Rural productive inclusion and sustainable (agri-)food systems: the geography of transitions

Inclusão produtiva rural e sistemas (agro)alimentares sustentáveis: geografia das transições

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ABSTRACT

The transition to sustainable food systems can provide opportunities for the productive inclusion of people in situations of exclusion, especially in rural areas, and contribute to reducing the effects of the climate crisis. This study aims to understand productive and sustainable inclusion cases in rural areas and verify the role of public policies. The experiences studied in two regions of the Brazilian Northeast characterise innovation niches, highlighting the generation of new technical and social solutions that trigger a transition to sustainable and inclusive food systems. Using a quali-quantitative methodology, we analysed the cases' socio-technical configurations (STCA) within the scope of transition studies and network analysis. The results show the importance of family farmers' cognitive and organisational capacities. In conclusion, policies supporting these emerging niches must be strengthened according to

the territorial context. Finally, mitigating the adverse effects of external environmental technologies, such as wind energy, on rural communities is essential.

Keywords: Productive inclusion. Sociotechnical transitions. Food regimes. Food systems. Agroecology.

RESUMO

A transição para a sustentabilidade dos sistemas alimentares pode oferecer oportunidades para a inclusão produtiva em contextos de exclusão, sobretudo nas áreas rurais, e contribuir para o enfrentamento da crise climática. Este estudo tem o objetivo de compreender casos de inclusão produtiva e sustentável em meio rural e verificar o papel das políticas públicas. As experiências estudadas, em duas regiões do Nordeste brasileiro, caracterizam-se como nichos de inovação, ressaltando as soluções técnicas e sociais que conduzem à transição para sistemas sustentáveis e inclusivos. Mediante uma metodologia qualiquantitativa, procedeu-se à análise das configurações sociotécnicas (ACST) no âmbito dos estudos de transições e análise de redes. Os resultados mostram a importância das capacidades cognitivas e organizativas oriundas de agricultores familiares. Conclui-se que é necessário fortalecer as políticas que apoiem esses nichos emergentes, conforme o contexto territorial. Por fim, é fundamental mitigar os efeitos negativos das tecnologias ambientais externas, como a energia eólica, sobre as comunidades rurais.

Palavras-chave: *Inclusão produtiva. Transições sociotécnicas. Regimes alimentares. Sistemas alimentares. Agroecologia.*

1 INTRODUCTION

This paper aims to present the results of studies on rural and sustainable productive inclusion in the Northeast of Brazil, with the potential to guide new research agendas on the subject and contribute to the development of public policies for rural productive inclusion (RPI). The situation of vulnerability of a significant portion of the Brazilian population in recent years is proven by official data indicating that, in 2017, hunger (severe food insecurity) was present in 10.3 million people, with 36.7% of households having some level of food insecurity (84.9 million people) (IBGE, 2020).

This situation was exacerbated by the Covid-19 pandemic, starting in 2020, especially in rural areas, substantially affecting the productivity of small agricultural businesses, the improvement of market access strategies, and the productive inclusion associated with the promotion of food security (Veredas, 2020). However, some studies (Veredas, 2019 and 2020) have highlighted a series of alternative food systems throughout the country, which have strengthened short commercialisation circuits, appropriated innovations to some extent, and regained control over territorial food supply flows.

Based on the assumption that social exclusion is a multidimensional process, this analysis aimed to identify productive aspects and commercial combinations that could generate RPI processes in different contexts and with the participation of various social actors. At the same time, the analysis conceptualised these experiences as innovation niches that could lead to a transition towards sustainable and inclusive food systems.

The analysis used a theoretical framework closely linked to the applied methodology to address these objectives. In addition to the concepts of RPI and inclusive innovation, the study applied a multilevel perspective of socio-technical transitions (Geels, 2019; Geels; Schot, 2007), which addresses transitions in their inseparable social and technological aspects, as well as its strand that considers the territorial dimension, known as the geography of sustainability transitions (Binz *et al*., 2020; Truffer *et al*., 2015).

The text has five parts in addition to this introduction. The next part describes the conceptual basis of the study used as theoretical support. The third part presents the study's methodology, contextualising its conceptual basis and describing tools and procedures. The fourth part explains the results of the analysis of the configurations with a discussion of relevant aspects of the study, and the fifth part ends with the conclusions section.

2 THEORETICAL BASIS: SOCIO-TECHNICAL TRANSITIONS AND GEOGRAPHY OF TRANSITIONS

The conceptual basis of this study connects to the approach to socio-technical transitions, also known as the multilevel perspective (MLP) (Geels, 2002, 2019; Geels; Schot, 2007). These theories analyse social transformations that lead to the transition to more sustainable systems that may, for example, refer to industrial, energy, housing, or food systems. Following this approach, the systems are named "socio-technical" because they emphasise the inseparable union between technology and social aspects for transitions. In this regard, MLP defines three levels of focus for transitions (Geels; Schot, 2007): the technical niche that appears at the micro level where innovations emerge; the socio-technical regime (meso level) that refers to routines and techniques shared by a productive sector and its respective institutions (science, markets, policies, culture, etc.) forming a homogeneous and stable set; and the socio-technical panorama that concerns the macro level, that is, the exogenous contexts that can influence niches and regimes (for example, macroeconomic events, profound changes in the cultural pattern, etc.).

The approach is based on the existence of established socio-technical regimes that are thus dominant in their sectoral spectrum and other areas of society. The idea of transition is precisely the replacement or partial transformation of the established regime by an emerging one. Historically, transitions have occurred from the emergence of new technical niches that innovate within the field of an existing regime (Schot; Kanger, 2018).

The success of these niches depends on several factors, the most important of which is the creation of a critical mass (in quantity and quality) of niches that follow the same socio-technical trajectory. In turn, panoramas play an important role as an exogenous disruptive element concerning the regime and, therefore, can help in the emergence of new niches.

However, it is important to emphasise that the MLP proposal has also been criticised. One of the main initiators and propagators of this perspective, Frank Geels (2011), received and discussed several questions about its foundations. In this work, he pointed out the main criticisms as a lack of agency, difficulty in operationalising and specifying socio-technical regimes, methodological concerns (especially with data sources), and a lack of attention to socio-technical panoramas, among others. While he answered some criticisms categorically (in defense of the proposal), he valued others as challenges to be faced within the scope of the difficult task of studying socio-technical changes.

However, two criticisms have emerged in recent years regarding the MLP and are fundamental to this work. One of them points to the lack of attention to the spatial aspects of transitions, that is, neglecting the specificity of places and the geography of intra-organizational relationships of actors in general (Kanger, 2022; Köhler *et al*., 2019). As a result, economic geographers have suggested a new approach known as the geography of sustainability transitions (Binz *et al*., 2020; Hansen; Coenen, 2015; Truffer *et al*., 2015) that adds the spatial dimension to transition studies.

Another point of criticism is the lack of attention paid to studies on the transition of food systems compared to other supposedly more relevant topics, such as energy or mobility (El Bilali, 2019). Indeed, agri-food activities have a significant impact on the environment as they are responsible for a quarter

of global greenhouse gas emissions (Ritchie *et al*., 2022). To address this deficit, the geography of transitions is proposed as an ideal approach for analysing food transitions.

This analysis is relevant considering that food systems are one of the areas that emerge as an opportunity to promote RPI due to its interdependencies with other dimensions such as health, economy, and the environment (Favareto *et al*., 2022). Investigating how, in these domains, it is possible to generate inclusion processes from the study of practical experiences implies the observation of a set of variables that, in the same way, configure different types of inclusion. It is understood that research must approach the problem of RPI from a multidimensional perspective that takes into account both the interdependencies between the domains to promote inclusion and the context and particularities of the territories which contain the experiences of productive inclusion (Favareto *et al*., 2022; Veredas, 2019, 2020).

3 METHODOLOGY

The study was performed in the territories of Itapipoca in the state of Ceará and Polo da Borborema in Paraíba, Brazil. The choice of these two regions came from a previous study that developed the Typology of Rural Productive Inclusion (TIPR) (Valencia *et al*., 2022a, 2022b). This typology analysed 66 experiences of family farming documented in databases, selecting 33 of these experiences from the North, Northeast, and South regions of the country. The study classified these experiences into different types based on two criteria: capacity for technical and social innovation, and level of interaction or cooperation among farmers. Both territories analysed in this article are among the most robust in the typology (TIPR), whether in terms of innovation or cooperation, hence their choice.

The study used the methodology proposed by Heiberg *et al*. (2022) and Miörner *et al*. (2021), known as Socio-technical Configurations Analysis (STCA), to identify socio-technical transitions in the niches. This set of qualitative and quantitative procedures was developed within the scope of the geography of socio-technical transitions (Binz *et al*., 2020; Hansen; Coenen, 2015; Truffer *et al*., 2015). Based on a body of selected discourses (qualitative data), this approach seeks to establish the social and economic relations of subjects and ideas through quantitative metrics. In addition, this methodology faces the problem of the lack of consideration of territorial aspects (spaces, scales, and places) in studies on transitions (Köhler *et al*., 2019). Therefore, it is a recent and original methodology that contributes significantly to understanding socio-technical transitions – an approach considered the most relevant among the set of theories of socio-technical change (Sovacool; Hess, 2017). Despite being recent, the methodology has been applied in some sectors like water supply (Heiberg *et al*., 2022; Miörner *et al*., 2022), energy (Markard *et al*., 2021), and sanitation (Lesch *et al*., 2023).

STCA seeks to visualise and measure the processes of social and economic alignment in contexts of transitions in time and territory. These alignments are characterised as sets of actors and institutions (or innovation niches) that form a configuration that functions successfully regarding socioeconomic development in a specific economic sector and geographic context. In addition to determining these transition trajectories, this methodology also seeks to verify the role of existing socio-technical regimes (in the same sector of the niche) that may threaten these emerging trajectories.

The combination of actors, institutions, technologies, and networks from a specific sector constitutes these socio-technical configurations. Thus, the method starts with determining two types of basic elements. On the one hand, the actors can be people, leaders, or institutions such as government entities or organised civil society. By definition, both actors have some relevance in the context under study. On the other hand, there are the concepts: technologies, values, activities, or actions of the context.

The methodology begins with semi-structured interviews with key actors in the territorial contexts of Itapipoca, Ceará, and Borborema, Paraíba. The interviews sought to reveal local organisational aspects,

successful productive experiences, difficulties, relationships with external agents, and policies, among others. Consequently, all the elements explain the organisation and socioeconomic development of these territories.

The research used discourse analysis to define local social networks for food production development in these regions. The main objective of the interviews was to understand the broad and central alignments of these innovation niches and not their particular aspects. Ultimately, the STCA aims to investigate the general and not specific aspects of the social and economic alignments that explain these realities. In this regard, the study conducted five groups of interviews in Ceará, of which three were chosen (Balanço do Coqueiro, Cetra, and the network of market vendors), and four groups in Paraíba, of which two were used (POLO network and ASPTA). These choices resulted from the significance and representativeness of the interviews for the niches.

The study constructed a matrix of relationships between actors and concepts from the transcripts of the interviews with key actors. In other words, the actor-concept matrix is formed by several rows corresponding to the number of actors, and the columns to the number of concepts (Table 1). The values of the matrix correspond to the existence of a relationship (value 1) or not (value 0) between the respective actors and concepts. The relationship networks are established based on the matrices.

Table 1 – Hypothetical actor-concept matrix (A = actors, C = concepts).

	C1	*C2*	*C3*	*C4*	*C5*
A1	0	0	1	1	1
A2	1	1	0	0	0
A3	0	0	1	0	1
A4	1	0	0	0	1

Source: elaborated by the authors

To perform STCA, one works with the matrix of relations between concepts (concept-concept), quoted by the number of actors that relate each pair of concepts. In other words, a matrix similar to Table 1, however, where the rows and columns are the same, the list of concepts; therefore, the same number of rows and columns (square matrix). Each cell of this matrix (the relation between a pair of concepts) is filled with the number of actors that configure the relationship. This matrix (concepts-concepts) is obtained through the relatedness technique (Balland, 2017). The procedure provides, from the actors-concepts matrix, a matrix of concepts-concepts with the respective numbers of actors.

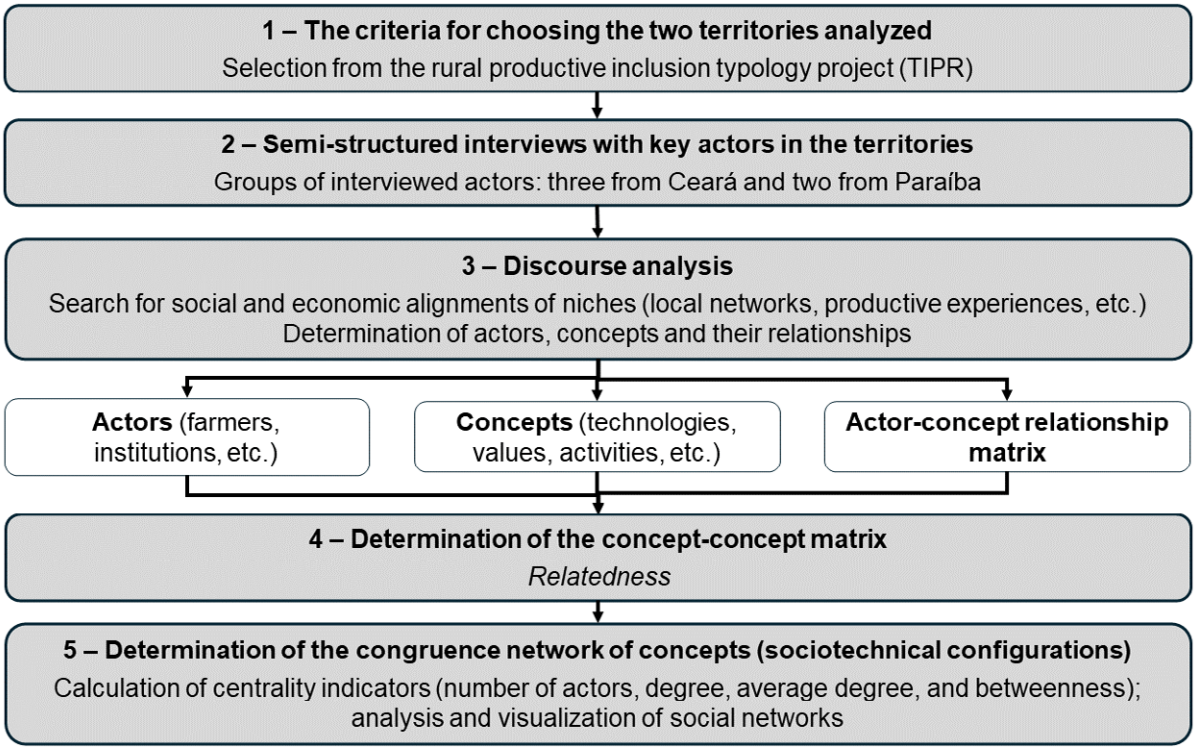

Figure 1 – Methodological diagram of analysis of socio-technical configurations (STCA)

Source: elaborated by the authors.

These operations result in the matrix (concepts-concepts) to construct the STCA network (Figure 1). This network is composed of the configuration concepts and is called the Concept Congruence Network. Centrality indicators can be applied to it, such as density (degree), referring to the number of connections of an element in the network, and intermediation centrality (betweenness), which measures the intermediation capacity of an element (Hanneman; Riddle, 2005).

These networks are presented through a radial centrality network (Figure 2). The circles (light blue) refer to the density values, that is, the closer the concept is to the center, the more connections it has; and the widths of the lines connecting concepts correspond to the degree of betweenness. The concepts (represented by colored circles) are subdivided into three types: innovation niches of an emerging system (green circles), dominant system (dark blue circles), and regulation or policies (red circles).

Furthermore, some global indexes were calculated for each network, such as absolute and average densities (average number of actors per concept). These indicators measure the connectivity between network elements, allowing comparison between different networks.

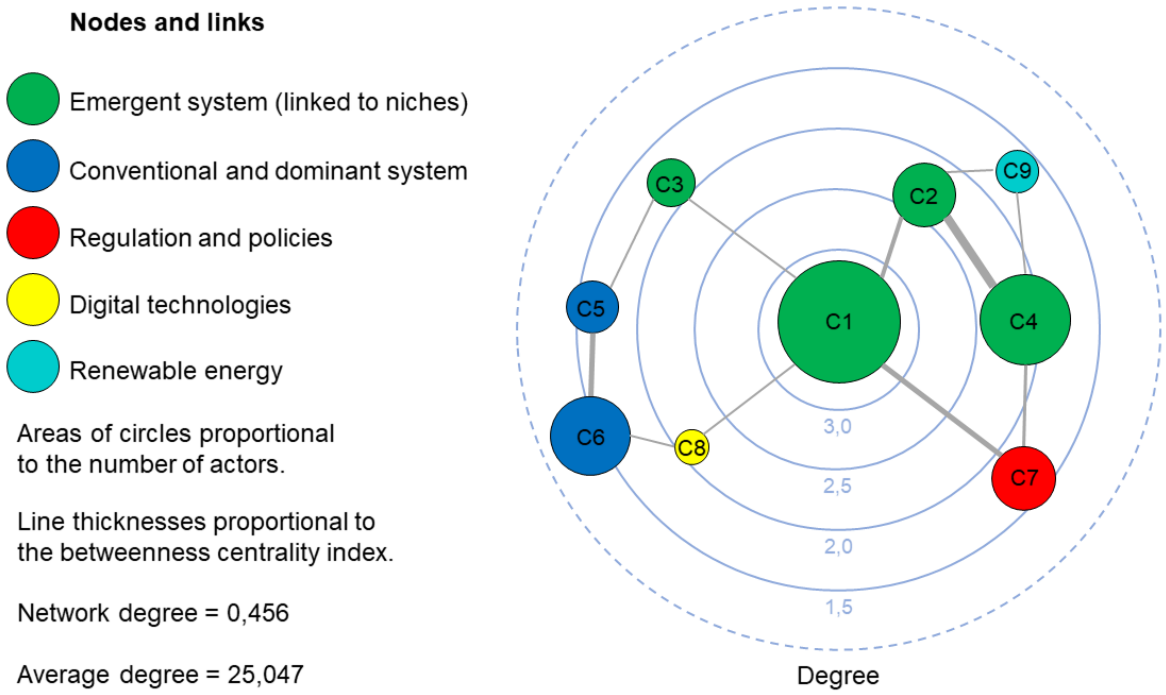

Figure 2 – Hypothetical network of concept congruence (C = concept)

Source: elaborated by the authors.

Network visualisation and indicators allow the understanding of the alignment of configurations in each context. Thus, several aspects of the configurations can be identified as exemplified below:

- Lines demarcate connections between concepts;
- The more central the network, the greater the concept's capacity to relate to other concepts (density), which shows its power to influence the configuration;
- The larger the size of the circles, the greater the number of actors linked to the concept, which denotes the capacity for engagement/linking to the concept;
- The greater the width of the lines connecting the concepts, the greater the capacity for intermediation, that is, for being important entities in the network that links different groups of concepts – another way of indicating the degree of influence of the concept in the network.
- The network density indicator shows that, for example, the network in Figure 2 has almost half (0,456) of the possible connections between knots (concepts) in the network, meaning that the global structure of the network is well connected.

In this way, it is possible to verify the influence of certain concepts (technologies, forms of organisation, etc.) in the context in question. Identifying, at the same time, the power these configurations have in the network of relationships as a whole, the degree of institutionalisation (formal and informal), and, equally, confronting the antagonistic socio-technical systems (or regimes).

The social networks from the STCA resulted in robust sets of information in both territories under study. Thus, the quantitative data from the analysis of all five groups of these territories show that 447

actors were evaluated, and an overall average of 3.57 actors for each concept, revealing the complexity of the sociotechnical configurations existing in these contexts.

4 RESULTS AND DISCUSSION

The regions of this study, located in the states of Ceará and Paraíba, have reached the present day after several heterogeneous and differentiated transformations in their respective food regimes over time. These regimes are characterised by social and economic inequalities, and by the exclusion of traditional family farming from opportunities and support given to modern agriculture. In the recent period, the dominant regime has been of a transnational corporate nature that often appropriates environmentalist discourse to strengthen the private domain of food to the detriment of public food models – here defined as the conventional and dominant socio-technical agrifood regime (McMichael, 2016).

Facing this prevailing regime are the niches targeted by this study, which identify them as experiences of social and technical innovation. They support a potential new regime under construction, marked by healthy and sustainable food production within the scope of agroecology and, mainly, by a local community logic based on the territory. Thus, the current socio-technical configurations of the two regions under analysis are presented below, contrasting in different ways with the dominant regime.

It is important to remember that studies on innovation generally highlight that denser networks of actors (large numbers of actors and links between them) are often associated with situations of greater capacity for innovation, which depends on the territorial context in terms of trust and shared conventions (Glückler, 2007; Glückler; Doreian, 2016; Glückler *et al*., 2017).

4.1 NICHES OF INNOVATION: NETWORKS IN ITAPIPOCA, CEARÁ

The territory of the Curu and Aracatiaçu Valleys, historically occupied by the Tremembé indigenous people, *quilombola*s (maroon societies), and peasants, has seen an increase in agrarian tensions and the beginning of the struggle for access to land during its agricultural modernisation process (centered on sugar cane and coconut in the 1970s). At the same time, these tensions became more pronounced at the beginning of this century, given the tourism developments on the territory's coast (Souza, 2010, p. 22). However, it was also a time when the notion of territorial development gained national emergence, and historical struggles gained legitimacy and visibility based on actions to strengthen family farming through training based on agroecology.

The Network of Agroecological Farmers of the territory emerged through the training process in Agroecology in 2005, promoted by Cetra with the support of international cooperation. From this training, a group of farmers – from the municipalities of Itapipoca, Trairi, Tururu, Irauçuba, Apuiarés, and Amontada – decided to create the Agroecological and Solidarity Market of Itapipoca. The market became a kind of "extension of the training activity, providing the opportunity for meetings, exchange of information, and expansion of the network's reach, with gradual incorporation of new participants" (Souza, 2010, p. 23, freely translated).

Operating once a week, the market aims to dynamise the production of rural families, provide healthy food, and ensure an increase in family income (ACCV, 2021). Coordinated by the farmers themselves, the Itapipoca experience has been consolidating and encouraging the creation of new markets in other territories. The Network of Agroecological and Solidarity Markets was created in 2019, involving around 300 farming families, young people, *quilombolas*, and Indigenous people through training, network meetings, and strengthening of agroecological and solidarity experiences in the municipalities and territories (Cetra, 2024).

Two initiatives of the Network are worth highlighting: the first is the creation of a monthly agroecological market in Fortaleza (Ceará) with the participation of farmers from the Network, involving all territories under the assistance of Cetra. Since not all market vendors can participate, there is a coordinated action that consists of market participants bringing products from their neighbors to sell and then passing the money on to the producer.

The second initiative appears in the context of the pandemic, with the organisation of groups of customers to make online sales. Based on pre-existing contacts, with the help of their children and advisors, they began to offer a "menu" of products every week to their old customers. As a result, new customers emerged and joined the online sales groups of the market vendors. In addition to more customers, online sales required the families of the market vendors to improve planning in their production, whether for family consumption or the newly created market. It was also an important mechanism in the sense that some family members began to participate more in the sales process (preparation of products, packaging, deliveries, search for new payment methods, etc.).

Regarding the greater involvement of family members, it is worth highlighting the role of young people in this process, especially a group of young people called "Balanço do Coqueiro" from the Maceió Settlement (historically important in the fight for land in the region), in Itapipoca. The group is composed of young people from settler families, and its "organisational" action began as an artistic-cultural movement, to later be complemented with productive actions, such as the production of coconut oil using the pressing method, as well as innovation in the presentation of the product (labeling, packaging with different volumes, search for new markets, online sales, in addition to already consolidated markets such as agroecological markets).

This action facilitated the inclusion of other young people, the diversification of opportunities for income generation and appropriation of cultural identity, and the succession of farmers from older generations.

This is the context that constitutes the three studied niches: Balanço do Coqueiro (BC), Cetra, and Rede dos Feirantes ("Marketers' Network" - FF). Together, these experiences make the notable niche of agroecological markets in the territory of the Curu and Aracatiaçu Valleys, advised by Cetra and actively participated in by BC.

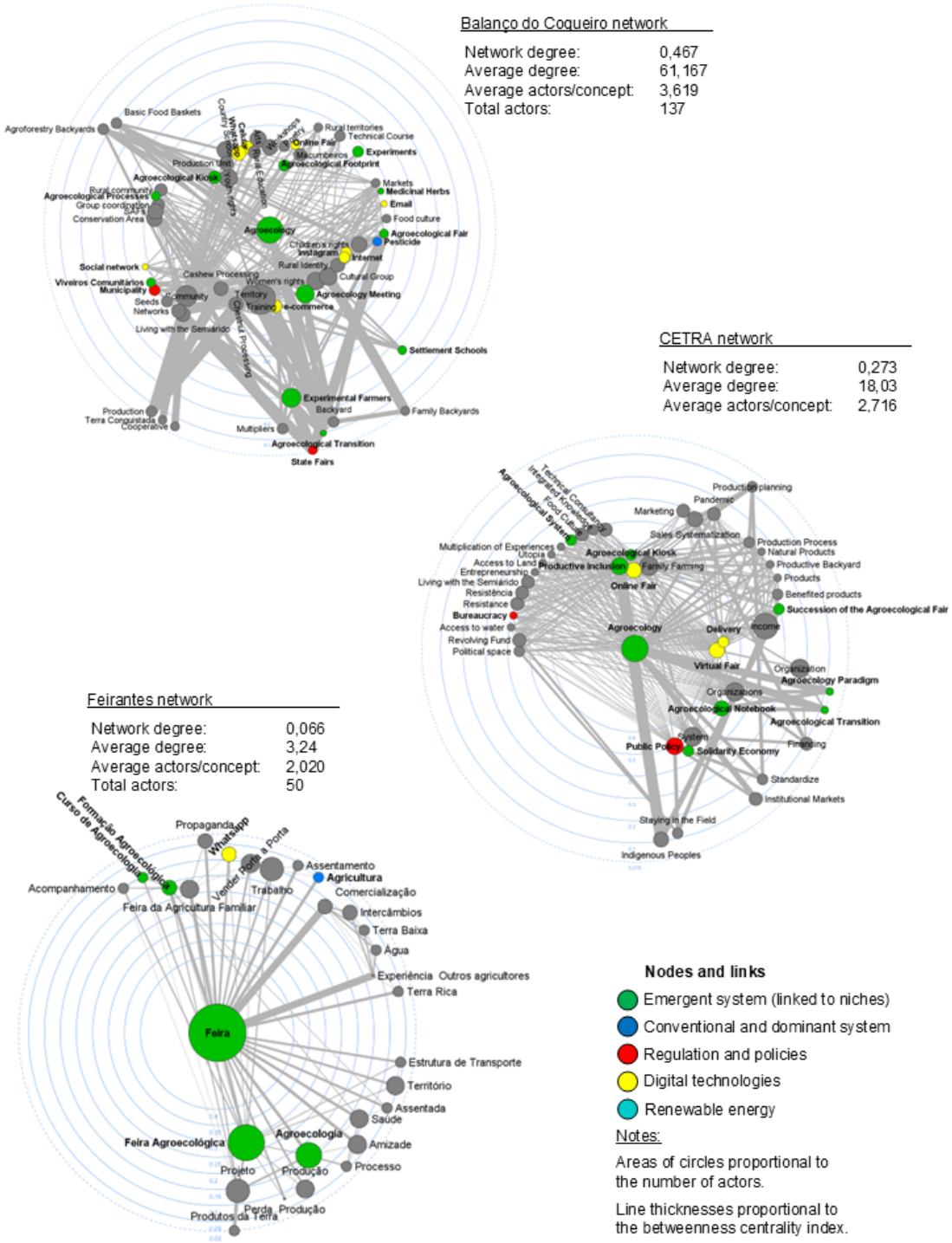

Figure 3 – Congruence networks of socio-technical configurations in Ceará

Source: elaborated by the authors.

General network statistics show that BC and Cetra are clearly denser and more complex networks than FF (Figure 3). This result is partly explained by the smaller number of actors involved in the latter (137, 95, and 50, respectively). Furthermore, among the two densest networks, the BC network is the most powerful in terms of density/volume of links, as it has a higher total and average density, average number of actors per concept, and even total number of actors. It is worth remembering that greater density presupposes a likely greater capacity for social cooperation in the respective network and, therefore, a greater possibility of innovations, as indicated by the literature on innovation studies (Glückler *et al*., 2017). Furthermore, the strongest connections between concepts (identified by the

width of the lines in the figure – betweenness centrality) clearly show the strong configurations in the BC network, while the other two do not.

In the BC configuration, agroecology is the center of the network, that is, the emerging regime linked to the studied niches. From this central point, at least four clusters of closer concepts are identifiable. One in the northern quadrant, clearly linked to agroecology (with the concepts "agroecological kiosk" and "agroecological footprint") and two other determining aspects. The first is related to digital technologies with the use of "cell phones" and "WhatsApp" and, therefore, goes in the direction of production commercialisation ("online market"). The second determining aspect is creativity in the sense of "arts" (for example, "poetry"). Added to this is a point of religiosity of African origin with the "Macumbeiros". To this group, we must add technical education ("technical course", "Rural School" and "workshops"). This leads to the connection between agroecological production, digitalisation, and creativity. This union exposes a convergence of different types of knowledge (analytical, synthetic, and symbolic) relevant to innovation processes (Asheim, 2007).

In the southeast portion, the influence of digital technologies ("internet", "e-mail", and "Instagram") is once again visible, aiming to access new markets ("online commerce" and "Agroecological Market"). In this sector, it is interesting to highlight the importance of the discussion on human rights ("women's rights" and "children's rights"). In terms of production, this group is linked to the "processing" of "cashew" and "nut".

In the small group to the southwest, the importance of "seeds" emerges with a territorial culture character marked by "coexistence with the semi-arid region" within configurations linked to "social networks". However, one can also observe the role of the government ("municipality") in the sense of collective actions ("community nurseries"). Here, another government element also deserves to be highlighted: that of the "state markets", located in the southernmost portion. Despite being on the edge of the network densities (outermost circles as described in the methodology section), this group is a point of union of both previous sectors (southeast and southwest). This group mentions the agroecological transition.

In this configuration, the dominant regime linked to the use of "agrochemicals" is represented in the middle of the southeast group, which characterises a possible attempt to confluence different types of conflicting regimes, where farmers are forced to choose between one or the other - a possible situation in transition processes (Geels; Schot, 2007).

As the second densest, **Cetra network** presents a simpler configuration centered on "agroecology". Just above the central concept, to the north, is "family farming", strengthened by agroecological activities ("agroecological kiosk") and digital technologies ("online market"), and with the objective of "productive inclusion".

This sector is linked to two aspects. One in the west-northwest portion is related to the difficulties for the "agroecological system", such as "bureaucracy", and elements of "resistance", the search for "political space" and "access to land". The ways to overcome these obstacles are "entrepreneurship", "technical consultancy" and "integrated knowledge" for the "multiplication of experiences". Here, it is important to highlight the search for a new, more sustainable reality linked to "food culture" as a "utopia".

The second aspect is located in the east-northeast sector and concerns, in particular, "income". Here, the fundamental elements are "production planning", "sales systematization", "processed products" and "fresh products". A prominent concern is the "succession of the ecological market" to maintain activities since the pioneering stallholders are aging - a relevant challenge for the evolution of a new regime.

In the southeast portion, the constituent elements of an "agroecological transition" are observed: digital technologies ("delivery" and "virtual market"), the role of "policy" linked to the "solidarity economy"

and "institutional markets". Here, "Indigenous peoples" (at the southern end of the configuration) also appear as an important node for "productive inclusion", demanding an improvement in "income".

The **FF network** is the least dense, but very important for the information it generates. The central point is the concept of "market", as could not be otherwise in this case. The latter is associated with two groups of concepts: the south-southeast group, the most relevant, because it brings together the "agroecological market" and "agroecology" itself (concepts with a significant number of actors). On the other side, there is the north-northeast group, linked to agroecological learning ("agroecology course" and "agroecological training"), digital technologies ("WhatsApp"), and "commercialisation". Included in this group is conventional agriculture (dominant regime), which is basically present at the markets, often in conflict, but sometimes as an opportunity to seek customer loyalty for agroecological stallholders.

The set of these three networks in Ceará highlights the centrality of agroecology as a beacon of niches around differentiated production, through sustainability and collective work. The main characteristics of this group of socio-technical configurations are:

- Local community and social organisation as the main strength of experiences;
- Important role of digital technologies in accessing markets, basically related to mobile devices and digital social media (which was strengthened by the occurrence of the Covid-19 pandemic);
- Little presence of policies as a structuring or supporting element of experiences, which characterises a weakness in the sense of strengthening actions and disseminating knowledge; and
- Intense confrontation of niches with the dominant conventional regime, especially in the Cetra network, resulting from a historical process of exclusion and economic inequality, and the search for social rights by rural popular sectors reflected in the differentiation between socio-technical systems.

4.2 NICHES OF INNOVATION: NETWORKS AT POLO BORBOREMA, PARAÍBA

Polo ("hub") Borborema results from a long tradition of social and political resistance to political and economic situations that are adverse to peasant agriculture. It is currently structured by the articulation of 13 rural workers' unions, 150 community associations, a regional association of agroecological producers – EcoBorborema – and the CoopBorborema cooperative, also formed by family farmers. (Interview AS-PTA, 2023).

The networks promoted by Polo Borborema include Rural Workers' Unions, non-governmental organisations such as AS-PTA, and forums of civil society organisations, such as the *Articulação do Semiárido Paraibano* ("Articulation of the Semiarid in Paraíba" - ASA-PB). As a political actor, the hub has built a proposal for local development and the promotion of agroecology (Silveira *et al.*, 2010).

One path to productive inclusion in this territory is through the 12 fixed agroecological markets, held weekly in several municipalities, and another seven markets that take place at specific events, such as the Women's March, youth meetings, the harvest festival, and three markets organised at the state level, in partnership with the ASA-PB.

The management of the markets is defined by a group of stallholders (organisation rules, space management, market fund management, adjustments to functioning). This management is done

monthly in itinerant meetings on the stallholders' properties, which also contributes to the participatory certification of agroecological products.

In addition to the markets, recent "agroecological grocery stores" have a prominent role for women farmers in the region. Since the beginning of the formation of Polo Borborema, a group of women has consolidated around the theme of "health and food", bringing the debate to the center of the actions on agroecology. Actions have advanced with the improvement and implementation of agroecological yards, small animal farming, productive diversification in economic plots, processing of production, and, lastly, the installation of a kitchen school.

In this context, the niches under analysis are configured as follows: the workers' union organisation of Polo Borborema and the non-governmental organisation AS-PTA. The statistical data of the respective socio-technical configurations show that both networks are dense in links between concepts and, consequently, the actors involved (Figure 4). However, an interesting difference is that ASPTA has a lower total and average density despite having a considerably larger number of actors (99) than the Polo (66) (in any case, close in intensity). This means the Polo Network is slightly more complex and, therefore, more interconnected and active. Consequently, the Polo Network has a significant capacity for social cooperation, an essential element for innovation processes (Glückler *et al*., 2017). Furthermore, these configurations are involved in conflicts with other socio-technical regimes.

The **configuration of the POLO network** does not present a single central concept but rather a set of central themes (represented in Figure 4 in the incomplete circle of central concepts). Even so, "agroecology" stands out (especially due to the greater number of actors), linked to the "agroecological market". In terms of emerging niches (linked to agroecology), the *Marcha das Margaridas* ("March of the Daisies") in the eastern part also deserves attention, an event for women's rights that takes place every four years. Noticeably, this mobilisation of women goes hand in hand with the "processing of agroecological cotton". Likewise, along with these are the "community vegetable bank" and the "solidarity baskets", connecting production and commercialisation (technical-productive sphere) to the fight for women's rights.

On the other hand, the role of "policy" appears to promote both agroecological production and conventional "agriculture". Related to the conventional regime is the production using "agrochemicals". In this context, the "product with agrochemicals" is close to "agroecology", but as a production that harms agroecological producers (verified in the interview transcripts). Therefore, the conventional regime (with agrochemicals) conflicts with emerging (agroecological) niches.

In this context, the contradictory and controversial role of renewable energy in the region, specifically regarding "wind energy", also deserves emphasis. As an environmentally friendly energy alternative, this technology appears to disrupt the organisation of communities and the entire trajectory of territorial construction – a problem to be discussed later. Several other studies warn of this same problem in different geographies. In the Northeast region of Brazil, the economic and physical marginalisation of local communities is observable (Gorayeb *et al*., 2018), a problem that extends to other countries in the Global South, Africa, and Asia, but also affects the Global North (Sovacool, 2021).

In the same sense, such situations of injustice occur in other supposedly sustainable sectors, such as solar and nuclear energy, electric vehicles, electronic equipment recycling, and climate change mitigation activities, among others (Marino; Ribot, 2012; Ramos-Castillo *et al*., 2017; Sovacool *et al*., 2021). These examples emphasise the dark side of technological innovations concerning both their production and use, causing harmful impacts on the environment (Coad *et al*., 2021), as well as their uneven geographical distribution of positive and negative effects between and within nations (Boschma *et al*., 2025; Pinheiro *et al*., 2022).

The **ASPTA configuration** has a central concept, "commercialisation" – the core of this network. Linked to this is "agroecology", which spreads across various aspects of the region's economic activities. There are "community seed banks" with the important contribution of "participatory certification" of products (validating their quality), and the "network of markets" and promotional actions such as *Natal sem Veneno* ("Christmas without Poison"). An example of a product in this context is "agroecological cotton".

In this scenario, the debate on rights also arises through the "Women's March", in the *northwest branch* of the network related to remarkable territorial identity aspects such as the "Semiarid" and the "Borborema territory" itself.

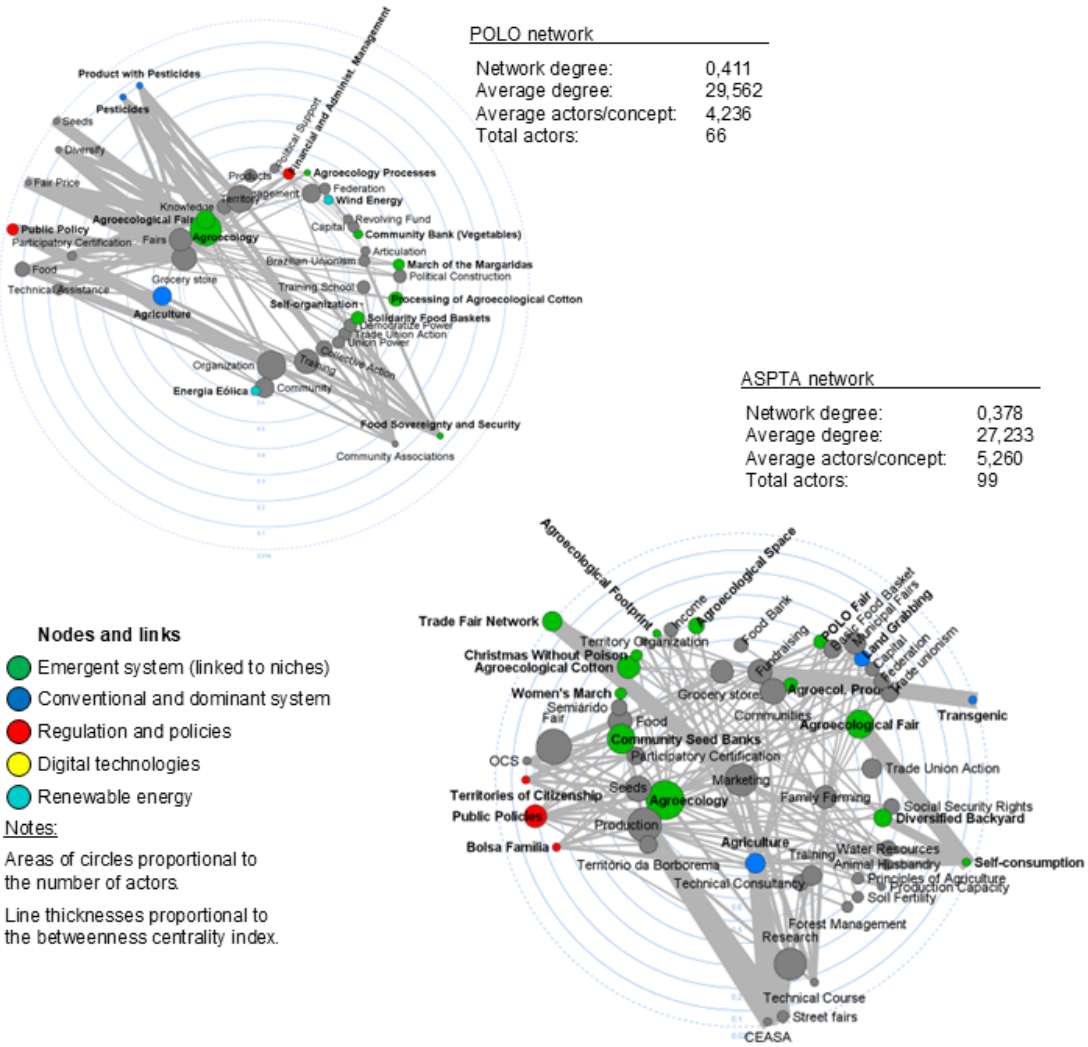

Figure 4 – Congruence networks of socio-technical configurations in Paraíba

Source: elaborated by the authors.

In terms of "policies", in the western sector, there are two important federal government programs that contributed to the formation of this production: *Territórios da Cidadania* ("Territories of Citizenship") and "Bolsa Família" ("Family Welfare"). The first program provided support mainly for "community seed banks", while "Bolsa Família" is linked to the "Agroecological Market" and the "training" of farmers.

Regarding the dominant and conventional regime, its repercussions in the northeastern portion of the network can be seen as dysfunctional in the configuration of the niches (confirmed in the

respective interviews). The two structuring elements of the regime are “transgenic” food and “land concentration”, thus defining the technological domains and access to land in this configuration. To counter these elements, the niches respond through “municipal markets” and the “POLO market” of an agroecological nature, that is, through the commercialisation of differentiated products (healthy and sustainable); and also through “unionism” or “union action”.

The combination of the two networks points to configurations that are less convergent with agroecology than in Ceará, although intense. Similar to those in Ceará, the networks in Paraíba are marked by collective work for sustainable food production, with the main characteristics being:

- Collective organisation linked to unionism and organisation;
- Technification of productive activities with a predominantly traditional character – apparent absence of digital technologies;
- Consistent presence of policies of a social and productive nature;
- Niches in confrontation with the conventional food regime and, additionally, with a contradictory regime in the area of sustainability linked to the production of renewable energy (wind).

In general, for both territories – Itapipoca in Ceará and Borborema in Paraíba – some results of the study point to a relevant element in practical and scientific terms. A transition process is related to both technical and social development - the latter referring, at least, to the minimum conditions for a creative life. In other words, referring to the important inseparable complementarity between social and technological capabilities for innovation processes (Fagerberg; Srholec, 2009). Therefore, the social organisation of the communities under analysis is an essential element in generating innovations, as pointed out by the specialised literature on social cooperation in small or multinational companies (Broekel; Boschma, 2016; Hill *et al*., 2014).

Furthermore, different knowledge bases, mainly practical and symbolic bases originating from traditional knowledge, are relevant both for innovation processes (Tartaruga, 2021) and for sustainable development (Tartaruga; Sperotto, 2021). However, it is important to emphasise that the study of these territories has as a differential the emphasis on inclusion and, therefore, the centrality of social and economic inclusion in innovations (inclusive innovations) for healthy and sustainable nutrition. These results point to facing the three main challenges of inclusive or grassroots innovations (Smith *et al*., 2014); important questions for academia (science), and the construction of development policies to reduce poverty (Kaplinsky, 2011).

First, the need for creativity on the part of local social groups to deal with the lack of access to markets and to the government. Second, the requirement for pioneering the creation or promotion of inclusive and sustainable economies through leadership and social cooperation. Finally, the convenience of trying to do things differently (in daily life, production, etc.) through new ideas based on local knowledge, thus highlighting the structural impediments to inclusive innovation.

5 CONCLUSIONS

The number of studies on sustainability transitions has grown significantly in recent years due to ongoing environmental and social transformations. In this context, food systems have a significant impact on both climate change and socioeconomic inequality processes in several regions of the world. Thus, this study verified essential aspects of understanding these phenomena in Northeastern Brazil in the recent period.

As supported by the literature on transitions, only a robust and significant constellation of relationships between territorial actors and technical innovations can bring about a true transition to a more sustainable and healthier regime for local communities, especially the most vulnerable ones. The results presented here show some degree of systematisation and organisation – an alignment – of the niches under analysis from different contexts, a fundamental characteristic to enable the emergence of a new effective socio-technical regime. However, the alignments of the niches depend, to a large extent, on informal institutions in the community, such as trust and friendship, and, to a lesser extent, on formal institutions (laws, regulations, etc.). Even so, some commendable experiences should be highlighted, such as the participatory certification of agroecological products. The strength of these informal institutions is based on the territory – Semiarid, Borborema territory, among others – as a referential substrate for the communities.

This characteristic of the niches – reduced institutional formalisation – indicates the difficulty in achieving a greater technical leap in technological development experiences. This condition can be explained by the relatively low incidence of innovation policies, especially towards capacity building, incentives for the self-organisation of groups in the territory, and access to digital technologies complementing agroecological processes. Another explanation for this situation is the pressing need for basic conditions of survival and even existence when, for example, we talk about women's or youth's rights.

However, it can be stated that social actors share cultural values that predate the formation of market networks. Social roots in the creation, control, and maintenance of these markets are important because they favour the viability of markets and, in turn, the processes of productive inclusion. The territories under analysis present niches of innovation that are still emerging but contemplate significant improvements in the social conditions of vulnerable groups.

In this context, niches in their trajectory of transition to a sustainable regime can follow different strategies. They can follow a strategy of *technological substitution* concerning the dominant regime, which is not the case in this research, since the niches would have to be well structured and strong to be able to simply replace the technologies of the incumbent regime – a strength that they do not have to face the dominant regime.

The niches may also follow a path of *misalignment and realignment*, which is more plausible for the cases under study. In this case, the sociotechnical panoramas (macrostructural elements in the direction of sustainability) play a fundamental role in pressuring the dominant regime to change (misalignment) and thus providing opportunities for emerging niches to obtain their space in windows of opportunity (realignment). At the same time, these sociotechnical panoramas encourage external agents (e.g. governments, universities, or NGOs) to support the niches in these territories.

Results also revealed the threat of another external incumbent regime: renewable energy in the region, especially in Borborema. Despite its appeal to environmental sustainability, there is already scientific literature criticising the implementation of wind farms in the Northeast of Brazil in recent years. In this scenario, traditional communities suffer the loss of control over their lands, which also affects their capacity for social and economic organisation. This problem is fundamentally related to the private planning processes of these activities, with the essential support of local and regional authorities.

Finally, this work points to a relevant and viable research agenda on socio-technical transitions related to the regions under analysis, with significant repercussions for the country. As supported by the literature on transitions, the implementation of sustainability transitions depends on a convergence of niches that follow the same direction to overcome the existing regime. Added to this is the pivotal role (positive or negative to the transition) of the geographic context in which these niches are inserted. Therefore, several lines of research open up here, such as the identification and study of more niches like those analysed here and its (joined) strength in overcoming the prevailing regime; the identification

of the convenient characteristics of the territorial contexts for the transition; and the evaluation of the most favourable and efficient policies for these niches.

In addition to the food system, the introduction of foreign environmental technologies is another important topic for future analysis. As discussed previously, wind energy is one such technique with seemingly laudable environmental assumptions, but with negative repercussions for local communities. This need for a deeper understanding is part of the research on the adverse impacts of some climate change mitigation activities, especially in the most economically vulnerable regions, both in developing and developed countries.

This article contributed to the debate on sustainable socio-technical transitions by demonstrating how to enhance rural productive inclusion through local innovation niches. By highlighting the decisive role of the cognitive and organisational capacities of family farmers and community networks in the Northeast region of Brazil, the research demonstrated the relevance of the territorial context for the success of these transitions. However, important limitations were identified, such as the reduced institutional formalisation of the initiatives and the low incidence of policies aimed at strengthening these experiences. It is therefore recommended that future research investigates strategies to fill these gaps, in addition to critically analysing the local impacts of external environmental technologies, such as renewable energy, on rural communities.

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NOTES

1 | In addition to sociotechnical transitions, 13 other approaches were evaluated, including technical systems, theory of social practices, socio-technical imaginaries, and actor-network theory.

2 | The computational procedure was performed in the EconGeo package of the R statistics software (RStudio Team, 2020). The function provides the network of relationships between concepts based on the co-occurrence matrix (actors-concepts).

3 | Network indicators calculated in the social network analysis and visualization software Visone (2024).

4 | Network density varies from 0 to 1, in which 1 means the network has the maximum possible connectivity (all entities are directly connected).

5 | Expressions presented in quotation marks refer to concepts present in the configuration networks.

6 | Cetra – Centro de Estudos do Trabalho e de Assessoria ao Trabalhador e à Trabalhadora ("Center for Studys on Labour and Consultancy for Workers"). Available at: https://cetra.org.br/quem-somos/

7 | AS-PTA Agricultura Familiar e Agroecologia ("Family Agriculture and Agroecology") (https://aspta.org.br/quem-somos/).

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