

## Perception as an indicator of improvements on previous environmental diagnostics of wind farms

### *A percepção como indicador para melhorias em diagnósticos ambientais prévios de parques eólicos*

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**Abstract:** Rio Grande do Norte (RN) is the state with the highest wind energy generation in Brazil. Wind farms are among the enterprises that generate significant environmental impacts, and the populations near these areas are the most affected. When it comes to parks with an estimated production above 10MW, the presentation of the Environmental Impact Study and the Environmental Impact Report (EIA/RIMA) is required. Based on the analysis of the environmental perception of the population affected by these projects, it is possible to propose impact indicators in the economic, social, and environmental spheres that contribute to the preliminary assessment of environmental impacts and inform future EIA/RIMAs. The goal of this study was to conduct a survey, using secondary data, of the impacts identified through the environmental perception of residents near wind farms in municipalities of RN, and to compare them with those previously identified in the socioeconomic section of the EIA/RIMA diagnoses. This study highlights relevant aspects that, during and after the construction of this type of enterprise, should be considered through the environmental perception of the population. However, these aspects are not present in the EIA/RIMAs. Therefore, this research becomes important for environmental agencies and environmental consultancy companies that request and carry out the EIAs/RIMAs to consider them as preliminary indicators of social and environmental impacts.

**Keywords:** Socio-environmental impacts; EIA/RIMA; Rio Grande do Norte.

**Resumo:** O Rio Grande do Norte (RN) é o estado com maior geração de energia eólica no Brasil. Parques eólicos estão entre os empreendimentos que geram impactos ambientais significativos e as populações próximas a esses são as mais afetadas. Quando se trata de parques com produção estimada acima de 10MW, a apresentação de Estudo de Impacto Ambiental e o Relatório de Impacto Ambiental (EIA/RIMA) é necessário. Baseando-se na análise de percepção ambiental da população afetada por empreendimentos, é possível propor indicadores de impactos nas esferas econômica, social e ambiental, que contribuam no levantamento prévio de impactos ambientais e subsidiem futuros EIA/RIMAs. O objetivo deste estudo foi realizar o levantamento, por meio de dados secundários, de impactos identificados pela percepção ambiental de moradores próximos a parques eólicos de municípios do RN e compará-los com os identificados previamente na parte socioeconômica do diagnóstico dos EIA/RIMAs. O presente estudo traz à luz aspectos relevantes que, durante e após a construção desse tipo de empreendimento, devem ser considerados através da percepção ambiental da população. Apesar disso, não estão presentes em EIAs/RIMAs. Assim, torna-se uma pesquisa importante para que órgãos ambientais e empresas de consultoria ambiental que solicitam e realizam os EIAs/RIMAs respectivamente, considerem como indicadores prévios de impactos ambientais sociais.

**Palavras-chave:** Impactos socioambientais; EIA/RIMA; Rio Grande do Norte.

## 1. Introduction

The growth of the population and its demand leads to an increase in economic activities which, consequently, cause positive and negative impacts on the environment (SENA; MONTE-MOR, 2018). The resolution of the Conselho Nacional do Meio Ambiente (CONAMA) 01 of 1986 defines environmental impact as:

Any alteration of the physical, chemical, and biological properties of the environment, caused by any form of matter or energy resulting from human activities that, directly or indirectly, affect: the health, safety, and well-being of the population, social and economic activities, the biota, the aesthetic and sanitary conditions of the environment, and the quality of environmental resources (RESOLUTION CONAMA, 01/1986, p. 1).

Impacts are considered those that affect and/or interfere with culture, family memory, habitual activities, economic activities, and the location where the population is situated (NUNES *et al.*, 2019).

Wind farms are among the enterprises that generate the most significant environmental impacts, and the populations near them are the most affected (IMPROTA, 2008). Therefore, preliminary Environmental Impact Assessment (AIA) studies are required for their installation (RESOLUTION CONAMA, 462/2014). Depending on the size, location, and the polluting potential of the activity, the submission of the Environmental Impact Study and the Environmental Impact Report (EIA/RIMA) to the environmental agency is necessary, according to CONAMA Resolution 462/2014.

Of the entire wind energy generation system in Brazil, the Northeast region accounts for 90.3% (ABEEÓLICA, 2022). Rio Grande do Norte (RN) is the second state with the highest wind energy generation and the highest number of new wind farm installations in 2022 in Brazil (ABEEÓLICA, 2022).

Environmental perception can be understood as a cognitive process of the individual, in which reality is presented through the senses and the sensory stimuli of the environment, passing through cultural and personal filters, which are transformed into impressions or thoughts with meanings (OLIVEIRA, 2009). Faggionato (2009) environmental perception is defined as the process of awareness of the environment by humans, that is, perceiving where one is situated, leading them to protect and take care of the surrounding environment. Considering the analysis of environmental perception in populations affected by enterprises, it is possible to propose indicators of impacts in the economic, social, and environmental spheres (NUNES *et al.*, 2019) these can contribute to the preliminary estimation of environmental impacts. Environmental impact indicators are parameters that provide information about the state of the environment (NUNES *et al.*, 2019), enabling the identification of environmental changes, as well as monitoring and evaluating the quality of the environment (SANTOS *et al.*, 2004). Given this, the study of environmental perception is extremely important for understanding the interrelations between humans and the environment (SENA; MONTE-MOR, 2018). It is necessary to analyze the perception and desires of the population in relation to the enterprises, both to serve as a foundation for suggesting actions to mitigate environmental impacts and to promote environmental justice (SENA; MONTE-MOR, 2018). Studies of environmental perceptions represent the final stage in the process of balanced and efficient environmental management (FILHO *et al.*, 2009), using social involvement to identify environmental impacts and subsequently create action plans, providing responsible authorities with guidance for decision-making in the political, socioeconomic, and development spheres (ULIBARRI *et al.*, 2019; TESCHNER; HOLLEY, 2021; ULIBARRI; ANASTASIA, 2022; SHANDU, 2024).

The present study aimed to conduct a survey, using secondary data, of impacts identified through the environmental perception of residents near operational wind farms located in municipalities of Rio Grande do Norte (RN). It also sought to compare these impacts with those previously identified in the socioeconomic diagnostics of EIA/RIMA (Environmental Impact Assessment/Environmental Impact Report), with the purpose of comparing the impacts reported by the consulting team before the construction of the projects with the impacts perceived by the populations after the construction. In this way, the study aims to identify potential prior indicators of social environmental impacts that were not mentioned but need to be considered in future EIAs/RIMA.

## 2. Method

A bibliographic review was conducted between the years 2010 and 2022, using Google Scholar, of scientific articles, academic papers, and conference abstracts, considering the keywords: environmental perception; socio-environmental; socio-economic; wind; wind energy; Rio Grande do Norte; and RN. Subsequently, a survey was conducted on the website of the state environmental agency, the Instituto de Desenvolvimento Sustentável e Meio Ambiente — IDEMA (<http://sistemas.idema.rn.gov.br/servicos/RIMA.php>), of EIAs and RIMAs for wind farms in the municipalities studied in

the scientific articles, academic papers, and conference abstracts. For the present study, a total of six articles, two abstracts, and one thesis on environmental perception were used; four EIAs and six RIMAs for the environmental diagnosis of the social environment. Since no study was found on the environmental perception of the local population and the EIA or RIMA for all the wind farms in RN, the analysis of other impacts identified by surrounding populations was adopted.

Through the method of descriptive coding (see Belotto, 2018) and according to the impacts identified in the EIAs, RIMAs, as well as in the scientific articles, academic papers, and conference abstracts found, the impacts were divided into nine categories as follows: 1) local economy; 2) infrastructure; 3) landscape; 4) general impacts for the municipality; 5) fauna and flora; 6) sound; 7) tourism; 8) health, safety, and well-being; and 9) energy generation. Additionally, they were grouped into positive and negative impacts. The criteria used for selecting the nine categories were related to the types of impacts mentioned in the different documents analyzed. Finally, a comparative analysis was conducted to identify the impacts that were not identified in the EIAs and RIMAs but were mentioned in articles or published papers.

### 3. Results and discussion

Below are the articles and papers found and used for the present study.

*Table 1 – List of scientific articles, academic papers, and conference abstracts on environmental, socio-environmental, and socio-economic perception of wind farms in Rio Grande do Norte by municipality.*

Municipalities	Environmental, Socio-environmental, and Socio-economic Perception	Number of interviewees	Download
Touros	Nunes <i>et al.</i> (2019)	14	<a href="#">Download</a>
Rio do Fogo, João Câmara, Parazinho e Pedra Grande	Costa (2017)	5	<a href="#">Download</a>
Parazinho e João Câmara	Silva; Azevedo (2020)	2	<a href="#">Download</a>
Galinhos	Santos (2019)	10	<a href="#">Download</a>
Galinhos	Macedo <i>et al.</i> (2021)	30	<a href="#">Download</a>
Macau e Guamaré	Gê <i>et al.</i> (2022)	NM*	<a href="#">Download</a>
Serra do Mel	Silva (2019)	12	<a href="#">Download</a>
Areia Branca	Ferreira; Camacho; Carvalho (2019)	70	<a href="#">Download</a>
Bodó	Santos (2018)	17	<a href="#">Download</a>

\*NM = not mentioned, the perception article does not provide this information.

Source: Authors (2025).

Below are the four EIAs and six RIMAs analyzed to identify the impacts reported by the consulting team and compare them with the impacts perceived by the populations (Table 2).

*Table 2 – List of Environmental Impact Study (EIAs) and Environmental Impact Reports (RIMAs) of wind farms in Rio Grande do Norte found according to the municipalities from the articles/papers in the literature review on the website of the Institute for Environmental Protection (IDEMA).*

Municipalities of influence of the wind farm	EIA/RIMA	IDEMA
Touros	EIA — Complexo Eólico Marco Zero	<a href="#">Download</a>
Touros-Rio do Fogo-Pureza	RIMA — Eólicas Lagoas de Touros IX e X	<a href="#">Download</a>
Touros-Pureza	EIA — Central Eólica São Pedro RN	<a href="#">Download</a>
Parazinho-João Câmara	RIMA — Parque Eólico Campo Dos Ventos II	<a href="#">Download</a>
Parazinho-João Câmara	EIA — Parques Eólicos Campo Dos Ventos I, III e V	<a href="#">Download</a>

Parazinho	RIMA — Parque Eólico Renascença V	<a href="#">Download</a>
Parazinho-João Câmara	RIMA — Complexo Eólico Asa Branca	<a href="#">Download</a>
Parazinho	RIMA — Parque Eólico Ventos de São Miguel	<a href="#">Download</a>
Galinhos	RIMA — Central Eólica Rei dos Ventos I	<a href="#">Download</a>
Pedro Avelino-Macau-Pendências	EIA — Complexo Eólico Aurora	<a href="#">Download</a>
Serra do Mel	Not found*	-
Areia Branca	Not found*	-
Bodó	Not found*	-

\* Only the perception of the population regarding the impacts of wind farms in these municipalities was analyzed.

Source: Authors (2025).

In total, positive and negative impacts were found for wind farms in 14 municipalities of Rio Grande do Norte. Below, in Figure 1, the highlighted municipalities for which the information was found can be observed.

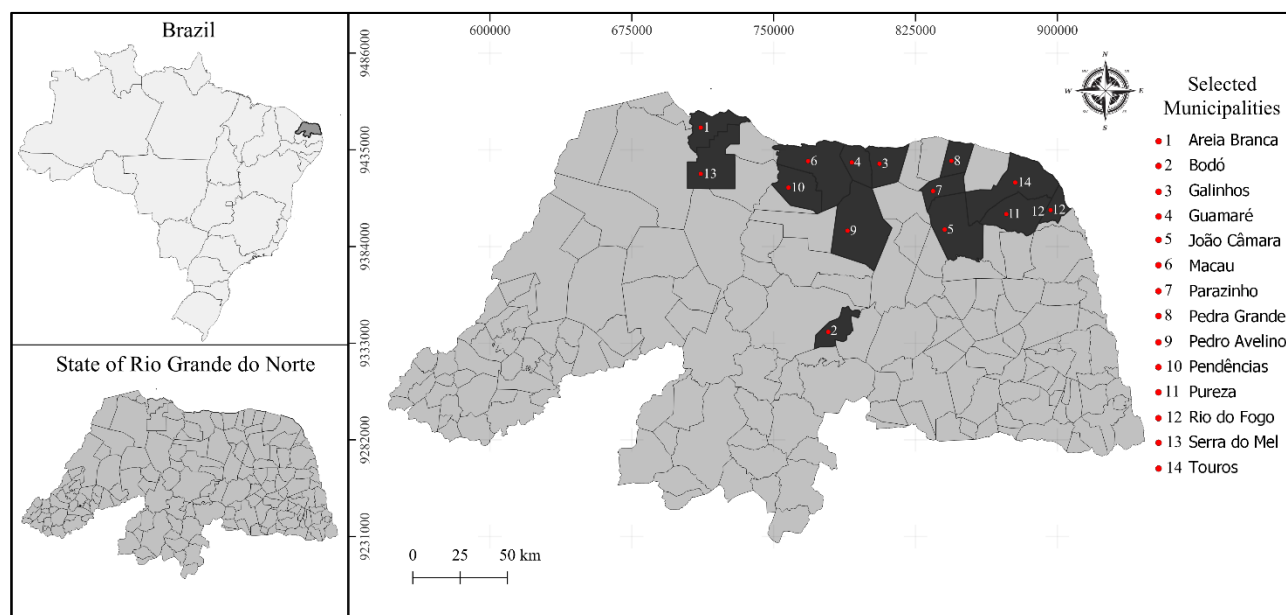


Figure 1 – Sampled municipalities for the survey of positive and negative impacts of wind farms in Rio Grande do Norte.

Source: Authors (2025).

### 3.1 Preliminary diagnosis of the socioeconomic environment

Among the positive impacts mentioned in the EIAs and RIMAs, the most cited were job creation; occupation and income; increased circulation of money in the market; and consequently, an increase in tax and revenue collection. Regarding the negative impacts, of the four RIMAs and one EIA analyzed for the municipalities of Parazinho and João Câmara, only the EIA of the Campo dos Ventos I, III, and V Wind Farms mentions a single anticipated socio-environmental impact: the increase in prostitution.

Goarayeb *et al.* (2016), they report the social impacts attributed to the Xavier community, located in the municipality of Camocim, on the west coast of the state of Ceará: in addition to having their artisanal fishing activities harmed, other negative social implications related to the installation of the wind farm were mentioned, such as the privatization of areas previously used by the community, discomfort caused by the noise generated by the blades of the wind turbines, insecurity caused by the fear of an accident involving the blades and turbines, among others.

It was observed that, in three of the 14 municipalities (Galinhos, Parazinho, and João Câmara), all five RIMAs and one EIA were conducted by the same consulting company. This indicates a lack of diversity in the approach to

socioeconomic impacts and may lead to a limited view of the impacts and the failure to consider the specificities of the local communities. Furthermore, in general, the socioeconomic diagnosis in EIAs and RIMAs is limited to the application of questionnaires to the local population, focusing on basic demographic information (such as education level, family structure, occupation and income, and the perception of infrastructure in the municipality where the project will be implemented). However, these questionnaires do not address aspects related to people's perception of the project and its impacts. Therefore, it is clear that to better understand the potential conflicts that may arise from the implementation of wind energy projects, effective participation from surrounding communities is needed through constant and transparent dialogue between them and the developers.

The comparative study conducted by Brannstrom *et al.* (2022) examined the perception and support of host communities in relation to wind farms in three coastal communities on the western coast of Ceará: Amarelas, Maceió, and Patos. The study considered aspects of justice, consultation, environmental impact, and the benefits provided by these projects. The results revealed that the host communities showed different levels of support for the wind farms. However, in general, it was found that support is more likely when communities perceive tangible benefits, such as economic and social improvements, and when they are involved in a transparent and participatory manner in the decision-making process.

### 3.2 Perception studies in the socio-economic environment

The main positive impact perceived by the populations and reported in scientific articles, academic papers, and conference abstracts on perception was the generation of jobs and income. Additionally, the population also highlighted receiving financial benefits through land leasing and improvements to access roads. Among the negative impacts perceived by the populations and reported in the scientific articles, academic papers, and conference abstracts, the most prominent were, particularly in the municipalities of Parazinho and João Câmara, the increase in criminality and drug use. Some negative impacts were also mentioned in the scientific articles, academic papers, and conference abstracts that were not found in the EIAs and RIMAs. Of these, the impact on the groundwater table and the turtle nesting sites were mentioned only by Gê *et al.* (2022); and the late knowledge of the wind farm implementation by the population, as well as the changes in the crab route, were also mentioned only by Santos (2019), in other words, these may be impacts that are still little perceived by the populations but could arise depending on the specifics of the project location or after some time following its construction. In Table 3, the impacts mentioned in the different scientific articles, academic papers, and conference abstracts found can be observed.

*Table 3 – List of negative impacts cited in scientific articles, academic papers, and conference abstracts on perception that were not found in the Environmental Impact Study (EIAs) and Environmental Impact Reports (RIMAs).*

Impact	Category	Bibliography
Interruption of local access	Infrastructure	Costa (2017); Gê <i>et al.</i> (2022); Macedo <i>et al.</i> (2021); Nunes <i>et al.</i> (2019); Santos (2019)
Reduction of agricultural activity	Local economy	Costa (2017); Nunes <i>et al.</i> (2019); Santos (2019)
Land ownership conflicts	General impacts for the municipality	Ferreira; Camacho; Carvalho (2019); Gê <i>et al.</i> (2022)
Aumento da criminalidade	General impacts for the municipality	Costa (2017); Silva; Azevedo (2020)
Drug use	Health, safety, and well-being	Costa (2017); Gê <i>et al.</i> (2022); Silva; Azevedo (2020)
Real estate speculation	General impacts for the municipality	Costa (2017); Gê <i>et al.</i> (2022)
Damage to fishermen and traders	Local economy	Gê <i>et al.</i> (2022); Macedo <i>et al.</i> (2021)
Conflict over the receipt of benefits	Health, safety, and well-being	Costa (2017); Nunes <i>et al.</i> (2019)
Damage to the mangrove forest	Landscape	Gê <i>et al.</i> (2022); Macedo <i>et al.</i> (2021)
Impact on the groundwater table	Landscape	Gê <i>et al.</i> (2022)
Late knowledge of the wind farm implementation by the population	General impacts for the municipality	Santos (2019)

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Misinformation regarding the compensations and negative impacts of the project	Health, safety, and well-being	Ferreira; Camacho; Carvalho (2019)
Changes in the crab migration route	Fauna and flora	Santos (2019)
Impact on turtle nesting sites	Fauna and flora	Gê <i>et al.</i> (2022)
Changes in fish behavior due to the noise emitted by the towers	Fauna and flora	Santos (2019); Macedo <i>et al.</i> (2021)
Sediment deposition on the streets that caused respiratory complications in residents	Health, safety, and well-being	Silva; Azevedo (2020)
Expropriation of houses	General impacts for the municipality	Ferreira; Camacho; Carvalho (2019)
Increase in vehicle traffic	Health, safety, and well-being	Silva; Azevedo (2020)
Lack of public support to address conflicts	General impacts for the municipality	Ferreira; Camacho; Carvalho (2019)

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*Source: Authors (2025).*

In Galinhos, the population was surprised by the announcement of the installation of wind farms, and despite protests against the construction, the developers discredited the social movement and managed to build the project (DANTAS *et al.*, 2019, SANTOS, 2019). Although the generation of jobs and income was mentioned by the population as a positive impact, one article and two conference abstracts on perception analyzed mentioned that the jobs available after construction were low-paying, had little significance during the operational phase, and that the timeframes for the emergence of opportunities were long. The community's perception after the installation includes the belief that the wind farms did not succeed in generating long-term jobs, increasing income in neighboring communities, or contributing to improvements in the city's infrastructure. Similarly, the report highlights the alteration of the community's way of life, influenced by the creation of roads allowing access by vehicles, leading to concerns about the increase in criminality and the facilitation of drug trafficking (DANTAS *et al.*, 2019).

Costa (2017), when analyzing the negative social impacts of wind energy in municipalities of Rio Grande do Norte, an increase in the number of single pregnant women, the rise in prostitution, and the growing number of women infected with sexually transmitted diseases were observed. These impacts are related to the migration of people, mainly men, to small towns, where they temporarily settle to work on the construction of large projects. This movement of people also caused real estate speculation in the municipalities during this period, resulting in losses for some merchants.

Although some benefits (albeit temporary) are mentioned, most of the impacts addressed, both in scientific articles, academic papers, and conference abstracts on perception, as well as in the EIAs and RIMAs, regarding the installation of wind farms, are negative. Examples include the displacement of wildlife, noise emissions, the reduction in job and income opportunities after the construction phase, changes in the landscape, and the pressure on basic services due to the increased circulation of people/workers. It is important to emphasize that analyzing the perception of populations regarding the impacts of wind energy projects is crucial for conducting a thorough assessment with appropriate indicators to propose mitigation and compensation measures.

#### 4. Final considerations

Considering the perception of local populations when evaluating the impacts of wind farms is essential, as perception studies indicate that negative impacts are widely recognized by communities near the parks. There is a need to improve the specificity of socio-economic impact studies in EIAs/RIMAs, as the questionnaires used in these studies generally focus on demographic and socio-economic data without directly addressing people's perception of the impacts of the projects. Some negative impacts identified in scientific articles, academic papers, and conference abstracts on perception were not mentioned in the EIAs and RIMAs, highlighting a gap in the official assessment of impacts prior to the installation of wind farms. This underscores the importance of a comprehensive and inclusive assessment of the impacts on affected communities. Additionally, more attention must be given to the environmental perception of the population after the construction of the project, as one of the methods for monitoring environmental impacts. A more comprehensive approach, sensitive to the socio-economic impacts of wind farms, considering the perceptions of local populations and promoting more diverse and detailed studies, will help mitigate negative impacts and promote sustainable development in these areas.

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