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GOVERNANCE IN FIGHTING DESERTIFICATION IN RURAL COMMUNITIES

A GOVERNANÇA NO COMBATE À DESERTIFICAÇÃO EM COMUNIDADES RURAIS

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ABSTRACT

The aim of the article is to analyze how local governance structures affect the propensity to desertification resulting from anthropogenic action in rural areas susceptible to the problem in the state of Ceará. For this purpose, primary data was collected through the application of questionnaires to leaders of rural communities located in areas susceptible to desertification. Regarding methodology, initially, the PSR (Pressure-State-Response) model was adopted to describe the situation of desertification in the region supported by a set of indicators. Then, a matrix of governance indicators composed of six dimensions was developed. The two groups of indicators were aggregated into two indices: the Desertification Index (ID) and Governance Index in Desertified Areas (IGAD). To verify the relationship between governance and desertification, models were estimated using the method of ordinary least squares and quantile regression. The main results showed that there is a significant inverse correlation between the ID and the IGAD, showing that higher levels of implementation of the governance principles contribute to reducing desertification. It is concluded, then, that the fight against desertification requires the strengthening of the governance structure in Areas Susceptible to Desertification (ASD), in order to involve civil society, and public and private entities.

RESUMO

O objetivo do artigo é analisar como as estruturas de governança locais estão interferindo na propensão à desertificação decorrente da ação antrópica em áreas rurais susceptíveis ao problema no estado do Ceará. Para tanto, foram utilizados dados primários obtidos por meio da aplicação de formulários junto a lideranças de comunidades rurais localizadas em áreas susceptíveis à desertificação. Como procedimentos metodológicos, inicialmente, foi adotada a metodologia PER (Pressão – Estado-Resposta) para descrever a situação da desertificação na região com suporte em um conjunto de indicadores. Em seguida, foi elaborada uma matriz de indicadores de governança composta por seis dimensões. Os dois grupos de indicadores foram agregados em dois índices: Índice de Desertificação (ID) e Índice de Governança em Áreas Desertificadas (IGAD). Para verificar a relação entre governança e desertificação foram estimados modelos pelo método de mínimos quadrados ordinários e regressão quantílica. Os principais resultados mostraram que há uma correlação significativa inversa entre o ID e o IGAD, evidenciando que níveis mais elevados de implementação dos princípios de governança colaboram para reduzir a desertificação. Conclui-se que o combate à desertificação requer o fortalecimento da estrutura de governança na ASD, de modo a envolver a sociedade civil, entidades públicas e privadas.

Palavras-chave: Antropismo; Comunidades Rurais; ASDs; Governança.

INTRODUCTION

Desertification occurs on a global scale, causing social, environmental, and economic impacts and the displacement of thousands of people in search of land and food. There is evidence that the phenomenon threatens the ability of ecosystems and economies to provide the goods and services that society needs (Rosenzweig *et al.*, 2008). According to Li *et al.* (2018), global economic losses caused by desertification and drought reach US\$4.2 × 10^{10} per year. This context gives rise to the attention directed toward this topic, which is formalized in different international manifestos – such as the "2030 Agenda for Sustainable Development" which established the objectives of controlling desertification and halting and reversing land degradation (Li *et al.*, 2018) – and nationally, in the State Action Programs to Combat *Desertification* and Mitigate the Effects of Drought (PAEs).

In Brazil, especially in the semi-arid region, the worsening of the climate situation and the harmful action of humans on nature are accelerating degradation processes in dry lands in the coming decades (Marengo *et al.*, 2016, Refati *et al.*, 2023). Anthropogenic action in the Brazilian Semiarid region, resulting from socioeconomic vulnerabilities, leads to the intensive use of natural resources and strongly impacts the local environment. Degraded areas are advancing rapidly, making large areas

unsuitable for productive activities (Moura, 2016).

Given this configuration that involves the acceleration of human-made desertification processes and institutional recognition of the need for urgent actions, good governance structures can play a crucial role in the effectiveness of rural public policies, since traditional administrative structures have proved to be inadequate to manage such policies effectively, which denotes the need for adjustments at different levels of government and greater participation of local authorities (Oman; Arndt, 2006). From a regional development perspective, good governance facilitates cooperation between government, companies, and civil society, improves the coordination of actions, and enhances the results of public policies, whether environmental, economic, or social (Bruszt; Palestini, 2026; Danson *et al.*, 2018; Goldstein; Glaser, 2012; Yang; Lou, 2020).

However, depending on local contexts, where there is an economic crisis and low levels of education and social participation, the transition to a local governance model is a slow and difficult process (Briassoulis, 2019) that can have negative impacts and contribute to increasing inequalities and exclusion in rural areas, in addition to serving the interests of local groups (Cheshire; Everingham; Lawrence, 2014), factors identified as accelerating desertification. It is noted that there are barriers to the implementation of actions that mitigate the expansion of desertification, including the cross-cutting way in which such actions are and should be incorporated into legislation and government plans, as highlighted by Imeson (2012). In this sense, the importance of a good governance structure to manage such actions is highlighted.

The fact that desertification governance is strongly related to the way society responds and behaves when faced with the need to reduce land degradation (Imeson, 2012), that is, to the way society promotes and combats desertification, guided the construction of the following hypotheses to be tested in this article: i) governance in its multidimensional aspect, that is, when all its dimensions are added together, produces a negative and significant impact on the propensity for desertification motivated by human action; ii) individual aspects of governance act differently on this propensity; iii) the effects of governance are differentiated if specific aspects of the propensity for desertification are analyzed, such as factors that put pressure on the phenomenon (pressure), that describe the situation of the phenomenon (state), and that reflect actions taken to combat them (response).

The theoretical model that underlies the development of these hypotheses was constructed based on an academic debate that has not yet reached consensus, which highlights the inverse relationship between governance and human action on the environment, given that a good governance structure can foster the necessary social capital to achieve cooperation between all actors involved in the development and implementation of strategies that meet the specific demands of each region vulnerable to anthropogenic desertification processes (Sun;Tan, 2023). Changes in human actions that cause desertification require transformations in society and such transformations require efficient governance (Alsayegh *et al.*, 2023; You *et al.*, 2019; Kanie *et al.*, 2018).

From this perspective and given the theoretical and methodological challenges of measuring two subjective concepts such as propensity for desertification and governance, this article aims to analyze how local governance structures affect the propensity for desertification resulting from human action in rural areas susceptible to the problem in the state of Ceará. Although the international literature recognizes the role of governance in combating desertification (Briassoulis, 2011; Liu *et al.*, 2013; Bao *et al.*, 2017; Yang, 2017; He; Yue, 2023), studies that quantitatively analyze this relationship are scarce (Sun;Tan , 2023). Even rarer are those that approach the issue based on research using primary data in rural areas and semi-arid regions. In this context, this article makes two main contributions. The first concerns the choice of the study object: rural communities located in areas susceptible to desertification in the Brazilian semi-arid region. The second, it uses a mathematical approach that allows analyzing the causal relationship between governance and desertification assuming specific aspects of the two concepts. In this way, the aim is to contribute information to the construction of a theoretical basis that, in agreement with Martinez-Valderrama *et al.* (2022), is necessary to strengthen strategies to combat desertification in semi-arid regions.

Therefore, the present study was structured with a theoretical framework that highlights the relationship between the dimensions analyzed, followed by a presentation of the materials and methods explored in the construction and relationship of the indices, and finally, there follows a deeper discussion of all the dynamics that involve governance and desertification in the state of Ceará.

GOVERNANCE AND STRATEGIES TO COMBAT DESERTIFICATION IN BRAZIL

According to the World Bank (World Bank, 2017), governance consists of the traditions and institutions through which authority in a country is exercised, comprising the process by which governments are selected, monitored, and replaced, the government's ability to effectively formulate and implement sound policies, and the respect of citizens and the State for the institutions that govern economic and social interactions between them. In its report, the Commission on Global Governance (1995) emphasizes that governance encompasses all the diverse ways in which people and institutions, public and private, manage their common problems, through a continuum that accommodates conflicting or different interests, in order to take collective actions.

The principles of governance reinforce the notion that this process aims to produce effective results, and is not just restricted to the planning and implementation of public policies. Timmers (2000) emphasizes that the expected result in public governance is the improvement of services provided to society and the benefits obtained by the population. Therefore, governance is a reference to the development and implementation of policies of global interest, such as environmental and development policies. This vision was included in the new approach to the problem of desertification, principally after the United Nations Conference on Environment and Development (Rio 92), which signaled the realization of the United Nations Convention to Combat Desertification (UNCCD) in 1994.

Brazil and 192 other countries joined the convention and made clear the importance of the declaration that would unfold into plans, programs, and policies. Desertification was no longer linked only to ecology but was beginning to present strategic contours from a political perspective of development (Herrmann; Hutchinson, 2006).

Programs aimed at combating desertification, such as the National Action Program to Combat Desertification (PAN-Brazil), have incorporated the adoption of governance structures as a modern form of administration, introducing the participation of organized civil society and enabling co-participation, co-management, and consequently co-responsibility. Viana (2013) highlights, however, that despite the program being a categorical reference for combating desertification in the country, it was not instituted by law or decree and currently has only resulted in a few limited actions, being treated as of secondary importance by the federal government.

Difficulties in implementing plans to combat desertificação are observed in different parts of the world and are associated with divergent interests that generate the need for a broad governance model, with the participation of all those involved (Briassoulis, 2019). However, participatory processes in governance are not limited to the *modus operandi* of policies, as they cover broader aspects relating to patterns of coordination and cooperation between social and political actors (Diniz, 1995).

The importance of a good governance structure to combat desertification is also reinforced by Yang (2019), but achieving good governance is a slow process and difficult to operationalize, as it means controlling, restricting, and adapting the population to make changes relating to environmental issues (Rodorff *et al.*, 2019). These conditions, in turn, require the adoption of principles such as: participation; rule of law; transparency; responsibility; guidance by consensus; equality and inclusiveness; effectiveness and efficiency with audit support; political stability and absence of violence/terrorism; normative/regulatory quality; and control of corruption (Kaufmann; Kraay; Mastruzzi, 2008).

MATERIAL AND METHODS

This section is divided into two subsections that refer to the study area and analysis methods.

DESCRIPTION OF THE STUDY AREA

The observation units selected for the study were rural communities in municipalities located in Areas Susceptible to Desertification (ASD) of the Inhamuns hinterland (the municipalities of Independência, Tauá, and Arneiroz), located in the semi-arid region of Ceará. These municipalities have low levels of social and human capital in rural areas as well as some geo-environmental characteristics in common, such as low average rainfall, shallow soils, high soil and air temperatures, relief characterized as crystalline and sedimentary, and water scarcity (Rodrigues, 2006).

According to Sabourin (1999), rural communities can be understood as "villages" formed mostly by farmers who carry out their activities individually or collectively. By using natural resources as the main raw material for economic activities, they assume a leading role in the issue of desertification, sometimes as causative agents, sometimes as victims of the phenomenon. Another justification for choosing this local scale is the understanding that the fight against desertification must involve the

participation of the local population in decision-making and governance processes.

Rural communities were selected using proportional stratified random sampling. The sample size was defined by a mathematical procedure and resulted in 91 communities (21 in Tauá, 18 in Arneiroz, and 52 in Independência), extracted from a population of 715 communities (196 in Tauá, 132 in Arneiroz, and 387 in Independência).

The primary data collection instrument was a questionnaire applied to community leaders or representatives in December 2017 and January 2018. Representatives can be understood as people appointed by residents as able to respond on behalf of the community. According to Sousa *et al.* (2017), these agents perform functions that, a priori, give them authority and knowledge to provide information regarding the real situation of the community they represent.

ANALYSIS METHODS

The analysis methods are divided into three subsections to identify the measurement of desertification, the measurement of governance, and the relationship between these two themes.

MEASURING THE PROPENSITY FOR DESERTIFICATION

The multidimensionality of the concept of desertification makes its measurement a major challenge for researchers. Zucca *et al.* (2012) state that there are different systems of indicators that seek to express the levels of desertification in a region but emphasize that they all present biases due to the impossibility of covering all factors. However, the propensity for desertification, which expresses not the intensity of desertification itself, but how vulnerable an area is to the problem, can be approximated using a set of indicators that capture its probable causes.

The aforementioned authors suggest the adoption of a measurement model that groups desertification factors into five classes: DPSIR (Driving force – Pressure – State – Impact –Response). In a more simplified way, these classes can be summarized, without losing scope, into three classes that characterize the Pressure-State-Response (PSR) approach.

The Pressure-State-Response (PSR) approach is applied in studies aimed at understanding the relationships between the environment and human activities (Neri *et al.*, 2016) based on a causal chain

that, in the case of desertification, can be constructed as follows: i) pressure indicators: characterize the pressures on environmental systems; ii) state indicators: reflect the situation of the environment in a given space/time horizon; and iii) response indicators: evaluate the responses of society and government in combating desertification and environmental concerns.

The use of PSR in this investigation, therefore, required systematizing a set of information capable of leading to an understanding of the conditions of ASD in the Inhamuns hinterland in terms of desertification, the pressures that contribute to the worsening of the problem, and the responses or actions that can alleviate or prevent impacts caused by human activities in the region. Table 1 contains the indicators selected to quantify the propensity for desertification in each community. The choice of each indicator was made based on a literature review.

Table 1 | Indicators selected to characterize desertification in rural communities included in the Sertão dos Inhamuns ASD.

INDICATOR	Classification	Relationship with desertification
Illiteracy	Pressure	Direct
Behaviors that harm the environment	Pressure	Direct
Goat farming	Pressure	Direct
Sheep farming	Pressure	Direct
Existence of agricultural practices that harm the environment (e.g., intensive mechanization)	Pressure	Direct
Firewood extraction	Pressure	Direct
Burning vegetation'	Pressure	Direct
Presence of rocky outcrops	State	Direct
Presence of degraded area	State	Direct
Presence of deforested area	State	Direct
Presence of sandization	State	Direct
Presence of soil compaction	State	Direct
Presence of erosion processes	State	Direct
Migration	State	Direct
Loss of vegetation cover	State	Direct
Loss of fertility	State	Direct
Loss of productivity	State	Direct
Water quality	State	Inverse
Reduction of native fauna	State	Direct

Reduction of native flora	State	Direct
Access to water for domestic consumption	Response	Inverse
Access to garbage collection	Response	Inverse
Access to sewage treatment	Response	Inverse
Areas destined for recovery	Response	Inverse
Areas designated for environmentally protected areas	Response	Inverse

Source: The authors

The aggregation of the presented indicators was carried out in two stages, adapted from Sousa *et al.* (2017). Initially, desertification propensity indices were calculated for each dimension, namely: pressure (ID_P), state (ID_E), and response (ID_R), and subsequently the sub-indices were aggregated to obtain the Desertification Index (ID).

Each indicator received a score that ranged from 0 (presence of a situation unfavorable to desertification) to 1 (presence of a situation favorable to desertification). The ID, therefore, ranged from 0 to 1, with the closer it is to 1 (one), the greater the level of desertification propensity in the area of the community. After calculating the ID, the communities were classified into three groups (Lowest ID, Intermediate ID, and Largest ID). This taxonomy was defined through cluster analysis using the k-means method, a multivariate analysis technique that classifies objects into groups according to their similarities, in order to form groups that are internally homogeneous and heterogeneous among themselves (Fávero and Belfiori 2015).

The comparison between municipalities regarding sub-indices and index was carried out using the Kruskal-Wallis Non-Parametric Test, described in Fávero *et al.* (2009).

MEASURING THE LEVEL OF GOVERNANCE

The number of governance indicators has grown significantly in recent years (Davis; Kingsbury; Merry, 2012) with the purpose of supporting public policies and directing investments (Oman; Arndt, 2006).

Although there is no consensus on the concept of governance, a literature review managed to identify common points in the definitions by different scholars on the subject. These common points involve the six dimensions adopted in this research and presented in Table 2, which, together with the studies by Sumner *et al.* (2008), allowed the definition of the 53 indicators used.

Table 2 | Dimensions and indicators of rural governance adopted in the research.

DIMENSION	DESCRIPTION
Efficiency and effectiveness	Refers to the implementation of measures capable of efficiently and effectively combating desertification, that is, in the best possible way.
Participation	Related to the ability of the rural community to mobilize and articulate itself in networks that enable knowledge of the local reality and empowerment of this population.
Access	Concerns access to goods and opportunities that promote sustainable coexistence and subsistence in the countryside.
Accountability	Analyzes financial and organizational responsibility within rural communities.
Capacity	Analyzes competence and professionalism in community activities.
Implementation	Refers to the capacity to implement public actions aimed at combating desertification.

Source: The authors, based Sumner *et al.* (2008)

Each indicator was evaluated according to its occurrence in the community area, receiving a score from 0 (zero) to 3 (three): Absent (0), Low levels (1), Medium levels (2), and High levels (3). The final score given to the indicator in the community area was obtained by the ratio between the score achieved and the maximum score that could be obtained, in this case, the value 3, corresponding to the condition of high level of occurrence. In fact, in the final analysis of the indicator, the values achieved varied from 0 (no existence in the community area) to 1 (high level of existence in the community area).

The procedure adopted to prepare the aggregate indices for each dimension (IGADw) and, subsequently, the Governance Index in Desertified Areas (IGAD) was similar to that described in the ID calculation. It is noteworthy that a direct relationship was assumed between all proposed indicators and IGAD. The parameterization of the index, according to the cluster analysis carried out, classified the communities into three groups (Minor IGAD, Intermediate IGAD, and Larger IGAD). The closer to 1(one), the higher the level of governance in the community.

ANALYSIS OF THE RELATIONSHIP BETWEEN DESERTIFICATION AND GOVERNANCE

The analysis of the relationship between desertification and the level of governance in rural communities was carried out in two stages. Initially, the existence of a correlation between desertification and governance indices and between their respective dimensions was identified. To this end, the Pearson Correlation Coefficient was calculated.

The study chose two methods for analysis, Ordinary Least Squares (OLS) and Quantile Regression. Quantile Regression was selected because it is feasible to assume that a significant impact of governance on desertification may have different intensity depending on the state or intensity of degradation. This means, for example, that governance may have greater influence in areas with milder desertification processes than in areas where the phenomenon is more pronounced. In the event of a situation like this, the Ordinary Least Squares (OLS) method for estimating causal relationships may not be appropriate, given that it provides estimators that represent the average effect of the independent variable on the conditional distribution of the dependent variable. In other words, the estimators obtained by OLS may be unable to capture possible differentiated effects of any explanatory variables in regions with lower or higher levels of desertification (Bocquier *et al.*, 2010).

In this investigation, the OLS method and Quantile Regression were applied, firstly, to analyze the relationship between the governance index of desertified areas on the desertification index and on each of its dimensions, separately. Then, regressions were estimated to analyze how each dimension of governance can influence desertification.

RESULTS AND DISCUSSION

The results presented below, relating to the 91 rural communities, included in the ASD of the Inhamuns hinterlands and distributed across three municipalities, allow us to observe the scope of the research. A population estimate determined that it reached approximately 15,580 people[1], belonging to the 3,995 families that make up the interviewed communities.

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1 According to IBGE (2010), the average number of people per rural household in the State of Ceará is 3.9.

The high demographic density of the semi-arid region of Northeastern Brazil, whose population is equivalent to 40% of the total number of residents in the northeastern region (IBGE, 2010), produces negative impact in soil use and treatment. In the productive activities of this region, the primary sector predominates (agriculture and livestock) which, in addition to guaranteeing non-monetary income (self-consumption), seeks to earn monetary income based on rainfed crops (Marengo, 2008; Simões *et al.*, 2010). The scenario in the region is characterized by a rigid land structure and agricultural practices with a low technological level, which lead to negative anthropogenic practices and, consequently, environmental degradation (Sales, 2002). Thus, the region under analysis is an environment prone to the worsening of degradation processes and desertification.

DESCRIPTION OF DESERTIFICATION IN RURAL COMMUNITIES IN THE ASD OF SERTÃO DOS INHAMUNS

In order to make the analysis of desertification more objective, it was decided to aggregate desertification indicators according to their classification (pressure, state, and response). Comparing the three municipalities, a similar pattern is observed in the dimensions of desertification. This pattern allows for a more general analysis based on ASD as a whole. State indicators demand greater attention in the fight against desertification, given their greater value relative to the other dimensions (Figure 1). These indicators reflect local conditions regarding human actions that contribute to the existence of degraded and deforested areas, soil compaction, erosion processes, loss of soil cover, and agricultural productivity. This scenario, as described by Santra *et al.* (2017), is typical of areas in the process of desertification.

Figure 1 | Average pressure, state, and response indices of the communities of Arneiroz, Independência, Tauá, and ASD dos Inhamuns.
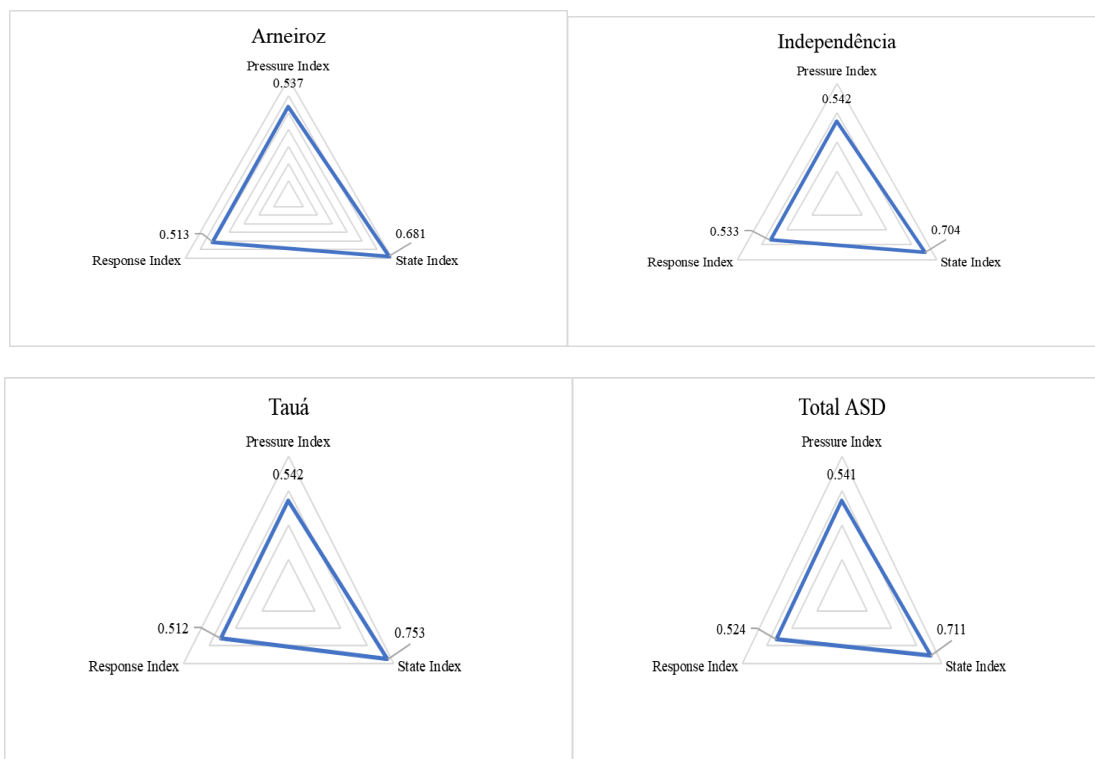
Source: The authors, based on the research data

Further, to achieve a better global view of the level of desertification in the ASD, the three indices analyzed were aggregated into the Desertification Index (DI), which was delimited into three levels, as shown in Table 3. The ID analysis concludes that 51.6% of communities are at intermediate levels of desertification, corroborating the highest frequencies measured by the same index at the municipal scale (44.4% in Arneiroz, 55.8% in Independência, and 47.6% in Tauá). It is also noteworthy that the Municipality of Arneiroz had the highest relative number of communities (38.9%) with the lowest IDs, and the Municipality of Tauá had the highest percentage of communities (33.3%) belonging to the category of highest IDs. These differences, however, are not statistically significant. These municipalities are neighbors and have very similar soil and vegetation characteristics. Thus, this result corroborates what is stated in Imeson (2012) about the fact that similar types of soil and landscapes denote similar responses to desertification. The relatively small percentage of

communities included in the class with the highest levels of desertification can be explained, in part, by the results of the study by Oliveira Junior (2023) which identified a percentage of 94.07% of lands with low vulnerability to desertification in the nucleus of desertification of Inhamuns .

Table 3 | Relative frequency distribution of communities, by level of desertification, in the Municipalities of Arneiroz, Independência, Tauá, and ASD dos Inhamuns. (%).

ID categories	Interval	Arneiroz	Independência	Tauá	Total ASD
Low IDs	0.367 ≤ ID ≤ 0.535	**38.9**	21.1	19.0	24.2
Intermediate IDs	0.539 ≤ ID ≤ 0.640	44.4	**55.8**	47.6	**51.6**
High IDs	0.647 ≤ ID ≤ 0.751	16.7	23.1	**33.4**	24.2
Total		100	100	100	100

Source: The authors, based on the research data

Considering that a good governance structure includes the conscious participation of civil society, the low perception of the population regarding the severity of desertification was observed as a local weakness. Although the existence of the phenomenon in the region is not recent, it is noted that the population in the ASD is still unable to understand the extent of the problem. In 75.8% of the communities represented in the sample, residents are not aware that they are part of a desertification center (Table 4). This fact becomes even more significant when the questioning is directed towards knowledge of the phenomenon itself, as in 57.2% of the communities residents have little (29.7%) or no (27.5%) perception of the existence of the processes of desertification, which is easily confused with the effects of drought.

Table 4 | Proportion of rural communities according to residents' perception of aspects related to local desertification in the ASD of Sertão dos Inhamuns (%).

Indicators	Absence	Low Levels	Medium Levels	High Levels
Residents' knowledge of the fact that the community is located in a desertification center	**75.8**	15.4	5.5	3.3
Aware of existence of desertification processes	27.5	29.6	**33**	9.9
Community knowledge of what the PAE represents	**94.5**	3.3	2.2	0
Have heard previous discussion on desertification	**74.7**	9.9	12.1	3.3

Source: The authors, based on the research data

The State Program to Combat Desertification and Mitigation of the Effects of Drought in Ceará (PAE-CE) was prepared in 2010 and implemented in the three ASDs in the State, guided by the National Action Program to Combat Desertification (PAN-Brazil). PAN-Brazil, however, has not consolidated a program, nor has it organized action or met with action in a State department, and "[...] only moves small groups in very restricted actions." (Viana, 2013, p.177). Souza (2023) adds that the situation observed in the Caatinga biome, where the ASD studied is located, falls short of that proposed in this document regarding the implementation of strategies that reduce the impact of the causes of desertification. In Ceará, PAE-CE also led to few actions in the ASDs, limited to the allocation of resources for the distribution of water in water tankers. This is reflected in the communities' perception of what the PAE represents, indicated as absent in 94.5% of the locations analyzed.

The population's apathy is worrying, especially because there is a historical component that favors the continuity of negative habits and actions that contribute to the advancement of desertification. Furthermore, without the population's participation in decision-making processes, there is a weakening of social networks already threatened by the existence of the problem, given that, according to Chiba (2017), desertification causes the rupture of social networks due to the loss of cultural heritage or scarcity of resources and the consequent change in the reciprocity that exists between members of a community.

The population's low perception of the problem of desertification is a long-standing and global reality. International (Neves; Roxo, 2010; Onate; Peco, 2005; Mazhar; Shirazi, 2023) and national (Araújo, 2016; Souza, 2012; Santos, 2023) studies point to this trend. This conjunction leads to the problem of lack of governance and low capacity to lead and regulate a policy to combat desertification. This subject will be further explored in the following section.

CHARACTERIZATION OF GOVERNANCE IN RURAL COMMUNITIES LOCATED IN THE INHAMUNS ASD

Governance indicators act together, however their analysis in dimensions allows us to observe behaviors and dynamics not perceptible in the aggregate analysis. Based on this, Figure 2 presents the average indices of governance dimensions for the communities interviewed in the municipalities of Arneiroz, Independência, Tauá, and in the ASD as a whole.

Figure 2 | Average indices of governance dimensions in desertified areas in the communities of Arneiroz, Independência, and Tauá, and the ASD dos Inhamuns.
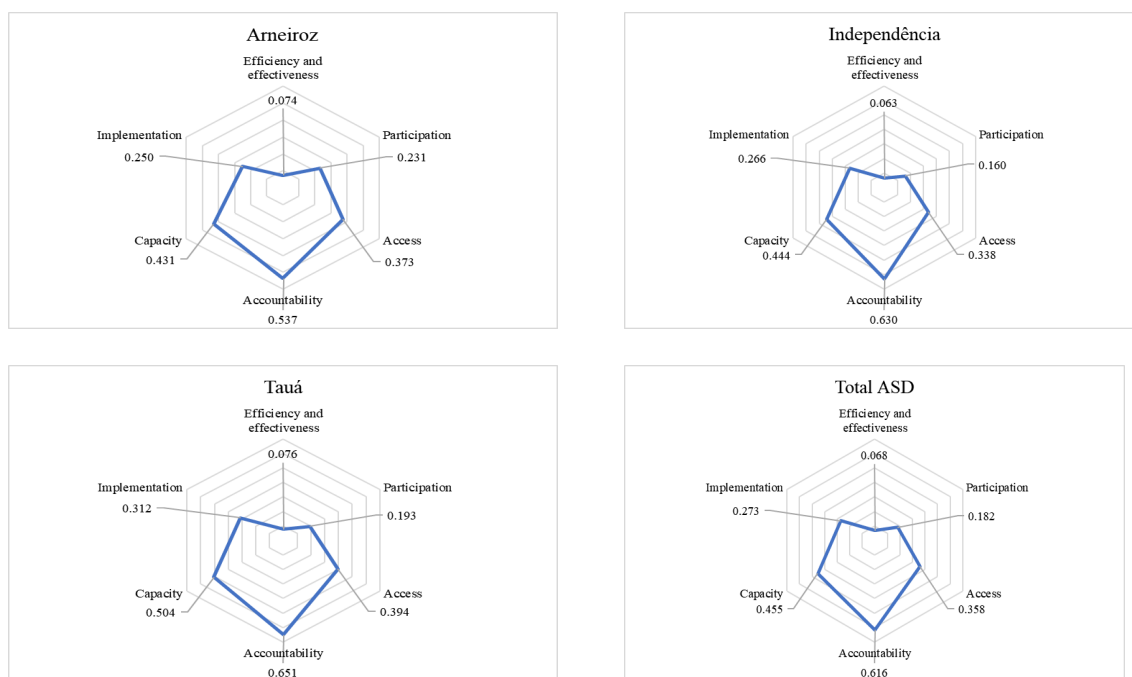
The analysis of the aforementioned figure allows us to observe that the municipality of Tauá is slightly more capable than the others in most dimensions, although this is not a statistically significant difference, according to the Kruskal-Wallis test. In the disaggregated analysis, the dimensions that contributed least to IGAD were Efficiency and Effectiveness, Implementation and Participation, and those that contributed most were Capacity and Accountability. This result highlights the confidence of the sampled population in the institutions and organizations closest to them, the community associations, in defending their interests,. However, it also highlights the lack of activities and mobilizations to seek solutions that benefit the quality of life of rural populations and conscious actions to coexist with the semi-arid region. This is a risk factor since effective governance involves collective action and leadership (Chaple, 2016).

The general level of governance in each community was represented by the aggregation of all dimensions assessed in the IGAD. From this index it was possible to hierarchize the communities into categories as shown in Table 3. Of the communities analyzed, 53.8% were classified with intermediate IGAD, which varies from 0.268 to 0.426. The municipality of Arneiroz presented the highest relative frequency of communities with the lowest IGAD (38.9%), however it presented the same number of communities as belonging to the intermediate IGAD. The municipality of Tauá had the highest percentage of communities with the highest IGAD (33.3%), however the highest frequency observed for communities in this municipality was in the intermediate IGAD class (42.9%). Independência stood out among the intermediate IGADs, presenting 63.5% of its communities in this category.

Table 5 | Percentage of communities by level of governance, in the municipalities of Arneiroz, Independência, and Tauá, and ASD dos Inhamuns (%).

IGAD categories	Interval	Arneiroz	Independência	Tauá	Total ASD
Low IGAD	0.115 l–l0.254	**38.9**	26.9	23.8	28.6
Intermediate IGAD	0.268 l–l0.426	**38.9**	**63.5**	42.9	**53.8**
High IGAD	0.437 l–l0.664	22.2	9.6	**33.3**	17.6
	Total	100	100	100	100

Source: The authors, based on the research data

A very small percentage of communities reached the class with higher levels of governance. There are communities in a better governance situation than others, but in fact no communities with high levels were observed (considering that the IGAD varies from 0 to 1). The formulation and execution of collective actions to make communities self-governed were not observed, which would be, according to Shah and Shah (2006), the concept of local governance. The low degree of governance in rural communities in Inhamuns is the reality of many rural regions (Sousa *et al.*, 2017; Delgado; Grisa, 2014), despite rural governance being a key point for the effectiveness of rural development policies (Zaitul *et al.*, 2023; Pomeranz; Stedman, 2020).

RELATIONSHIP BETWEEN DESERTIFICATION AND GOVERNANCE IN RURAL COMMUNITIES IN THE ASD OF SERTÃO DOS INHAMUNS

The relationship between desertification and governance in rural communities in the Sertão dos Inhamuns ASD is studied in this section. Initially, a descriptive analysis was developed (measures of central tendency and dispersion) for the dimensions of governance and desertification and for the aggregate indices (Table 6). This is a synthesis of the values presented in the previous sections that reinforces the high levels of desertification, especially due to the state and response dimensions, and the low levels of governance caused mainly by deficiencies identified in indicators of the participation and implementation dimensions. There is greater homogeneity between communities regarding the desertification situation. Governance varies more intensely across the region.

Table 6 | Descriptive statistics of the component variables of the quantile regression models estimated in the research. Data referring to the ASD of Sertões dos Inhamuns as a whole.

Variables	Average	Standard deviation	CV	Min	Max
IGAD Efficiency and Effectiveness Dimension	0.063	0.084	13.2	0.000	0.433
IGAD Participation Dimension	0.181	0.142	78.5	0.000	0.711
IGAD Access Dimension	0.358	0.112	31.3	0.179	0.667
IGAD Accountability Dimension	0.616	0.282	45.8	0.000	1,000
IGAD Capacity Dimension	0.455	0.245	53.8	0.000	1,000
IGAD Implementation Dimension	0.273	0.121	44.3	0.000	0.625
IGAD – Governance Index in Desertified Areas	**0.325**	**0.125**	**38.5**	**0.115**	**0.664**
IDp – Pressure Dimension	0.541	0.128	23.7	0.250	0.875
IDe – State Dimension	0.711	0.139	19.6	0.333	0.923
IDr – Response Dimension	0.524	0.090	17.2	0.238	0.667
ID – Desertification Index	**0.592**	**0.084**	**14.1**	**0.367**	**0.752**

Source: The authors, based on the research data

The combination of high average desertification values with low average levels of governance suggests an inverse relationship, proven through correlation analysis. The analysis of Pearson correlation coefficients between ID and IGAD showed that there is a significant inverse correlation (-0.381), that is, higher levels of implementation of governance principles are associated with lower levels of desertification, corroborating the hypothesis that the presence of a governance structure reduces the advancement of desertification under anthropogenic conditions (Table 7).

Table 7 | Pearson correlation coefficient matrix between desertification indexes (DI) and governance in desertified areas (IGAD) and their respective dimensions

Indexes/Dimensions	ID – Desertification Index	IGAD – Governance Index in Desertified Areas
ID – Desertification Index	-	-0.381 **
IDp – Pressure Dimension	0.844 **	-0.346 **
IDe – State Dimension	0.837 **	**-0.123**
IDr – Response Dimension	0.291 **	-0.382 **
IGAD – Governance Index in Desertified Areas	-0.381 **	-
IGAD Efficiency and Effectiveness Dimension	-0.270 **	0.611 **
IGAD Participation Dimension	-0.342 **	0.769 **
IGAD Access Dimension	-0.429 **	0.743 **
IGAD Accountability Dimension	-0.270 **	0.839 **
IGAD Capacity Dimension	-0.425 **	0.900 **
IGAD Implementation Dimension	0.106	0.424 **

** Significant correlation at 1%, * Significant correlation at 5%

Source: The authors, based on the research data

The only aspect of governance that does not have a significant relationship with desertification is the Implementation dimension, just as the State dimension was not significantly related to IGAD. Among the desertification dimensions and IGAD, the Pressure (-0.346) and Response (-0.382) dimensions stand out. This means that governance leads to more significant results in indicators related to the causes of desertification and those related to society's responses to this problem. A significant inverse relationship is also observed between the governance dimensions and ID, except for the Implementation dimension. This relationship is discussed, even if in a non-quantitative way, in the research by Ventura *et al.* (2014), Lima and Magalhães (2016), Wang *et al.* (2022), and He and Yue (2023), among many.

The estimation of regression models made it possible to confirm the causality of the relationship between governance and desertification, in addition to quantifying the average impact of increases in governance levels on the reduction of desertification in ASD Sertões dos Inhamuns. The estimation results are presented in two groups. Initially, it is possible to analyze the influence of governance as a whole (IGAD) on ID and its dimensions. Table 8 shows the results of the two estimation methods: OLS and quantile regression. A first result shows that the idea that governance could cause different impacts depending on the degree of desertification is not valid, given that the Wald test showed that there is no statistically significant difference between the estimated coefficients in the different quantiles of the ID distribution. Therefore, the analysis of the relationship between the variables can be made based on the values corresponding to the OLS. Thus, there is a significant impact of (aggregate) governance on desertification as a whole and on the pressure and response dimensions. This impact is greater on the pressure dimension, with it being observed that an increase of one unit in governance reduces the pressure dimension Index by 0.354, on average.

Table 8 | Result of the estimated models – Influence of governance on the aggregate Desertification Index (DI) and the pressure and response dimensions

ID = f (IGAD)					
Description	MQO	QUANTILE REGRESSION			
		q25	q50	q75	q90
IGAD	-0.254***	-0.298***	-0.255***	-0.365***	-0.384***
Constant	0.675***	0.657***	0.673	0.761***	0.817***
N	91	91	91	91	91
R²	0.145	0.094	0.098	0.095	0.179
	F ANOVA reg = 18.61***	Wald test = 1.59			
ID $_{Pressure}$ = f (IGAD)					
Description	MQO	QUANTILE REGRESSION			
		q25	q50	q75	q90
IGAD	-0.354***	-0.321***	-0.317***	-0.360***	-0.456***
-Constant	0.656***	0.578***	0.644***	0.724***	0.845***
N	91	91	91	91	91
R²	0.119	0.038	0.079	0.105	0.118
	F ANOVA reg = 13.40***	Wald test = 0.28			
ID $_{Response}$ = f (IGAD)					
Description	MQO	QUANTILE REGRESSION			
		q25	q50	q75	q90
IGAD	-0.272***	-0.262**	0.373***	-0.227***	0.000
Constant	0.613***	0.554***	0.669***	0.655***	0.619***
N	91	91	91	91	91
R²	0.146	0.002	0.089	0.118	0.000
	F ANOVA reg = 10.77***	Wald test = 0.39			

OLS – Heteroscedasticity-robust. Significance level *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: The authors, based on the research data

Considering the significant influence of IGAD on ID, we also sought to analyze the isolated impact of each dimension of governance on desertification and its dimensions. Given the significant correlation between the "state" dimension of desertification and some of the governance dimensions, it was decided to include it in this analysis. Therefore, four additional regression models were estimated (Table 9).

Table 9 | Result of the estimated models – Influence of governance dimensions on the aggregate Desertification Index (DI) and the pressure and response dimensions.

ID = f(IGADEfi, IGADPart, IGADAcesso, IGADAccount, IGADCapac, IGADImplem)					
Description	MQO	q25	q50	q75	q90
IGADEfi	0.000	-0.112	-0.067	0.003	0.046
IGADPart	0.004	0.028	-0.002	-0.069	-0.127
IGADAcesso	-0.231**	-0.290*	-0.270*	-0.217*	-0.086
IGADAccount	0.031	-0.023	-0.010	0.024	0.046
IGADCapac	-0.129**	-0.072	-0.038	-0.112	-0.157***
IGADImplem	0.158**	0.185*	0.088	0.131*	0.195*
Constant	0.671***	0.657***	0.700***	0.733***	0.718***
R^2	0.287	0.187	0.157	0.167	0.264
	F ANOVA reg = 6.06***		Wald test = 113.87***		
IDPression = f(IGADEfi, IGADPart, IGADAcesso, IGADAccount, IGADCapac, IGADImplem)					
Description	MQO	q25	q50	q75	q90
IGADEfi	-0.211	-0.573	-0.157	0.171	-0.095
IGADPart	0.080	0.155	0.056	-0.215	0.056
IGADAcesso	-0.160	-0.054	-0.189	-0.150	0.161
IGADAccount	-0.021	0.037	-0.125	-0.259*	-0.102
IGADCapac	-0.176	-0.205	-0.053	0.083	-0.319
IGADImplem	0.288**	0.206	0.204	0.380**	0.472
-Constant	0.612***	0.515***	0.664***	0.704***	0.713***
R^2	0.2476	0.1320	0.1537	0.1870	0.2114
	F ANOVA reg =5.34***		Wald test = 5.35***		
StateID = f(IGADEfi , IGADPart, IGADAcesso, IGADAccount, IGADCapac, IGADImplem)					
Description	MQO	q25	q50	q75	q90
IGADEfi	0.020	-0.378	0.328	0.149	-0.014
IGADPart	0.052	0.218	-0.020	-0.071	-0.028
IGADAcesso	-0.334**	-0.183	-0.288	-0.207	-0.183**
IGADAccount	0.149*	0.130	0.088	0.147**	0.174***
IGADCapac	-0.248**	-0.352**	-0.231	-0.289**	-0.234***
IGADImplem	0.460***	0.457***	0.485***	0.342**	0.271
Constant	0.716***	0.657***	0.736***	0.828***	0.833***
R^2	0.2851	0.2021	0.1612	0.1321	0.1628
	F ANOVA reg = 5.9***		Wald test = 10.77***		
IDResponse = f(IGADEfi, IGADPart, IGADAcesso, IGADAccount, IGADCapac, IGADImplem)					
Description	MQO	q25	q50	q75	q90
IGADEfi	0.192	0.186	-0.211	0.243	0.100
IGADPart	-0.120	-0.080	0.015	-0.221**	-0.170
IGADAcesso	-0.200*	-0.374**	-0.124	-0.149	0.115
IGADAccount	-0.036	0.029	-0.048	-0.057	0.012
IGADCapac	0.038	0.002	0.049	0.089	-0.052
IGADImplem	-0.273***	-0.277**	-0.313***	-0.236***	-0.288**
-Constant	0.684***	0.670***	0.687***	0.713***	0.694***
R^2	0.282	0.129	0.181	0.182	0.117
	F ANOVA reg = 6.0***		Wald test = 8.75***		

OLS ‒ Heteroscedasticity-robust. Significance level *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: The authors, based on the research data

The results obtained allowed the following inferences[2]:

  i) the dimensions of governance cause different impacts on communities with higher and lower levels of desertification (rejection of the null hypothesis of the Wald test);

  ii) considering global desertification, including the three dimensions, the access dimension influences communities with lower levels of desertification more intensely, the opposite is observed in the capacity dimension;

  iii)   when analyzing only the desertification pressure dimension, the results indicate a significant impact only on the implementation dimension, an impact that is greater when there are higher levels of desertification;

  iv) in the state dimension, it was noticed that the capacity and implementation dimensions of governance reduce desertification levels, but implementation tends to reduce its impact as desertification levels increase;

  v) Finally, only the governance implementation dimension has a significant impact on the desertification response dimension.

The results presented draw attention to the fact that concern with creating a good governance structure is an essential element in combating desertification. And even if changes are not possible in all dimensions involving the concept, specific aspects or particular indicators of governance can be improved with significant results in combating the phenomenon.

FINAL CONSIDERATIONS

The study proved the hypothesis that a good governance structure can reduce desertification in the Sertões dos Inhamuns ASD, a fact evidenced by the identification of a negative and significant causality between the two concepts. Proving this relationship is particularly relevant given two characteristics identified in the region: a high degree of desertification and low levels of governance.

There is no governance structure characterized by the implementation of instruments that facilitate the fight against desertification, a fact verified by the low level of implementation of indicators in the efficiency, effectiveness, and participation dimensions. The organization of community associations and the support and trust of the population in their leaders stand out positively, reflected in the good performance of the Accountability dimensions and Capacity.

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2 Analyses carried out based on the results of quantile regressions, given the rejection of the null hypothesis of the Wald test.

Given the scenario observed in the Sertão dos Inhamuns ASD, the study draws the attention of decision makers, within the scope of strategies to combat desertification, to the need to strengthen local governance instruments in order to enhance their interventions. In this sense, it is important to implement measures that encourage popular participation in decision-making processes, as well as promote public awareness of the seriousness of desertification in the region and the need to control it to achieve better socioeconomic and environmental conditions in the region.

REFERENCES

ALSAYEGH, M. F., DITTA, A., MAHMOOD, Z., KOUSER, R. The Role of Sustainability Reporting and Governance in Achieving Sustainable Development Goals: An International Investigation. **Sustainability**, v. 15, n. 4, p. 3531, 2023.

ARAÚJO, JANE AZEVEDO de. A percepção da desertificação e da mudança na paisagem no município de Parelhas/RN. 2016. 124f. Tese (Doutorado em Desenvolvimento e Meio Ambiente) - Centro de Biociências, Universidade Federal do Rio Grande do Norte, Natal, 2016.

BAO, Y., CHENG, L., BAO, Y., YANG, L., JIANG, L., LONG, C., *et al.* Desertification: China provides a solution to a global challenge. **Frontiers of Agricultural Science and Engineering**, v. 4, n. 4, p. 402-413, 2017.

BOCQUIER, P., NORDMAN, C.J., VESCOVO, A., 2010. Employment Vulnerability and Earnings in Urban West Africa. **World Development**. v. 38, p. 1297–1314, 2010.

BRIASSOULIS, H. Combating land degradation and desertification: The land-use planning quandary. **Land**, v. 8, n. 2, p. 27, 2019.

BRIASSOULIS, HELEN. Governing desertification in Mediterranean Europe: The challenge of environmental policy integration in multi-level governance contexts. **Land Degradation & Development**, v. 22, n. 3, p. 313-325, 2011.

BRUSZT, LÁSZLÓ; PALESTINI, STEFANO. Regional development governance. IN: BORZET, T. A; RISSE, T. (Eds). **The Oxford handbook of comparative regionalism**, 2016, p. 374-404.

CHAPPLE, KAREN; MONTERO, SERGIO. From learning to fragile governance: Regional economic development in rural Peru. **Journal of Rural Studies**, v. 44, p. 143-152, 2016.

CHESHIRE, L; EVERINGHAM, J; LAWRENCE, G. Governing the impacts of mining and the impacts of mining governance: Challenges for rural and regional local governments in Australia. **Journal of Rural Studies**, v. 36, p. 330-339, 2014.

CHIBA, Y; SHAW, R; PRABHAKAR, S. Climate change-related non-economic loss and damage in Bangladesh and Japan. **International Journal of Climate Change Strategies and Management**, v. 9, n. 2, p. 166-183, 2017.

DANSON, MIKE; HALKIER, HENRICK; CAMERON, Greta (Ed.). **Governance, institutional change and regional development**. Routledge, 2018.

DAVIS, K. E.; KINGSBURY, B.; MERRY, S. E. Indicators as a Technology of Global Governance. **Law & Society Review**. v. 46, n.1, p. 71–104, 2012.

DELGADO, NELSON GIORDANO; GRISA, CATIA. Políticas de desenvolvimento territorial e pobreza rural no Brasil: análise das institucionalidades e da governança. **Estudos Sociedade e Agricultura**, v. 22, n.1, p. 132-163,2014.

FÁVERO, L. P., BELFIORE, P., SILVA, F. D.; CHAN, B. L. **Análise de dados**: Modelagem multivariada para tomada de decisões. Rio de Janeiro, Campus, 2009.

FÁVERO, L. P.; BELFIORE, P. **Análise de dados**: técnicas multivariadas exploratórias com SPSS e STATA. Rio de Janeiro, Elsevier, 2015.

FERNANDES, BERNARDO MANÇANO; WELCH, CLIFFORD ANDREW; GONÇALVES, ELIENAI CONSTANTINO. Land governance in Brazil. **Framing the Debate Series**, v. 2, 2012.

GOLDSTEIN, HARVEY A.; GLASER, KARIN. Research universities as actors in the governance of local and regional development. **The Journal of Technology Transfer**, v. 37, p. 158-174, 2012.

HE, WENSHENG; YUE, XIAO. Collaborative Governance in Desertification Control in China: A Case Study of Hobq Desert. **Sustainability**, v. 15, n. 3, p. 1979, 2023.

HE, WENSHENG; YUE, XIAO. Collaborative Governance in Desertification Control in China: A Case Study of Hobq Desert. **Sustainability**, v. 15, n. 3, p. 1979, 2023.

HERRMANN, STEFANIE M.; HUTCHINSON, CHARLES F. Links between Land Degradation, Drought, and Desertification. **Governing Global Desertification:** Linking Environmental Degradation, Poverty and Participation, p. 11, 2006.

IBGE - **Censo demográfico 2010**. Disponível em: . Acesso em: 15 Jan 2018.

IMESON, A. **Desertification, Land Degradation and Sustainability**; Wiley: London, UK, 2011.

KANIE, N.; GRIGGS, D.; YOUNG, O.;WADDELL, S.; SHRIVASTAVA, P.; HAAS, P.M.; et al,. Rules to goals: Emergence of new governance strategies for sustainable development. Governance for global sustainability is undergoing a major transformation from rule-based to goal-based. But with no compliance measures, success will require an unprecede. **Sustain. Sci**., v.14, p. 1745–1749, 2019.

KAUFMANN, DANIEL; KRAAY, AART; MASTRUZZI, MASSIMO. **Governance matters VII: aggregate and individual governance indicators 1996-2007**. The World Bank, 2008.

LIMA, JOSÉ ROBERTO DE; MAGALHÃES, ANTONIO ROCHA. Institucionalidade e governança para o combate à desertificação no Brasil. In: MOURA, Adriana Maria Magalhães (Org.).**Governança ambiental no Brasil : instituições, atores e políticas públicas.** Brasília : Ipea, 2016, p. 231-252.

LIU, NING; ZHOU, LIHUA; HAUGER, J. SCOTT. How sustainable is government-sponsored desertification rehabilitation in China? Behavior of households to changes in environmental policies. **Plos one**, v. 8, n. 10, p. e77510, 2013.

MARENGO, J. A. Vulnerabilidade, impactos e adaptação à mudança do clima no semi-árido do Brasil. **Parcerias Estratégicas**, v. 13, n. 27, p. 149-176, 2008.

MARENGO, J.A., TORRES, R.R., ALVES, L.A., Drought in Northeast Brazil—past, present, and future. **Theoretical and Applied Climatology**. 129 (3–4), 1189–1200. 2016.

MARTÍNEZ-VALDERRAMA, J., DEL BARRIO, G., SANJUÁN, M. E., GUIRADO, E., MAESTRE, F. T. Desertification in Spain: A sound diagnosis without solutions and new scenarios. **Land**, v. 11, n. 2, p. 272, 2022.

MAZHAR, NAUSHEEN; SHIRAZI, SAFDAR ALI. Community perceptions of the impacts of desertification as related to adaptive capacity in drylands of South Punjab, Pakistan. **Asia-Pacific Journal of Regional Science**, v. 7, n. 2, p. 549-568, 2023.

NERI, A. C.; DUPIN, P.; SÁNCHEZ, L. E. A pressure-state-response approach to cumulative impact assessment. *Journal of Cleaner Production*, Amsterdam, v. 126, p. 288-298, 2016.

NEVES, BRUNO; ROXO, MARIA JOSÉ. **A percepção de desertificação em Portugal: análise comparativa de inquéritos e notícias**. In: Actas do XII Colóquio Ibérico de Geografia 6 a 9 de Outubro 2010, Porto: Faculdade de Letras (Universidade do Porto). 2010.

OLIVEIRA JUNIOR, Israel. Evolução do uso e cobertura da terra e vulnerabilidade ambiental nos núcleos de desertificação do bioma Caatinga. **Caderno de Geografia**, v. 33, n. 74, p. 910-938, 2023.

OMAN, C. P., ARNDT, C. **Uses and Abuses of Governance Indicators.** OECD Publishing, 2006.

ONATE, JUAN J.; PECO, BEGONA. Policy impact on desertification: stakeholders' perceptions in southeast Spain. **Land use policy**, v. 22, n. 2, p. 103-114, 2005.

POMERANZ, EMILY F., RICHARD C. STEDMAN. Measuring good governance: Piloting an instrument for evaluating good governance principles. **Journal of Environmental Policy and Planning, v.**22, p. 428–440, 2020.

REFATI, D. C., DA SILVA, J. L. B., MACEDO, R. S., LIMA, R. D. C. C., DA SILVA, M. V., PANDORFI, H., *et al.* Influence of drought and anthropogenic pressures on land use and land cover change in the brazilian semiarid region. **Journal of South American Earth Sciences**, v. 126, p. 104362, 2023.

RODORFF, VERENA. Good Governance: A Framework for Implementing Sustainable Land Management, Applied to an Agricultural Case in Northeast-Brazil. **Sustainability**, v. 11, n. 16, p. 4303, 2019.

RODRIGUES, M. I. V. A **Propensão à Desertificação no Estado do Ceará:** aspectos agropecuários, econômicos, sociais e naturais. 2006. 132f. Dissertação (Mestrado em Desenvolvimento e Meio Ambiente) – Centro de Ciências, Universidade Federal do Ceará. Fortaleza, 2006.

ROSENZWEIG; KAROLY, D.; VICARELLI, M.; NEOFOTIS, P.; Attributing physical and biological impacts to anthropogenic climate change. **Nature**, v. 453, n. 7193, p. 353-357, 2008.

SABOURIN, E. Práticas de reciprocidade e economia de dádiva em comunidades rurais do Nordeste brasileiro. **Revista Raízes**, v. 1, n. 20, p. 41-49, 1999.

SALES, M. C. L. Evolução dos estudos de desertificação no Nordeste brasileiro. **Geousp, Espaço e Tempo.** São Paulo. n°11. p. 115-126. 2002.

SANTOS, FLÁVIO AUGUSTO MONTEIRO; DOS SANTOS PORTUGAL, ANDERSON. Percepção naturalista do ambiente de alunos concluintes EaD em um curso de Ciências Biológicas e suas implicações educacionais. **REMEA-Revista Eletrônica do Mestrado em Educação Ambiental**, v. 40, n. 1, p. 429-451, 2023.

SANTRA, P.; MOHARANA, P. C.; KUMAR, M.; SONI, M. L.; PANDEY, C. B.; CHAUDHARI, S. K.; SIKKA, A. K. Crop production and economic loss due to wind erosion in hot arid ecosystem of India. **Aeolian Research**, v. 28, p. 71-82, 2017.

SHAH, A. SHAH, S. The New Vision of Local Governance and the Evolving Roles of Local Governments. *In*: Shah, A. (ed.), **Local Governance in Developing Countries***, The World Bank, Washington, D.C., p. 1-45.2006.

SIMÕES, A. F.; KLIGERMAN, D. C.; ROVERE, E. L. LA; MAROUN, M. R.; BARATA, M.; OBERMAIER, M. Enhancing adaptive capacity to climate change: The case of smallholder farmers in the Brazilian semi-arid region. **Enviromental Science & Policy**, v. 13, p. 801–808, 2010.

SOUSA, M. C. D., LIMA, P. V. P., KHAN, A. S., ROCHA, L. A. Confluência do capital social, empoderamento e governança ambiental na sadia qualidade de vida em comunidades rurais no Ceará. **Revista de Economia e Sociologia Rural**, v. 55, p. 711-732, 2017.

SOUZA, BARTOLOMEU ISRAEL. DESERTIFICAÇÃO E DINÂMICA DA COBERTURA VEGETAL: conhecimentos acumulados e desafios vigentes. **Geo UERJ**, n. 42, p. 1-23, 2023.

SOUZA, LARISSA MAIA. **Percepção e Desertificação: a relação estreita para a compreensão desse processo degradativo na ótica do sertanejo**. In: VII CONNEPI-Congresso Norte Nordeste de Pesquisa e Inovação. 19 a 21 de outubro, Palmas, Tocantins. 2012.

SUMNER, A., ACOSTA, A. M., CABRAL, L., KAPUR, R., BOBDE, S., ... BROUILLET, A. (2009a). Access to governance and policy processes: what enables the participation of the rural poor Roma. **International Fund for Agricultural Development (IFAD)**. 2008.

SUN, JIAYI; TAN, DEQING. Non-cooperative mode, cost-sharing mode, or cooperative mode: Which is the optimal mode for desertification control?. **Computational Economics**, v. 61, n. 3, p. 975-1008, 2023.

VENTURA, S.; SELVA, ANA COELHO V.; CAVALCANTI, E. Reflexões sobre desertificação, governança e gestão ambiental municipal. In: **Territorios rurales, agriculturas locales y cadenas alimentarias: 16-17 octubre 2014, Palencia**. Editorial Universitat Politècnica de València, 2014. p. 373.

VIANA, C. F. G. **Da seca como episódio à desertificação como processo:** uma questão (não)institucionalizada. 2013. 244 f. Tese (Doutorado em Desenvolvimento Sustentável) - Universidade de Brasília, Brasília, 2013.

WANG, TAO; NYAMTSEREN, MANDAKH; PAN, JING. Implementation of Measures to Combat Aeolian Desertification in Mongolia. In: **Combating Aeolian Desertification in Northeast Asia**. Singapore: Springer Nature Singapore, 2022. p. 279-293.

YANG, L. Scholar-Based Governance as an Alternative Solution to the Collective Action Dilemma. In: **Knowledge-Driven Governance**. Springer, Singapore, 2019. 289p.

YANG, LIHUA. Types and institutional design principles of collaborative governance in a strong-government society: The case study of desertification control in northern China. **International Public Management Journal**, v. 20, n. 4, p. 586-623, 2017.

YANG, R.; LUO, X. L. Progress and prospects in rural space diversification, reconstruction, and governance from a development perspective. **Trop. Geogr**, v. 40, p. 575-588, 2020.

YOU, Y., LEI, J., WANG, Y., XU, X. Comparative study of the implementation of environmental policies to combat desertification in Kuwait and the Hotan Region of China. **Arabian Journal of Geosciences**, v. 12, p. 1-9, 2019.

ZAITUL, ZAITUL; ILONA, DESI; NOVIANTI, NEVA. Good Governance in Rural Local Administration. **Administrative Sciences**, v. 13, n. 1, p. 19, 2023.

ZUCCA, C.; DELLA PERUTA, R.; SALVIA, R.; SOMMER, S.; CHERLET, M. Towards a World Desertification Atlas. Relating and selecting indicators and data sets to represent complex issues. **Ecological Indicators**, v. 15, n. 1, p. 157-170, 2012.