

Socio-environmental conflicts and the implantation of wind farms in the Brazilian Northeast

Conflitos socioambientais e a implantação de parques eólicos no Nordeste brasileiro

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ABSTRACT

Wind energy is already quite relevant in the Brazilian electrical matrix, especially when analysing the country's Northeast region. This expansion of wind sources gained even more strength with the development of renewable sources in an international context of negotiations to reduce greenhouse gas emissions. However, the implementation and operation of wind farms generate significant socio-environmental impacts on the population around these large enterprises. This research analysed academic articles that portray negative socio-environmental impacts caused by the installation and operation of wind farms in the Northeast of Brazil to address the local conflicts resulting from them situations of environmental injustice. A typology of identified conflicts is presented, classified into four categories: economic, water, land and health and wellness, demonstrating a clear scenario of environmental injustice.

Keywords: Wind energy. Local communities. Environmental injustice. Energy crisis. Renewable energy.

RESUMO

A energia eólica já se mostra bastante relevante na matriz elétrica brasileira, sobretudo quando analisada a Região Nordeste do país. Essa expansão das fontes eólicas ganhou ainda mais força com o desenvolvimento das fontes renováveis, em um contexto internacional de negociações pela redução de emissões de gases de efeito estufa. Todavia, a implantação e o funcionamento de parques eólicos geram impactos socioambientais significativos na população residente no entorno desses grandes empreendimentos. A presente pesquisa analisou artigos acadêmicos que retratam impactos socioambientais negativos causados pela instalação e operação de parques eólicos no Nordeste brasileiro para então abordar os conflitos locais deles decorrentes em situação de injustiça ambiental. É apresentada uma tipologia dos conflitos identificados, classificados em quatro categorias, quais sejam econômicos, hídricos, fundiários, e saúde e bem-estar, demonstrando o nítido cenário de injustiça ambiental.

Palavras-chave: Energia eólica. Comunidades locais. Injustiça ambiental. Crise energética. Energia renovável.

1 INTRODUCTION

Most of the Brazilian electrical matrix comes from hydroelectric plants. However, wind sources represent 10.6% of the Brazilian electricity matrix (BEN, 2022), and the country leapt from 15th place in countries with the highest installed capacity in 2012 to 6th in 2021 (Abeeólica, 2022). Since 2001, a year in which there were several "blackouts", wind farm installations in Brazilian territory have been growing, with emphasis on the Northeast region.

Since the 1990s, in an attempt to reduce the region's energy shortage, especially for the population far from large urban centres, projects have been designed to generate decentralised energy in a more economically accessible way. Thus, Brazil established new political guidelines with the objectives of expanding and diversifying the Brazilian electrical matrix, ensuring security in the energy supply and increasing access to energy (Drummond; Ferraz; Ramos, 2022).

Furthermore, the increase in environmental concerns has also stimulated the search for new sources of energy production compatible with an electrical matrix that is increasingly less dependent on fossil sources and more sustainable. In this scenario, due to the favourable geographic position of the Northeast, wind energy production gained space in the region (Santana; Silva, 2021).

Although wind energy is considered a source of clean energy, based exclusively on greenhouse gas emissions criteria, and because it is obtained through the power of an inexhaustible resource, the wind, the installation of large farms also causes significant socio-environmental impacts, although little

explored when compared to the literature that deals with their positive attributes (Sobrinho Júnior *et al.*, 2022).

Based on studies conducted in the Northeast, mostly in the state of Ceará, the literature lists different impacts caused by the installation of wind farms, such as land invasions, weakening of subsistence activities, such as agriculture and fishing, erasure of the existence of traditional population, noise pollution, visual pollution, changes in bird behaviour and reproduction, burial of lagoons and disappearance of dunes (Sobrinho Júnior *et al.*, 2022). Therefore, given these impacts, the article aims to answer the following question: what are the main socio-environmental conflicts caused by wind farms in the Brazilian Northeast?

In this sense, the objective is to identify the main conflicts generated by installing and operating wind farms in the Northeast of Brazil. In order to achieve this general objective, two specific objectives were defined: identifying the environmental impacts of wind energy projects and building a typology of the main socio-environmental conflicts related to local populations.

This research is based on analysing the literature on wind farms installed in the Northeast and the conflicts presented.

The focus on the Northeast is justified, as the region is home to most of the wind farms installed in Brazil, which is responsible for 88.7% of the entire country's wind energy production (Abeeólica, 2022). Observing the bibliography analysed, a typology of socio-environmental impacts was identified, developed by Farias, Silva and Carvalho (2021), which served as a reference for categorising socio-environmental conflicts arising from these impacts. The article presents five sections. After this introduction, section 2 addresses environmental injustice. In section 3, the methodology is presented. The results and discussion are shown in section 4. Finally, in section 5, the conclusion is made.

2 THEORETICAL REFERENCES

This article uses the concepts of environmental justice and injustice. The first arises from the integration of the concept of social justice, associated with the extent to which the environment and natural assets must be accessible to the entire population fairly. Furthermore, it combines the search for everyone's right to live in a healthy environment and equity and respect for human rights in relation to environmental impacts, especially considering the most vulnerable and marginalised communities (Acselrad, 2010). On the other hand, when there is no guarantee of this accessibility, environmental injustice is used to describe the greater exposure to environmental damage to which marginalised groups are subjected (Porto; Finamore; Ferreira, 2013). Based on that, environmental injustice is present when the pros and cons of large enterprises - which use natural assets - occur unequally, and historically marginalised and vulnerable communities are the most negatively affected (Acselrad, 2008).

The positive impacts of wind energy and how they are seen on a global scale are undeniable. In Brazil, some of the most present arguments are the democratisation of electrical energy and the fact that it is renewable (Araújo *et al.*, 2020; Neri *et al.*, 2019; Paiva; Lima, 2019; Santana; Silva, 2021). In the Northeast, the exploitation of winds for energy generation is justified thanks to favourable geographical

characteristics, such as climate, latitude, relief, and wind speed, as shown in Figure 1 (Bezerra, 2021; Santana; Silva, 2021).

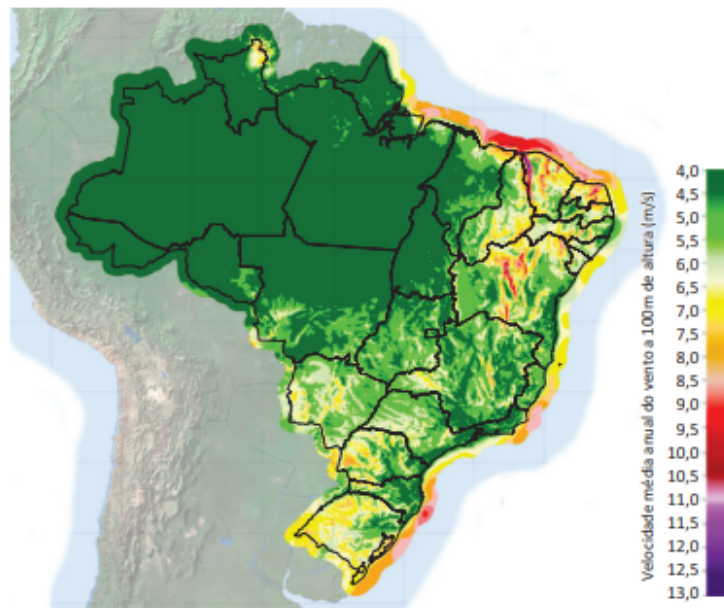


Figure 1 | Brazilian Wind Power Average annual wind speed at 100 meters high (m/s).

Source: Bezerra, 2021.

Therefore, large investments have been made in the region for wind exploration. Between 2009 and 2017, the region received 80% of the entire amount invested nationally in the sector, corresponding to an amount of BRL 80 billion (Santana; Silva, 2021). Despite the regionalist motivations that drove these investments, the benefits of energy generation have been directed to external groups without economically benefiting local communities, causing material and immaterial losses to those who have already been greatly neglected. (Farias; Silva; Carvalho, 2021; Pinto; Martins; Pereira, 2017; Santana; Silva, 2021).

This negligence is shown when, for example, most of the implementation of wind farms in the Northeast occurs in regions where the local population remains without access to energy. This is often not considered in the planning and installation of farms, mainly due to studies that evaluate impacts superficially. Therefore, on a local scale, many of the consequences of such projects can harm the environment and the local population, generating a scenario of environmental injustice.

Therefore, focusing on the discussion on environmental (in)justice and conflicts, the environmental injustices arising from wind farm projects in the Northeast of Brazil are also linked to the suppression of the cultures and material and symbolic bonds of these populations by strongly impacting the territory in which they live. Therefore, for such groups, there is an intrinsic relationship with their productive environment that encompasses material, symbolic, and cultural aspects related to the land, common open areas, biodiversity, and ecosystems, where they build their identities and social bonds. However, these relationships are constantly threatened and unstructured by projects that call themselves development and clean energy (Araújo, 2016).

Environmental conflicts arise when negatively impacted communities demand greater access to natural resources and report the compromise of their activities as a result of large projects to appropriate space and the physical environment (Acselrad, 2004; Farias, 2023).

Given this fact, it is noted that the advancement of wind energy in Brazil, together with the rhetoric of development and the growing use of renewable energy, is closely linked to inequality and environmental

injustices in the Northeast of Brazil since the ruling elite in Brazil, in conjunction with the market, has demonstrated an especially selfish and insensitive stance, indiscriminately prioritising its interests and immediate profits (Acsehrad, 2004). The economic benefits are concentrated in the hands of private companies, while local communities face the onus of the enterprises, often without access to basic resources and, in some cases, ironically, even electricity. (Gorayeb; Brannstrom, 2016).

3 METHODOLOGY

The literature review was conducted using searches in three databases: SciElo, Scopus and Web of Science. Data from academic articles collected in databases were used, as well as information from the official national database on Brazilian energy matrix (BEN) and data from the representative organisation of the Brazilian wind energy industry (*Associação Brasileira de Energia Eólica – Abeeólica*), which demonstrate the negative socio-environmental impacts caused to local communities living close to wind farms, focusing on the Northeast of Brazil.

In order to standardise data collection, the same keywords were used, and no additional filters were applied, as shown in Table 1.

Table 1 | Selection of articles

| Database | Terms | |
|----------------|-----------------------------|---|
| | Conflicts and "Wind Farm\$" | Brazil, Conflicts and "Wind Farm\$" |
| SciElo | 1 result | 6 results – 5 articles selected, after applying the exclusion criteria |
| Scopus | 313 results | 9 results – 5 articles selected, after applying the exclusion criteria |
| Web of Science | 252 results | 10 results – 2 articles selected, after applying the exclusion criteria |

Source: Author's elaboration.

It can be observed that with each addition of keywords, the number of results changes, representing the search bottleneck. We mainly considered articles found with the keywords "Brazil" and "Conflicts" and "Wind Farm\$" in the case of the SciElo database, and "Brazil" and "Conflict\$" and "Wind Farm\$" in the case of Scopus and the Web of Science.

Finally, searches were conducted according to relevance and number of citations on existing typologies of socio-environmental impacts to serve as an initial reference and demonstrate the still incipient typology of such impacts and their resulting conflicts within developing countries.

Once the bibliographical research was conducted, using the terms Brazil and Conflicts and "Wind Farm\$", and the exclusion criteria were applied, 12 articles were selected. Articles that were repeated across different databases and those that were not relevant to the proposed topic were excluded.

The selected articles mainly address the states of Rio Grande do Norte, Pernambuco and Ceará, with the largest amount of information found being on the regions of São Cristóvão, in the municipality of Areia Branca (RN), in the municipality of Serra do Mel (RN), the community of Xavier, in the coastal area of Ceará, and the Communities of Galos and Galinhos in Rio Grande do Norte. These articles address the Caatinga biome, predominant in the Brazilian northeastern territory, and most of the wind farms in these regions are in the installation or operation phase. The articles address local contexts from

2001 onwards, the time frame used in the research, when the energy crisis gained strength, and the strengthening of an energy transition from fossil fuels to renewable energy began in Brazil.

From this, a schematic table was drafted about the main socio-environmental impacts identified in the literature, meaning those impacts that have directly generated local socio-environmental conflicts, based on the typology created by Farias Silva and Carvalho (2021). This work was chosen as the basis for the construction of this research because, among the bibliography analysed, it was the only one that presented a preliminary typology of negative impacts and potential generators of conflicts. The initial classification of these impacts was essential to understand and classify the resulting conflicts. Impacts identified only in the Northeast of Brazil were considered, as the research aims to create a local typology, unlike research already conducted based on developed countries (Bell; Gray; Haggett, 2005; Bell *et al.*, 2013; Pasqualetti, 2011). Furthermore, only articles that deal with wind farms located onshore were selected, and articles that deal with impacts that do not necessarily generate local conflicts were excluded. Considering that the objective of surveying the impacts is to relate them to the resulting conflicts caused, only negative impacts were considered.

From these impacts, the consequent conflicts caused at the location of the wind farms were raised, as mentioned in the articles analysed, classified into the following types: (i) economic, (ii) land, (iii) water, and (iv) health and wellness. This typology was established based on common elements in the 12 articles analysed. The partial arbitrariness in the choice of such types of conflicts is recognised (as is the case in any typology not yet sufficiently explored in the literature). However, the elaboration of the typology was based on conflicts identified by specialised literature so that they have a basis for their framing in the proposed form. Furthermore, detailed descriptions and captions for each type surveyed are explained in the discussion of the results. Finally, it is important to clarify that the present study intended to conduct the typology of conflicts and not of impacts, which are only the causes identified for those.

4 RESULTS AND DISCUSSION

Once the articles were reviewed, 21 conflicts caused by the implementation of wind farms in the Northeast were identified, resulting from the socio-environmental impacts of the enterprises, mentioned 40 times in the literature and organised in an Excel spreadsheet. These conflicts were classified into four different types, namely: "economic", "land", "water", and "health and wellness" (Figure 2 and Table 1), detailed in this section according to the different factors that highlight the situation of environmental injustice.

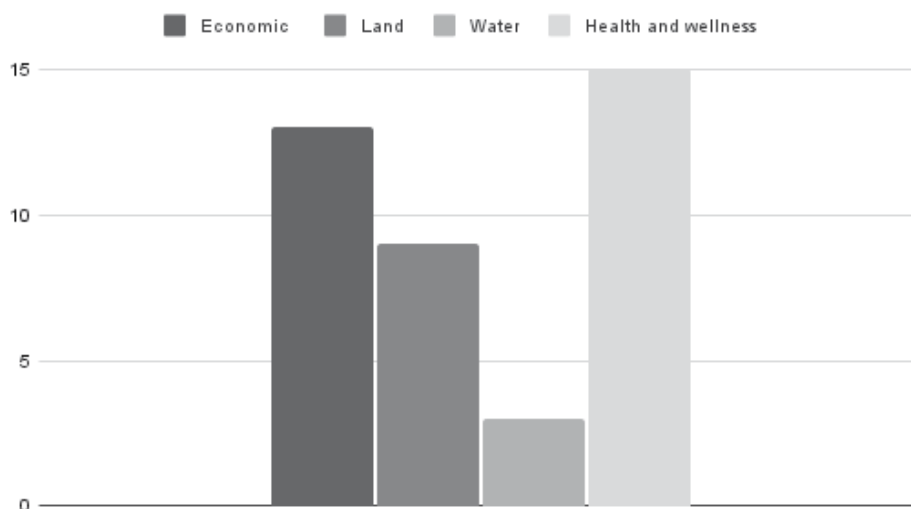


Figure 2 | Number of conflicts mentions.

Source: Author's elaboration.

It is evident that most conflict mentions (15) refer to those related to health and wellness, followed by mentions of economic conflicts (13), which will be exemplified and explained individually in the topics of this section. Furthermore, many mentions of conflicts identified as land (9) and only 3 related to water aspects. A detailed description of each of these types and a discussion of the results considering the concepts of environmental injustice and conflicts are provided below.

Table 2 | Conflicts arising from impacts

| Impacts | Conflicts | Concept | Bibliography |
|--|--------------------|--|---|
| Visual; degradation of the dune environment, soil and subsoils and the affected area; suppression of vegetation; fauna; local interference; noise and air pollution. | Economic | Generated by the restriction and reduction of local economic and subsistence activities. | BRANNSTROM et al. (2017) PINTO, MARTINS and PEREIRA (2017) FRATE et al. (2019) PAIVA and LIMA (2019) SANTANA and SILVA (2021) SOBRINHO JUNIOR et al. (2022) |
| Local interference and degradation of the affected area. | Land | Generated by disagreements between the local population and enterprises related to the use and occupation of land. | PORTO, FINAMORE and FERREIRA (2013) GORAYEB and BRANNSTROM (2016) BRANNSTROM et al. (2017) AVILA (2018) NERI et al. (2019) PAIVA and LIMA (2019) ARAÚJO et al. (2020) SANTANA and SILVA (2021) |
| Water pollution. | Water | Generated as a result of losses or compromise to the availability and/or quality of water in the region. | GORAYEB and BRANNSTROM (2016) BRANNSTROM et al. (2017) FRATE et al. (2019) ARAÚJO et al. (2020) |
| Local interference; air and noise pollution and visual impact. | Health and wellnes | Related to pathologies arising from the installation of the parks and/or interference with the feeling of comfort and safety of local residents. | GORAYEB et al. (2016) PINTO, MARTINS and PEREIRA (2017) BRANNSTROM et al. (2017) PAIVA and LIMA (2019) ARAÚJO et al. (2020) SANTANA and SILVA (2021) SOBRINHO JUNIOR et al. (2022) |

Source: Author's elaboration.

The considered impacts repeatedly appeared in several articles in the literature analysed, which made it possible to classify impacts based on the typology developed by Farias, Silva and Carvalho (2021), important for differentiating such impacts into types such as water pollution, local interference, noise pollution, contributing to the consequent creation of a typology of conflicts.

Furthermore, counting and analysing conflict mentions made it possible to identify in which phase they occurred. Therefore, of the 40 conflicts mentioned, approximately 42.5% of them arose since the installation phase and remained during the operation of the farms (Figure 3).

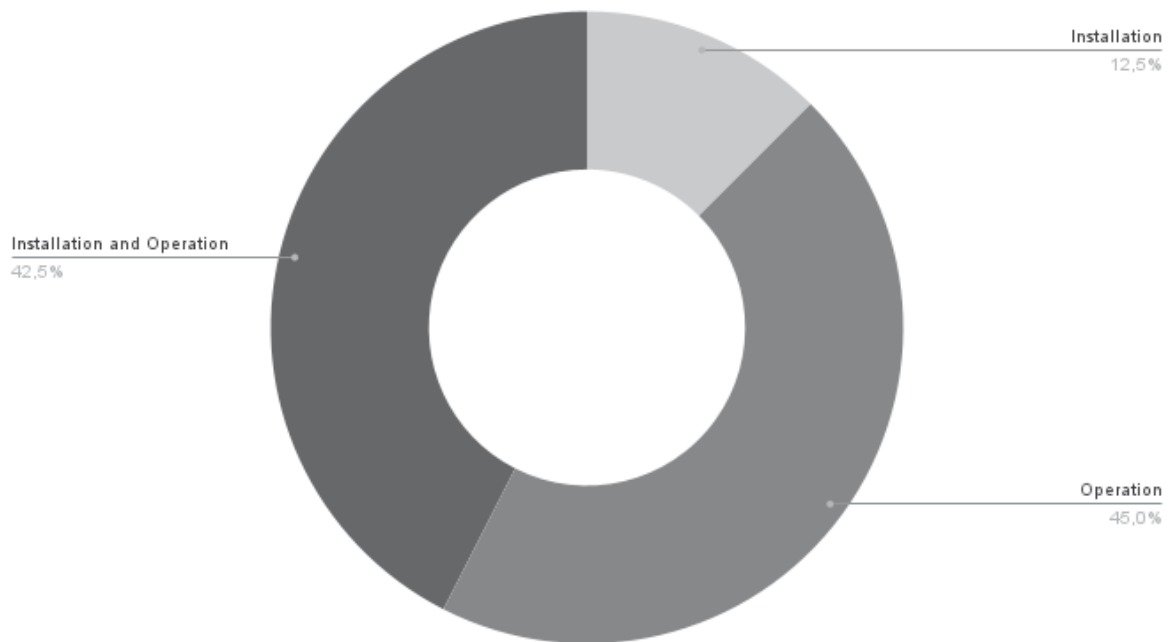


Figure 3 | Conflict phases.
Source: Author's elaboration.

The analysis is based on Acselrad's (2004) definition of socio-environmental conflicts. For the author, socio-environmental conflicts involve social groups with different ways of appropriating, using and significance of a territory, and they arise when at least one of the groups has its social forms of appropriation of the environment threatened by undesirable impacts, which may be related to soil, water, air or living systems, resulting from activities practised by other groups.

4.1 ECONOMIC CONFLICTS

Economic conflicts were defined as those generated by restricting and reducing local economic and subsistence activities. Of the total conflicts analysed, nine are in the economic category and were mentioned thirteen times in the bibliography. Within this classification, the thirteen conflicts arose from different impacts, namely: one from visual impact, one from degradation of the dune environment, two from vegetation suppression impacts, two from soil and subsoil degradation impacts, one fauna impact, one impact of degradation of the affected area, four impacts of local interference, one impact of noise pollution and one impact of air pollution, as characterised by Farias, Silva and Carvalho (2021).

Several economic conflicts related to losses caused to tourism were identified, causing the local economy to be strongly negatively impacted. One of the factors responsible for this is the change in the landscape caused by wind turbines during their operation phase (Frate *et al.*, 2019; Paiva; Lima, 2019; Pinto; Martins; Pereira, 2017; Sobrinho Júnior *et al.*, 2022). In some cases, residents have stated that the turbines are "mechanical monsters" that obstruct the view of the sunset (Frate *et al.*, 2019). In the northeastern context, they even affect coastal areas visited because they are considered vacation and leisure spots (Pinto; Martins; Pereira, 2017). In contrast, reports from residents were identified who, for example, consider the change in the landscape to be something positive and could contribute to wind turbine sighting tourism (Sobrinho Júnior *et al.*, 2022).

Another factor that alters landscapes is the earthworks of dunes. Due to the large movement of trucks and people, the sand on the ground levelled off, disappearing with the dunes in that region. For tourism and leisure in the region, this also makes some practices, such as kitesurfing, difficult, driving away tourists and harming local hotels (Brannstrom *et al.*, 2017).

Economic conflicts related to the income source generated by subsistence activities were also identified, harmed by changes in the land surface, drainage systems, and vegetation, and a reduction in environmental quality and biodiversity. Impacts such as the death of birds and bats, which contribute to the reproduction of vegetation, changes in the economy of communities close to the enterprises, such as shrimp farming and fishing in general, and the rural exodus caused by the impact on local agriculture are examples of causes of economic conflicts (Brannstrom *et al.*, 2017; Pinto; Martins; Pereira, 2017; Santana; Silva, 2021; Sobrinho Júnior *et al.*, 2022).

Most of the conflicts generated during the installation and operation phases, and which interfered with sources of subsistence, resulted from the impact on local agriculture, harmed by the reduction of arable areas, suppression of native vegetation and reduction in food production due to traffic of heavy vehicles and the noise of turbines. In some cases, the impacts occurred on crops that were the basis of the local economy, as in the case of the municipality of Serra do Mel (RN), where cashew production was affected, and the communities of Larginha and Pau Ferro, in the municipality of Caetés (PE), where there was a relevant change in the pace of corn production and a reduction in the supply of milk and eggs (Santana; Silva, 2021; Sobrinho Júnior *et al.*, 2022).

The issue of environmental injustice becomes evident in the economic conflicts described, given that affected communities face significant challenges due to the alteration of the natural environment, the basis of their economies. Such environmental impacts caused by the construction of wind farms can result in loss of income and rural exodus and even affect the subsistence of these communities, as previously demonstrated.

These factors highlight environmental injustices, as described by Porto, Finamore and Ferreira (2013), as they mainly harm already marginalised communities disproportionately affected by negative environmental impacts. In these cases, the profits from energy generating activities are not shared with local communities, who are left with only their costs and even their subsistence being compromised.

4.2 LAND CONFLICTS

Land conflicts were considered to be those caused by disagreements between the local population and enterprises related to the use and occupation of land. Four identified conflicts were classified as land conflicts, mentioned nine times in the bibliography analysed. Three of these conflicts resulted from local interference, and only one was from degradation of the affected area.

Several land conflicts were identified related to the restriction of access by the local population to spaces previously considered public (even though they were not) where wind farms were installed. In these cases, blocking access to roads previously used by the population, now fenced with bars and security gates with armed guards, generates access restrictions or increases travel time for the local population to essential public services such as schools, municipal waste collection and health units (Araújo *et al.*, 2020; Ávila, 2018; Brannstrom *et al.*, 2017; Gorayeb; Brannstrom, 2016; Porto; Finamore; Ferreira, 2013; Santana; Silva, 2021).

In the community of Xavier, in the municipality of Camocim (CE), the fencing of the wind farm area hindered the population's daily tasks, including subsistence activities, such as shellfish fishing, a source of income and food for the community. In 2013, through a term of commitment with the State Public Prosecutor's Office, the community's access to the road was released through control and, in addition, the entrepreneur responsible for the park built a refrigerated structure for storing fish and to serve as a community base for the local association (Brannstrom *et al.*, 2017).

Some authors also identify existing land conflicts that have intensified with the installation of wind farms due to the loss of political strength of traditional communities in the face of the enterprises.

In this sense, Ávila (2018) and Neri *et al.* (2019) indicate that the installation of wind farms, or the mere identification of the wind potential of a given location, leads to even greater difficulty for traditional people in having their lands recognised and demarcated, given the economic interest in such territories. This situation was also identified in Ponta do Tubarão State Reserve, located in the municipalities of Macau and Guamaré, in the state of Rio Grande do Norte, created after decades of social struggle by the local population and which, even though already protected, was the target of conflicts with the installation of a wind farm that politically weakened the protection of the conservation unit (Ávila, 2018).

In addition to land conflicts generated by local interference, Paiva and Lima (2019) mention land conflicts generated by the degradation of the area affected by the parks due to the destruction of archaeological sites and disrespect for the cultures of local people and their relations with the territory.

The land conflicts described above also make environmental injustice explicit. Generally installed in regions with populations that are already socially marginalised, these people find access to basic rights even more difficult and lose even more political power. In favour of a less polluting electrical matrix, the local population, who do not always benefit directly from such projects, has its fundamental rights curtailed, such as the installation of fences and the restriction of access to areas that were previously freely accessible. The case of the Xavier community illustrated above shows that, many times, some of these conflicts would be easily avoided and at no (or low) cost to the entrepreneur.

4.3 WATER CONFLICTS

Water conflicts were considered to occur due to losses or compromises in the region's availability and/or quality of water. This conflict occurs mainly due to the burial of rivers, lakes and lagoons. Of the total aspects analysed, the change in local water availability was mentioned three times in the bibliography and has "water pollution" as its causal impact.

The main cause of the burial of rivers, lakes and lagoons is the alteration of dunes, estuaries and beaches when the earthmoving of areas for the installation of turbines interrupts the flow of water between rivers and lakes existing between portions of dunes (Brannstrom *et al.*, 2017). In the bibliography analysed, this situation was identified in the installation and operation phases of wind farms in Ceará and Rio Grande do Norte.

In the community of Xavier, in the coastal area of Ceará, a wind farm buried interdune lagoons in the region, which impeded the population from accessing goods and services from outside the community and impeded subsistence fishing from being practised (Gorayeb; Brannstrom, 2016). Another example identified was the change in water availability due to interference in the water table due to the foundations of wind towers in the dunes in the coastal region of Ceará (Araújo *et al.*, 2020). In the communities of Galos and Galinhos, in Rio Grande do Norte, the region's river became shallower due to the movement of sand from the dunes, which resulted in restrictions on the population's navigability. Furthermore, the silting of rivers, lakes and ponds harms aquifers, aquatic fauna and flora in local regions, as by affecting the habitat, more sensitive beings die, and others emigrate, thus altering ecosystems (Frate *et al.*, 2019).

Thus, given the concept of environmental justice, water conflicts arise from the compromise of guaranteeing access to natural goods, a clear example of environmental injustice (Acselrad, 2010; Porto; Finamore; Ferreira, 2013). The affected local population is dissatisfied with no longer having access to water resources, such as lakes, ponds and rivers, which sometimes cease to exist for subsistence reasons and cultural values, often directly linked to these resources. For example, as they have different forms of interaction with bodies of water, these natural assets are considered sacred for many populations and linked to people's cultural identity (Gorayeb *et al.*, 2017). Therefore, when the installation of wind farms compromises water availability in a location, it is common for water conflicts to arise.

4.4 CONFLICTS RELATED TO HEALTH AND WELLNESS

Conflicts related to "health and wellness" were categorised as those related to pathologies resulting from the installation of farms and/or interference with the residents' feeling of comfort and safety. Following this description, it was possible to identify fifteen mentions of "health and wellness" conflicts, being the most mentioned type in the bibliography analysed. Seven of these conflicts were caused by impacts classified as "local interference", six by "noise pollution", and one by "visual impact".

Conflicts arising from the impact identified by local populations as a "territory of fear" stand out, resulting from the installation of signs that carry warnings (necessary for security reasons), such as "risk of death" and "escape routes" around the limits of wind farms. Although signage is mandatory in places where high voltage electrical cables are buried, it is possible to see them exposed on the surface, in areas with common access, in lakes, dunes, plantations and even fishing grounds, meaning a greater risk of accidents (Araújo *et al.*, 2020; Brannstrom *et al.*, 2017). In the aforementioned community of Xavier, the territory of fear is even more present, as in addition to the road signs, in 2009, there was an accident in which one of the turbines caught fire (Gorayeb; Brannstrom, 2016).

Consequently, in addition to there being signs that lead residents to a constant state of alert in places that previously represented moments of leisure, the easy visibility of these cables only reinforces the possibility of accidents, causing disturbance, compromising their quality of life and offering risk of life for these residents. Given this, it is important to consider the interference these facilities cause in the psychological health of communities so that their wellness is guaranteed.

Pinto, Martins and Pereira (2017) identified conflicts related to wellness generated by local interference both in the installation phase and in the operation of wind farms. These conflicts arose with electromagnetic interference from wind turbines, causing disruptions in communications and data transmissions (radio, television, etc.) in communities close to wind farms. Such conflicts fit into the "health and wellness" type, considering that access to information and communication is a fundamental right linked to human rights to achieve the Sustainable Development Goals (ONU, 2023).

Another conflict identified is related to the intense traffic of large vehicles during the installation process of wind towers, which generates local interference and air pollution, being identified twice in the bibliography explored (Araújo *et al.*, 2020; Brannstrom *et al.*, 2017). The clouds of sand and dust generated by this intense traffic impacted residential areas and schools, causing respiratory illnesses and affecting the health and wellness of communities near the wind farms.

According to Sette and Ribeiro (2011), any change in the composition of the air can constitute a real health problem for the individual. Therefore, in the case of intense heavy vehicle traffic, clouds of suspended particles significantly impact the population's health, as inhaling these particles can cause a series of respiratory problems, such as coughing, shortness of breath, and wheezing. and even the development of asthma in susceptible individuals, in addition to causing eye problems, such as eye irritation and, in more severe cases, even damage to the cornea.

During the operation phase, an impact that directly affects health and wellness can be observed in the case of the municipality of Caetés (PE), in the communities of Larginha and Pau Ferro, in which Santana and Silva (2021) identified reports of residents experiencing severe discomfort, dizziness and nausea generated by the shadows produced by the propellers. Furthermore, the disruption caused by noise pollution from wind tower turbines is the impact that was most often cited in health and wellness conflicts, mentioned seven times (Araújo *et al.*, 2020; Brannstrom *et al.*, 2017; Gorayeb; Brannstrom, 2016; Paiva; Lima, 2019; Pinto; Martins; Pereira, 2017; Santana; Silva, 2021; Sobrinho Júnior *et al.*, 2022).

In all the works analysed, complaints from residents regarding noise from the turbines are very strong, complaining of great noise disturbance, further intensified by the proximity of the turbines in some cases. Many residents reported that, with the operation of the wind farms, they began to have severe and constant headaches. Children also find it difficult to adapt to noise, causing constant crying and discomfort in general.

To better understand the extent of the negative impact that this noise pollution causes on residents, one must consider the environment before installing wind farms in remote locations, normally calm and silent, close to nature. As a result, although noise levels in these locations are within the limits established by regulations, residents are strongly affected by the difference in the environment without the wind towers, with reports of residents considering the noise similar to a "helicopter that never lands". (Araújo *et al.*, 2020, p. 12). Therefore, it is clear that wind installations impact the health and wellness of residents, with some people experiencing sleep disturbances, stress or other health problems due to the constant noise.

Furthermore, although wind turbines transmit small vibrations considered insignificant, farmers in the interior of Ceará reported the perception of these vibrations emitted by wind turbines, but also due to the movement of heavy automobiles, the carrying out of geotechnical and hydrogeological studies, and compaction from the soil. In some cases, there was structural compromise in houses and buildings made with more fragile materials (Sobrinho Júnior *et al.*, 2022).

The relationship between environmental injustice and health is intrinsically linked, as the environment in which humans live plays a fundamental role in their health. However, when analysing the costs and bonuses generated by wind energy, it is clear that they are not being distributed fairly. Communities that are already poor and suffer social injustices – including less access to healthcare facilities, doctors and medicines – are the ones that have the onus of their health and wellness. In return, entrepreneurs receive profit bonuses and the prestige of contributing to the advancement of sustainable development by generating clean energy. This highlights the intertwining of environmental and social injustices and the contradictions of clean energy.

5 CONCLUSION

Although wind energy is currently one of the least polluting, there are many negative impacts generated by wind farms, especially during their installation and operation phase. From the bibliography analysed, it was possible to identify a gap in the elaboration of typology for conflicts caused by the implementation of wind farms in the context of the Northeast of Brazil, with only typologies being found for the impacts caused and, above all, in the context of developed countries. Thus, this article identifies the main socio-environmental conflicts in the Northeast region generated by wind farms and categorises them into four types.

Conflicts related to impacts on health and wellness and economic conflicts are those with the highest number of mentions in the bibliography. Among the different causes for such conflicts, the impacts on health and wellness caused by noise pollution from wind turbines stand out, as well as discomfort related to the constant shadows from wind blades. From a psychological point of view, there is still a constant fear and feeling of danger due to accidents, road signs and exposed high-voltage wires. Furthermore, there are impacts on health and wellness related to impacts on subsistence activities, hampered or hindered by interference with local space and biodiversity, also reflecting economic conflicts due to damage to agriculture, fishing and tourism.

In land conflicts, impacts related to the accessibility of local populations to territories previously considered and used as public stood out, hindering their access to essential and daily services. Furthermore, cases were identified in which lands were invaded, and communities were culturally

"erased". In conflicts related to the availability and quality of water, the main causes were the silting of lagoons, lakes and rivers, intervening in aquatic life, terrestrial animals and local communities.

It is possible to affirm that the identified and classified conflicts emerge as a result of repeated environmental injustices. The population directly affected by the installation and operation of wind farms in the Northeast of Brazil faces significant environmental injustices, as while the benefits of the enterprises are not properly passed on to them, they fully bear the onus, including environmental impacts and changes to their way of life.

In short, the article identifies the main socio-environmental conflicts generated by wind farms in the Brazilian Northeast during their installation and operation, presenting four types of conflicts. In an international scenario of energy transition to renewable sources and with lower greenhouse gas emissions, it is expected for Brazil to increase the share of sources such as wind in its electrical matrix. However, the transition must be made with environmental justice as a starting point, observing and respecting the local communities directly affected. Otherwise, conflicts of different natures will arise, making it difficult for the respective enterprises to be considered "clean" and effective in offering energy to the population. The typology of conflicts presented in this work can contribute to planning the implementation of wind farms, given that many of them can be avoided at low cost and, in some cases, at no cost.

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