

# The Tuxá indigenous social network, interaction and exchange of information for the promotion of adaptive measures in the face of climate change

*A rede social indígena Tuxá, interação e troca de  
informação para a promoção de medidas adaptativas  
ante as mudanças climáticas*

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## ABSTRACT

Studies show Social Network Analysis (SNA) as a successful methodology within the environmental sciences. In the present study, this methodology was implemented in the Tuxás indigenous community in Bahia-Brazil, to understand the configuration of interaction and information flow of the people and their multilevel relationship to face the environmental problem of drought. By creating networks by scale, we identify actors and their roles within the community, characterising the centrality of actors and their internal and external relationships to create adaptive strategic actions that strengthen the links between them and local and regional initiatives. For data collection, structured interviews were conducted with key informants using the snowball methodology. As a result, the SNA made it possible to identify links, bottlenecks and potential institutions to reduce the vulnerability of the traditional population and to identify adequate ways to promote adaptation and solve environmental problems.

**Keywords:** Social Network Analysis. Indigenous Peoples. Adaptation. Vulnerability. Adaptive measures.

## RESUMO

*Estudos mostram a Análise de Redes Sociais (ARS) como uma exitosa metodologia dentro das ciências ambientais. No presente estudo essa metodologia foi implementada na comunidade indígena Tuxás da Bahia – Brasil, com o intuito de compreender a configuração de interação e fluxo de informação do povo e sua relação multinível para enfrentar a problemática ambiental da seca. Identificamos mediante a realização de redes por escalas, atores e seus papéis dentro da comunidade, caracterizando a centralidade dos atores e as suas relações internas e externas para projetar a criação de ações*

*estratégicas adaptativas que fortaleçam os vínculos entre eles e as iniciativas locais e regionais. Para a coleta de dados, foram realizadas entrevistas estruturadas a informantes-chaves usando a metodologia bola de neve. A ARS permitiu identificar elos, gargalos e potenciais instituições para diminuir a vulnerabilidade da população tradicional, assim como identificar caminhos adequados para promover adaptação e dar solução a problemáticas ambientais.*

*Palavras-chave: Análise de redes sociais. Povos indígenas. Adaptação. Vulnerabilidade. Medidas adaptativas.*

## 1 INTRODUCTION

Carrying out an SNA makes it possible to describe, quantitatively and qualitatively, important points of social phenomena linked to other specific themes, such as health, ecosystem, cultural, and environmental problems, among others (BERKHAM; GLASS, 2000; WASSERMAN; FAUST, 1994). As a result, interest in carrying out this type of analysis has grown in recent years in several research areas (FONTES; EICHNER, 2011; GOMIDE; SCHÜTZ, 2015; RIBEIRO; BASTOS, 2011).

Within the environmental and social sciences, some studies assess issues related to climate change and the establishment or measurement of adaptation mechanisms. However, these are mostly carried out outside the country and focus their attention on two aspects: 1) Network analysis existing institutions that address climate change, its impacts and adaptation mechanisms (BICKEL, 2017; CEDDIA, 2017; CORLEW, 2015; ISLAM, 2017; JAJA, 2016; JONES, 2014) and 2) Feasibility studies of adaptation in specific local communities (ANDRÉ, 2017; CHAUDHURY, 2017; DONG, 2017; FARRELL, 2015; NOH, 2015; RECKIEN, 2012; SCHRAMSKI, 2016; ZIERVOGEL, 2017).

In this article, we present how the analysis of social networks can contribute to implementing adaptive measures in the Tuxá Indigenous community of Bahia - Brazil. These people are located in three Brazilian states: Bahia, in Aldeia Mãe Rodelas and D'zorobabé; Fazenda Sítio, Indigenous Land, Ibotirama and Remanso Farm Indigenous Reserve; Pernambuco, in Inajá/Fazenda Funil and Kambiwá Tuxá (border Pernambuco/Alagoas) and Minas Gerais, Buritizeiro. Their dispersion is the result of the construction of the Luiz Gonzaga Hydroelectric Power Plant in 1988, which, according to studies carried out by Bernal and Rodrigues Filho (2020; 2021), generated alarming socio-environmental impacts on the indigenous group, including: intense changes in daily life, loss of identity, migration, division, poverty and, consequently, food and water deficiency, which, due to territorial loss and the impacts of extreme events produced by climate change, has been intensifying.

Knowing this situation, there was a need to implement adaptive measures to reduce the population's vulnerability. In this sense, in order to identify the main ways for its establishment, we have developed three social networks, identifying, on the one hand, the potential bottlenecks and, on the other hand, the ways that can contribute to the implementation of adaptive measures more effectively, dealing with the Tuxá problem from scaled interconnectivity. The study analyses four networks: the exchange of information about the drought of the Tuxá people, the network of potential social bottlenecks, the network of social and institutional connections for adaptation, and adaptive multiscalarity. We identified the density of the people's communication network and the centrality of individuals, and such results served as a basis for analysing the collaborative relationships between those involved.

## 2 LITERATURE REVISION

### 2.1 THE COMPLEMENTARITY OF SOCIAL NETWORK ANALYSIS (SNA) AND ITS APPLICATION IN VULNERABILITY AND ADAPTATION STUDIES

The SNA is a methodology used for decades in different areas of knowledge. It permits identifying social interactions and studying existing networks, whether informal, spontaneous or unintentional (GROSSETTI, 2003; 2004), as well as making it possible to analyse the structure of existing connections between individuals in a given social context (TOMAEL; MARTELETO, 2013).

Recent research claims that SNA became a common denominator in dealing effectively with socio-environmental problems (BODIN, 2009; BURGOS; MERTENS, 2017; VELÁZQUEZ *et al.*, 2005). Within the surveys that show how the application contributes to understanding social vulnerability in the face of the effects of climate change, some carry out specific assessments on individuals and social groups concerning the problem. However, others analyse how institutions, implemented public policies, trust and communication in networks are essential to practice efficient adaptation measures.

Kate *et al.* (2015), for example, assess the structural nature and extent of climate-based communication among Pacific Island professionals; the authors identify key regional centres and isolated clusters to create a set of place-based tools that would enhance and facilitate the linking of different climate change resources (human, economic, research and adaptation). The study's results reveal a diffuse and strongly connected network without isolated spatial or sectoral groups.

In the same year, Matthew (2015) criticises the use or interpretation of poverty as an indicator of vulnerability because social relations, according to him, shape the multidimensionality of vulnerability. Analysing members of 54 families in Nigeria, the author shows that poverty by itself is an incomplete measure of the vulnerability of an individual or a household due not only to the randomness of biophysical risk but also to different obligations and rights associated with wealth. The analysis done by the author shows that young women and men tend to gain more wealth compared to older men, and the gains of healthy women do not reflect their lower vulnerability compared to older men but rather their strategies to approach their vulnerable positions.

Studying the arid and semiarid zones of North Africa and the Middle East, Alary (2016) shows the existence of a link between family livelihoods and the social capital of Bedouin society and an important link between physical assets, nature, the level of education and the intensity of social ties within traditional society. This study presents particularities similar to that developed by Matthew (2015). In both, an individual's vulnerability is due not only to the randomness of the risk or a particular factor but also to the sum of aspects that make the individual and society more vulnerable.

Analysing disaster management and climate change policies in Bangladesh, Islam and Walkerden (2017) assess how they do or do not consider families' social networks. This study shows that, despite the importance of social networks in resilience and disaster recovery, these are not emphasised in government policies. However, organisations that link social networks (i.e. links of governments with organisations, states, donors and others) do. On the other hand, family bonding networks (relationships with family members and immediate relatives), bridging networks (families' relationships with neighbours and friends) and their local bonding relationships (mainly with non-governmental organisations (NGOs) and local government) are largely ignored.

It is observed that there is a need to incorporate studies that permeate these unitary scalar analyses, such as the incorporation of multilevel studies that clearly show the existing connections within a particular society and their interaction with other sectors and levels of the same society, guaranteeing, on the one hand, understanding the social characteristics of the group, and, on the other hand, calling

the attention of sectoral and governmental authorities, who, based on concrete data, propose plans, actions, projects, measures or concrete policies in line with reality and needs.

For example, Chaudhury *et al.* (2017), examining the connectivity and positions of vulnerable rural communities, families and their adaptability in Ghana, show that some external relationships expose families to misinformation and ignorance, as well as to other forms of capital, which in turn, strengthen their ability to access and mobilise resources to respond to environmental changes. The authors state that not all external relations have equal access and that the adaptation capacity of families within the community is stratified.

As seen in this study, the authors identify points at which local actors can link communities and households with key cooperating agencies to plan and implement effective adaptation. At this point, we refer to when a multiscale analysis on the subject would allow a real understanding of the Tuxá society, its vulnerability and the existing possibilities to make its adaptation viable. Some works carry out this type of analysis. Ernstson (2008), for example, considering the patterns of interaction between organisations, reveals that a core-periphery structure of central and semi-central organisations can build political connections with the authorities, where the periphery brings together all groups of users involved in daily activities, facilitating processes of collective action for protection. A few years later, Ernstson (2010) also showed how government agencies and civil society groups engaged in urban area management could connect through social networks to combine spatial scales of ecosystem processes.

This last work is one of the most important within the multiscalar analysis since, by making a structure, it unites ecological scales with structures of social networks, the latter being taken as patterns of interaction between groups of actors. The article shows that functionally interconnected local green areas are not addressed by any actor in Stockholm and that the management practices of civil society groups involved in local ecosystem management are crucial but regularly neglected. Finally, Cash (2006), by analysing the cross-scale in managing the environment, showed great complexity in analysing interactions. However, he states that the interaction between institutions on multiple levels and scales affects the dynamics of cross-scale interactions and between levels.

### 3 STUDY METHODOLOGY AND DATA PROCESSING

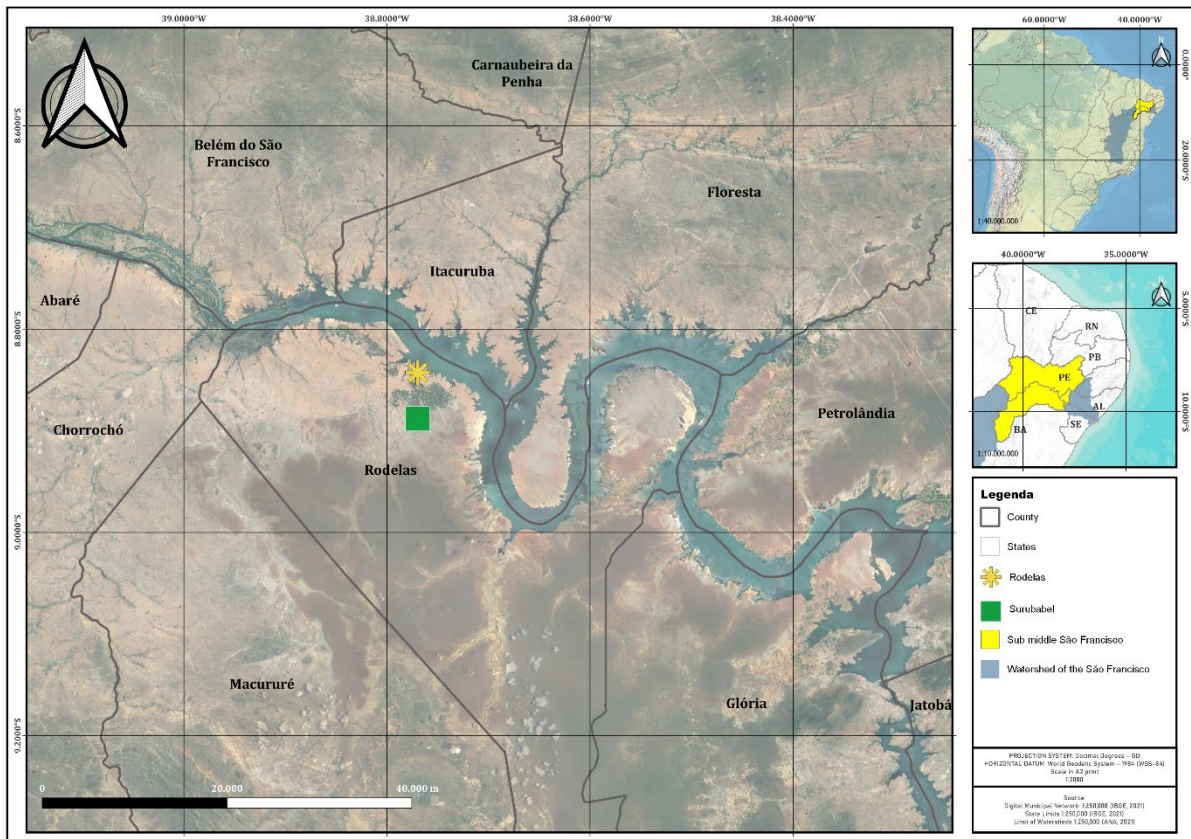
Methodologically, the study is qualitative and based on the research protocol of the 2014 Climate Change and Regional Development Sub-network in Brazil and the methodological procedures for carrying out the Social Network Analysis (SNA). The Climate Change and Regional Development Sub-network of the Climate Network of Brazil has a document called research protocol, which is currently used in research that incorporates analysis of Climate Change and its impacts, allowing the realisation of socio-environmental assessments recognised nationally and internationally.

Primary data were collected through structured interviews in the Tuxá indigenous community located in the semiarid region of the municipality of Rodelas-Bahia (see Figure 1). Data were collected in two field visits; the first in October 2017 and the second between November and December 2018.

The number of interviews was determined using the snowball methodology, allowing to reach the most prominent informants in the community, among them: leaders, teachers and indigenous representatives, who showed knowledge about the history of the people, the impacts of extreme events and about the decisions established in the community.

In total, 97 structured interviews (68 in Rodelas and 29 in Surubabel)) were applied to men and women from different areas to understand how this social group interacts internally and externally in the context of themes and knowledge about the impacts of droughts caused by climate change. The

networks presented in the study result from specific questions duly consolidated in a database and processed in the Ucinet and NetDraw software.



**Figure 1 |** Survey primary data collection areas

*Source: Elaboration of the authors*

Finally, it should be noted that this study meets the standards and requirements of the Research Ethics Committee of the Faculty of Human and Social Sciences of the University of Brasília (UnB), process duly registered in protocol No. 01037218.5.0000.5540 and approval No. 3.440.

## 4 RESULTS

### 4.1 THE TUXÁ DE RODELAS DROUGHT INFORMATION EXCHANGE NETWORK

Preparing and analysing the first network shown in Figure 2, it is noticed that, commonly, members of the indigenous people tend to talk about the drought and its consequences, mainly in those population that has a degree of representativeness, leadership and confidence (see Figure 2). A significant proportion of the population tends to dialogue specifically with five individuals who have an important degree of centrality within the people. This fact allows us to notice an adequate way to facilitate greater communication since their involvement with the population, their representativeness and ease of communication with a large number of people would enable better implementation of activities or local adaptive measures.

This network has a density of 0.2, which, contrary to presenting a saturation by interrelationships, is adequate since very high densities can lead to homogenisation and redundancy of knowledge, reducing

the effectiveness of collective action and the ability to adapt (BODIN, 2006; BURGOS, 2014). Existing links show an important connection between certain individuals, which helps us see the most representative.

To promote adaptive measures or implement public policies within the indigenous community, one can seek to gradually increase the network's density by promoting dialogue among the local population, a fact that would help make the actions carried out in the community more efficient.

The second network identifies active community members with an effective approach to institutions. We observe that five individuals are the most cited, constituting the most representative and, in turn, strategic actors to boost some activities, since, through this analysis, it is possible to identify the degree of importance that each actor has, their position within the community in relation to intercommunication, prestige and representativeness, in order to identify the influence that each one has on the population and at an institutional level.

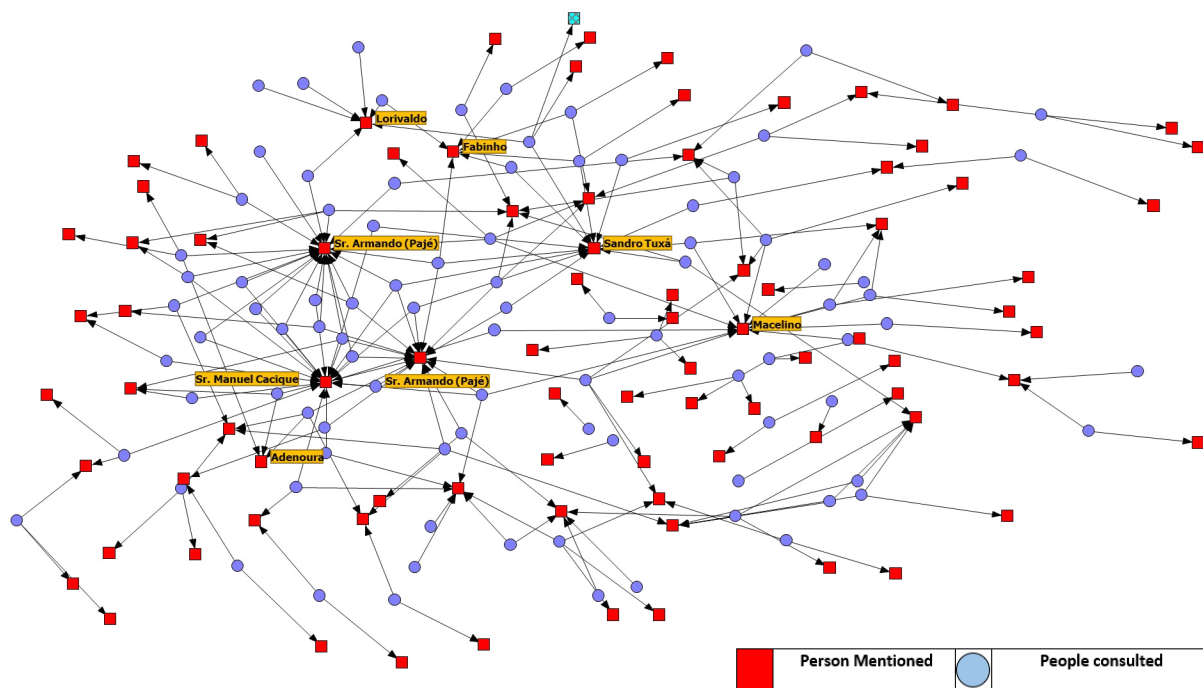


Figure 2 | Drought information exchange network

Source: Elaboration of the authors

Observing Figure 3, we can see a division in the population's perception of the representativeness of the actors. Some claim that the oldest representatives of the community are the ones who have the most contact with different institutions. However, other groups claim that active young people are the ones who interact the most. This perception is fundamentally due to two factors: the age of the people consulted and the role of the individuals.

Regarding the first point, it was identified that people over 40 years of age, for the most part, identify Mr Armando and Manuel as the actors who interact more with institutions. However, for younger people, they are Sandro Tuxá, Antônio Fernandez (Dinamam) and Uilton Tuxá. In relation to the older representatives of the community, it is observed that whoever appoints Mr Manuel (Cacique Bidú) as an articulator with different institutions are mainly housewives, retirees and older civil servants, noting here that representativeness is given by generation. Regarding the second factor, it is observed that Dinamam is indicated mainly by civil servants, students and farmers and Sandro Tuxá by civil servants, fishermen and retirees from the community, a fact based on the active function *in situ*.

The network makes it possible to identify the main people who maintain a significant relationship with institutions and their relationships in the community. Having presented the network to the population, it would generate greater confidence and discourage other isolated ones, aiming to bring together less representative actors. Therefore, the most appropriate paths for implementing adaptive measures, public policies or projects in the indigenous community are observed.

An adequate approach and activities focused on groups and directed by the most representative social actors would make it possible to obtain the expected results in the best way. Starting activities only with leaders does not guarantee success since personal factors of leadership and the adjacent actors also become determinants, because in many cases, successful projects and policies result from the generation of actions, the transmission of information, empathy, coordination and mediation, enabling the assimilation of actions, procedures and information.

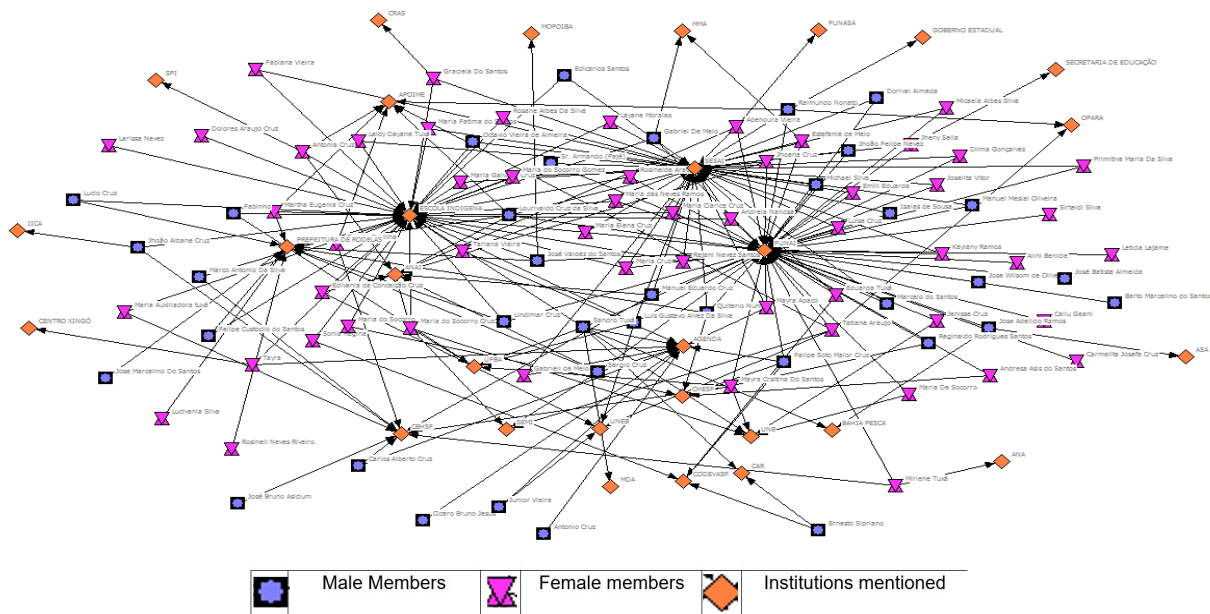


Figure 3 | Network of indigenous representatives before public and private institutions

Source: Elaboration of the authors

#### 4.2 THE IMPORTANCE OF INSTITUTIONS TO FACE CLIMATE CHANGE IN RODELAS

The strengthening and creation of institutions in evaluating and implementing adaptive measures to reduce the exposure and sensitivity of the vulnerable population become a determining factor (IPCC, 2014). In Brazil, over the last 20 years, the Amazon fund was recently reactivated and financed by donations from various governments and projects from multilateral institutions, non-governmental organisations (NGOs), companies, and public institutions that helped generate policies to mitigate climate change.

Advances in issues such as access to water, food, income generation, and agriculture, among others, have reduced poverty in some regions of the country and the exposure and sensitivity of the poor population to climate change. However, the development of projects and adaptation policies is still deficient. Rodrigues Filho (2016) states that Brazilian action in the face of climate change has been developed at a political-institutional and legislative level, mostly focusing on actions aimed at mitigation, leaving adaptation in a marginal space. In this sense, since Brazil is a country with a high vulnerability, it becomes urgent to include this point effectively in the national and institutional agenda (LINDOSO, 2013). Therefore, a continued effort and a global approach aimed at identifying strategies, policies and

instruments that strengthen institutions and develop effective measures to face the impacts of climate change are indispensable.

Through understanding the situation of vulnerability of the Tuxá indigenous people (BERNAL, 2021a; 2021b) and after identifying possible managers for the implementation of adaptive measures through the population's reports, it was verified the existence of 29 institutions that, over the past 15 years, have supported the people with various socio-environmental initiatives (see Table 1), including projects to improve income and access to water, as well as developing local capacities and combating drought.

Among the activities to face the drought, it is stated that the construction of dams was promoted, the acquisition of seeds and animals for agriculture and livestock, the strengthening of indigenous fish farming, the drilling of wells and more of the population's direct actions, such as assistance with food distribution, strengthening of public health, creation of alternative sources of work, among others.

Community leaders indicate that many projects generated positive results during their implementation. However, they claim that once they ceased to be monitored by the institutions, the projects and results began to decline. However, they state that the benefits were positive since, without them, the impacts of the last drought recorded between 2014 - 2018 would have caused greater losses for the local population.

**Table 1 |** Institutions that support the Tuxá people to face the Drought

<i>Initials</i>	<i>Institution Name</i>	<i>Initials</i>	<i>Institution Name</i>
AGENDA	Advice and Management in Nature Studies, Human Development and Agroecology	FUNASA	National Health Foundation
A-N-A	National Water Agency	STATE GOVERNMENT	State government
ANAI	National Association of Indigenous Action	IICA	Inter-American Institute for Cooperation in Agriculture
SUPPORT	Articulation of Indigenous Peoples and Organisations of NE, MG and ES	INSA	National Institute of the Semi-arid
WING	Brazilian semi-arid joint	MDA	Environmental Program of the Ministry of Agrarian Development
BAHIA PESCA	Bahia Pesca Government of Bahia	MMA	Ministry of the Environment
CAR	Regional development and action company	MOPOIBA	United Movement of Indigenous Peoples and Organizations of Bahia
CBHSF	São Francisco River Basin Committee	COJIPE	Pernambuco Indigenous Youth Commission
CX	Xingó Center	PR	City Hall of Rodelas
CHESF	San Francisco Hydroelectric Company	DEPARTMENT OF EDUCATION	Department of Education
CODEVASF	São Francisco and Parnaíba Valley Development Company	SESAI	Special Secretariat for Indigenous Health
CRAS	Social Assistance Reference Center	SPI	Indian Protection Service
AND GO	Indigenous School of Rodelas	UFBA	federal university of Bahia
FUNAI	National Indian Foundation	UNB	University of Brasilia
UNEB		State University of Bahia	

*Source: Elaboration of the authors.*

According to the SNA results and the perception of the Tuxá people, the institutions that most support the population are: Funai, the Rodelas indigenous school, Sesai, the Rodelas city hall, the CBHSF and the organisations Anai, Apoime and Agendha, institutions that, as they say, have become key to facing the



difficulties caused by climate change (see Figure 4). For example, they indicate that the indigenous school, Funai and Sesai support capacity building, sanitary improvement and food distribution, components considered essential to generate a better adaptation and coexistence with the drought. At the same time, CBHSF and Agency Agendha carried out water availability projects, helping to face the problem of drought.

Effective implementation of the proposed strategic lines for adaptation and mitigation requires consolidating public policies and adequate work between social actors and institutions. The human characteristics, potentialities and knowledge of the individuals involved become unnecessary if organisations and institutions do not value or promote them to plan projects or adaptive measures.

In this sense, we see how important it is to consider each suggestion and knowledge of the local population when planning and generating targeted policies. Alary (2016), Chaudhury *et al.* (2017) and Islam and Walkerden (2017) state that the understanding of cultural aspects and knowledge of the traditional population, added to an adequate support from organisations, governments and donors, allow the adequate design of adaptation policies and projects, guaranteeing excellent results at the time of their application.

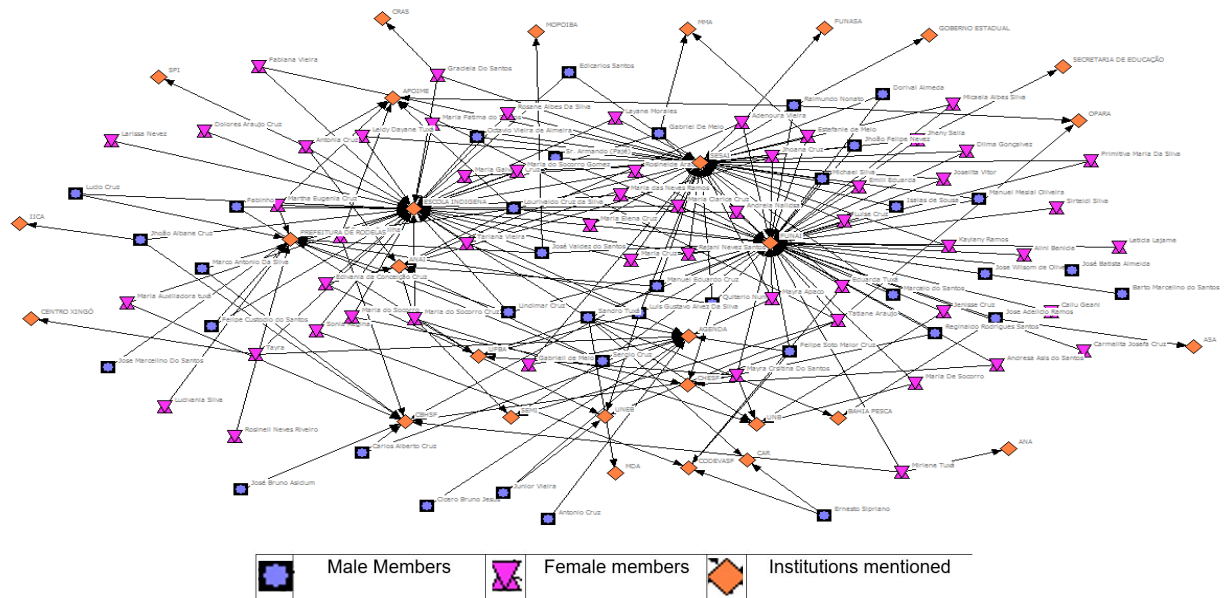


Figure 4 | Identification of institutions that have been supporting the Tuxá population to fight the Drought

Source: Elaboration of the author

These aspects are considered a new form of non-shared institutionality, horizontal coordination and integration of technical capabilities. The network shown in Figure 4 allows us to see the institutional ways that would help to better face the impacts of drought on the indigenous territory, where the institutional structure, linked to the population’s collective actions, becomes effective in guaranteeing coordination and adequate integration to lessen vulnerability. Therefore, the involvement of a greater number of institutions and social actors can lead to better results and adequate and effective planning and implementation of adaptation within the community (CHAUDHURY *et al.*, 2017).

#### 4.2 ADAPTIVE MULTISCALARITY AND NETWORK INTERCONNECTIVITY TO ENSURE TUXÁ ADAPTATION

According to Engle (2011) and other authors, the determinants to achieve an adequate adaptive capacity established by the IPCC (2007) include the involvement of economic resources, technology,

information, infrastructure and institutions (SMIT; WANDEL, 2006). In Sociological, Political Economy and Geography studies, adaptive capacity is related to the ability to act collectively, where social capital, trust and organisation are important (ENGLE, 2011; LEMOS, 2016; PELLING; HIGH, 2005).

In this sense, the generation of adaptive capacity depends on the availability of infrastructure, economic and technological resources, and social factors, such as social capital, coordination, information flows, trust, and willingness to learn and transmit knowledge (EAKIN; LEMOS, 2006). To reduce the vulnerability of the Tuxá indigenous population, some social technologies were identified as adaptation measures for the population (see Table 2). However, analysing the social context and the networks established so far, it is considered that they should be implemented through multiscale and interconnectivity.

The traditional way of conceiving science often meant that social and environmental issues were studied in a fragmented way. However, in analyses of conservation and the use of natural resources in the environmental sciences, it allowed associating these problems and analysing them under a differentiated model, making it possible to understand them better (MONTAÑEZ, 2005). These new analysis processes gave rise to the “*multiscale*” concept, where different levels of participation and complexity, including: geographic, social, political, and ecosystem aspects enter into a joint analysis comprising contexts, realities and local specificities (CASH, 2006).

“Multiscale” analytical approaches are particularly appropriate to understand this relationship between man, population mobility, environment, land use, and generation of public policies, among others, in different but interconnected scales and levels of spatial and temporal analysis (BARBIERI, 2007; CASH, 2006). The process of social dynamics, especially in multiscale, is considered from at least three elements: flexibility, discontinuity and superposition (COELHO, 2013). Another relevant aspect of multiscale from a more social perspective is the centrality of the notion of power, where the complex power relations between the most varied agents that operate at multiple scales allow analysing the multiscale of the territory, a society, public policies and the interaction of actors where power is manifested and exercised (COELHO, 2013).

Carrying out a multi-scale analysis applied to the evaluation of the different networks elaborated so far, we observed in the Tuxá people’s information exchange network about the drought that the indigenous population, preferably, tends to talk about the subject with five central actors of the community who, in turn, are representatives of the community and are dedicated to different economic activities. However, they concentrate information, knowledge about the indigenous reality, and confidence and power over the rest of the population, factors that can be used when implementing the proposed adaptive measures.

**Table 2 | Proposed adaptation measures**

<i>System</i>	<i>Description</i>	<i>Source</i>	<i>Guiding Institutions</i>	<i>References</i>
Recovery of Springs	Recovering or protecting a spring area, in addition to being an environmental investment, helps guarantee the water supply in the countryside and maintains local biodiversity.	Technology available on the market	Xingó Center	Gualdani, et al. (2015)
Plant genetic improvement	Genetic improvement of rainfed crops for the semiarid region, used in family production systems, aiming at obtaining plant materials tolerant to drought and high temperatures.	research and development	Embrapa Semiarid, IPA	Costa et al., (2005); Santos et al., (2008)

<i>System</i>	<i>Description</i>	<i>Source</i>	<i>Guiding Institutions</i>	<i>References</i>
Well Cacimbão	Small depth excavated well that exploit the groundwater to supply water for animals and irrigation.	Technology available on the market	Xingó Center	Gualdani, et al. (2015)
Selection of rhizobium strains for legumes	Selection and recommendation of autochthonous semiarid rhizobia strains for inoculation of cowpea cultivated in the semiarid region.	Technology available on the market	Embrapa Semiárid, Embrapa Agrobiologia and UNEB	Martins et al., (2003)
Eco Stove	More efficient model that reduces wood consumption between 40% and 50%. Saving firewood and reducing smoke emissions. As it is closed, it does not emit smoke or soot in the environment where it is installed, which will make the environment hygienic, clean and healthy for families.	Technologies transferred	Xingó Center	Gualdani, et al. (2015)
In situ water collection systems	Rainwater harvesting technologies: underground dams, cisterns, lifeguards	Technologies transferred	Embrapa Semiárid, IRPAA	Lopes and Brito (1998); Brito et al. (2008)
Biodigester	Equipment that produces biogas and biofertiliser, through fresh animal feces and water, at room temperature (20°C to 45°C). Production of biogas and biofertiliser (fertiliser), reducing the consumption of cooking gas sustainably.	Technologies transferred	Xingó Center	Gualdani, et al. (2015)
Construction of plant nurseries: family fish farming.	Improvement of the productive management of indigenous fish farming.	Technologies transferred	Embrapa Fishing and Aquaculture	Lima, A.; Prysthon, A.; Guedes, C. ; Bergamin, G.; Pedroza, M. (2012)

*Source: Elaboration by the authors with data from Angelotti (2011) and Gualdani et al. (2015)*

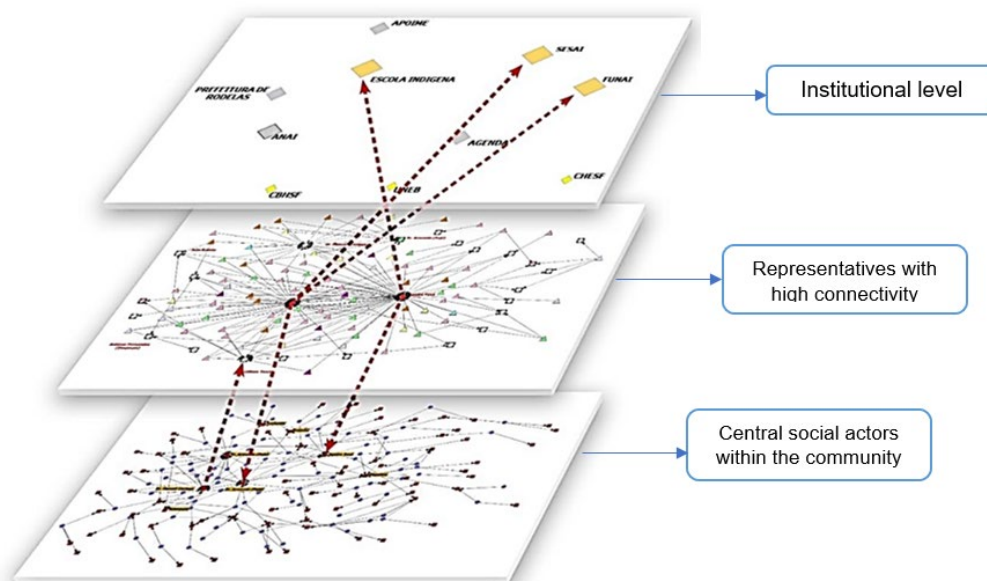
These individuals, empowered with a greater degree of centrality (which also means greater linkage with other actors), would help disseminate information on the adaptive measures and their better implementation. However, for this to happen, a wider interconnection and communication between these central actors, the population at large and the institutions that implement projects in Rodelas, observed in Figure 3, must be promoted.

In this network, we observed that three individuals mainly have greater contact with institutions and represent groups divided by generation and economic activities. Both Sandro and Mr Manuel are part of the indigenous people's information exchange network, constituting themselves as key actors and interlocutors between indigenous society and institutions, and are also part of the second network. However, we observe that it is necessary to establish an effective articulation between these individuals and Dinamam Tuxá, positioned at the level of indigenous representative before institutions with a high degree of centrality (see Figure 3). This factor will more effectively promote an adequate escalation before the institutions since the mentioned actor exerts a strong representation of the indigenous peoples in the region and Brazil.

Interconnectivity is another determining factor for the successful establishment of initiatives. Observing possible connections between different individuals in the community (see Figure 5): central actors (first level), interlocutors of the groups with institutions (second level) and institutions active in the region (third level); and adequate synchronicity when planning and implementing adaptive measures

for the Tuxás, would allow effective and lasting results, which not only materialise in the short term but rather establish themselves as solid long-term projects.

Projects implemented in different contexts often lose momentum as soon as the promoters leave. This type of implementation, which prioritises interconnectivity and the escalation of interactions regarding specific problems and solutions, aims to guarantee the success of the implemented initiatives, as well as to generate sustainability since both needs and possible solutions arise from the population. The linking of strategic individuals from the beginning up until the consolidation of initiatives can promote greater belonging to the final result, leading to the actions, initiatives and knowledge transmitted to the population to remain.



**Figure 5 |** System of interconnectivity of social actors and institutions. Multiscalarity for the implementation of adaptive measures

*Source: Elaboration of the authors*

So far, it has been observed that the SNA makes it possible to identify links or bottlenecks and potential institutions to reduce the vulnerability of the indigenous people, proving that an integral and multiscale analysis helps to identify these aspects, as well as to propose the most appropriate paths. It was shown that this approach allows to create adaptive capacity that is hardly generated in isolation but rather from the identification of demands, knowledge of families and actions of remote agencies, mitigating the risks related to the impacts of climate change.

In this scenario, the central actors and indigenous leaders play an essential role, and the recurrent situation in the daily life of individuals requires them and the rest of the group to reorganise in favour of adaptation. However, the indigenous representatives must seek funding from institutions, local, private and public agencies, and international cooperation agencies.

Showing the local reality, as well as the ways to face deficiencies, is a collective responsibility. However, planting solutions and spreading them is the responsibility of the central actors since they are the interlocutors of the local reality. Collective, integrative work, without exclusion, will enable a better adaptation of the indigenous peoples in Brazil, an aspect that must be widely promoted and debated.

## 5 CONCLUSIONS

Through the SNA, we observed the people's means of exchanging internal and external information regarding the impacts of climate change, as well as the existing social and institutional bottlenecks, which, together with adequate planning, could enable the implementation of more adaptive measures.

The identification and detailed understanding of socio-environmental issues and the dynamics of interaction and flow of information among the people made it possible to find the most recommended means for implementing adaptive measures. At the same time, we observe that the interconnectivity of levels becomes an essential factor in obtaining better and lasting results, encouraging future researchers and cooperation agencies to use this approach.

A successful example of an integral and multiscale analysis in the Tuxá occurred in the creation of the school. There, the people, relying on their knowledge and cultural bases, supported by local and regional institutions and mediated by central indigenous representatives and actors, managed to create the indigenous school, encouraging community members to face discrimination, revive their culture and generate more human and legal resources to fight for their rights (BERNAL, 2021b).

Finally, it is hoped that the results of this analysis will shed light and valuable information, both for the Tuxá people and for decision-makers in public and private sectors in the implementation of adaptive measures. Likewise, it is expected that these will help generate spaces for organisation, operationalisation and cooperation between different individuals, seeking to facilitate processes for implementation.

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