller, in terms of area, compared to the other municipalities in the territory. They were occupied between the 1970s and 1990s through rural settlement projects, whose pioneering activities focused on small-scale subsistence agriculture (from 2 to 400 ha). The level of consolidation of the border in these municipalities is associated with greater population access to infrastructure. Thus, although deforestation occupies vast areas and there is a higher rate of fires, access to health and education services places municipalities in a position of advantage in terms of territory health, compared to the other municipalities.

Group 5, closer to the "less health" model, brings together municipalities in which the agricultural occupation is more recent (Apiacás, Guarantã do Norte, Marcelândia, Nova Bandeirantes, Nova Monte Verde, and Peixoto de Azevedo). This most recent occupation does not necessarily concern the beginning of the military government-led colonization projects in the 1970s and 1980s, but probably a slower occupation process that extended the time for the conversion of the forest into arable areas. One of the explanations for the phenomenon is the gold prospectors who proliferated in part of these municipalities until the mid-1990s, especially in Peixoto de Azevedo. In this New Border, deforestation rates and areas occupied with soybeans and pastures are lower. However, a higher number of fires is observed, probably due to the use of fire for cleaning recently opened areas. These are municipalities with lower average GDP, but the best average for the structure of rural schools. Although they converge on the variables adopted in the study, these are municipalities

with particularities that deserve to be highlighted. In the case of Apiacás, for example, much of its territory is occupied by the Juruena National Park, which overlaps with indigenous lands (Kayabi, Munduruku, and Apiaka). On the other end, in terms of agricultural occupation, is Guarantã do Norte, a municipality crossed by the BR-163 (Cuiabá-Santarém), through which a significant portion of the soybean produced in Mato Grosso is transported, mainly to the Port of Miritituba, in Pará.

The municipalities that makeup Group 3, closer to the model of "more health" (Alta Floresta, Matupá, Nova Canaã do Norte, Nova Santa Helena, Novo Mundo, and Paranaíta), are in an intermediate category to Groups 4 and 5. The presence of family farming areas is not as large as in Group 4, either due to the larger area or the presence of medium and large farmers, occupying larger areas, which probably makes the average GDP of these municipalities almost double the other groups. They are municipalities of Consolidated Borders, widely deforested, and occupied by pastures and grain crops.

The categorization of municipalities based on variables of economy, collective health, food security, and environmental quality, for a proposition of ecosystem approach to the territory health presents weaknesses. Some important data were not used because they were outdated at the time of collection, such as the Gini index, which could express a contribution of the economy to health better than the GDP. The territory presents striking contrasts that were not included in the analysis, for example, the socioeconomic inequalities between rich urban areas and agribusiness farms, on the one hand, and the poverty of urban peripheries (IORIS, 2020).

Another difficulty faced was the total absence of organized public data available on animal health. Based on the concepts of One Health and EcoHealth, we also defined the collection of data on the prevalence of tuberculosis and bovine brucellosis, related to animal health (considering the wide occurrence of pasture production systems – predominant in rural properties in much of the territory). The INDEA – Institute of Agricultural Defense of Mato Grosso (state autarchy, linked to the State Secretariat of Economic Development of the state, with 14 regional units) was the body consulted, but no organized public data was found on these occurrences for the municipalities.

This can be identified as a gap in the use of these concepts (One Health and Eco Health) for the definition of global health in municipalities based on the definition of the concept of territory health, due to the absence/inclusion of data on animal health in the analysis.

Another important aspect to be mentioned is the interaction between the variables. When we adopted the largest GDP as a prerequisite to building the concept of Territory Health, we had to consider that, on the agricultural border of the Amazon, the generation of GDP in a given municipality is associated with a larger deforested area and, as a correlation, with a high rate of fires. Thus, while the GDP pulls the health of the territory upwards, deforestation and fires pull it down to the lower health position. It is in its equivalence that we build the model, a possible approximation, based on the existing data.

CONCLUSIONS

The debate on strategies for sustainable development for the Amazon includes thinking about innovative ways to address wealth generation, environmental preservation, types of soil occupation, and public policies in the society-environment interface. Climate change, biodiversity preservation, and waste generation are on the agenda and represent elements of national and international pressure on the design of development strategies in a region marked by heterogeneity and a history of contradictory development policies. On the other hand, one cannot ignore the costs, mainly social, taken on locally while a truly sustainable development solution is not made operational.

The present work was based on the discussion involving environmental health and territorial development to introduce the idea of Territorial Health, understood as a latent medium through which the construction of institutions and cooperation bonds take place to identify and solve common problems. From this analytical perspective, the environment is part of the development context and not an addendum to it. The model is centered on the relationships between the dimensions of development and not on the isolated assessment of each of its components. The model created is considered innovative because it places the economy, human health, and the health of the environment in relationship to and interacting with each other, in an approach that reflects the desirable place for

the development of a territory in the Amazon context. The effort is valid for making room for new analyses, as well as for the creation of programs and policies adapted to the conditions of the border, according to their level of consolidation. Thus, what we can take from the exercise of creating an ecosystem approach to territorial health are indications of compensatory movements in the fields of economics and human and ecosystem health, when these are in imbalance. For example, in the municipalities of Nova Fronteira seen in the Portal da Amazônia, the scarcity of economic resources, along with recent deforestation, demonstrates the need for government strategies in the construction of models of agricultural occupation adapted to the characteristics of the biome. In municipalities where family agriculture advances in forest environments, activities such as plant extractivism in non-timber species, with adequate management, could mitigate deforestation and climate changes while generating income and health in the territory.

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