

# Perception of the socio-environmental impacts caused by wind generators in the state of Piauí, Northeast of Brazil

*Percepção dos impactos socioambientais causados por geradores eólicos no estado do Piauí, Nordeste do Brasil*

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## ABSTRACT

The expansion of wind energy in Brazil has brought benefits, but many conflicts have arisen around rural communities. The research involved understanding the community's responses regarding the acceptance or rejection of wind farms in the Serra dos Pereiros community in Piauí from the procedural and distributive justice view. A questionnaire with ten answers was applied, which added together 31 variables. In statistical analyses, with a population sample of 69 people, the Likert scale, Cronbach's alpha coefficient, and Spearman's correlation coefficient (rs) were used. From the results, 5 responses presented moderate positive or strongly positive correlations: change in the landscape, opinion about wind farms, political process for implementing wind farms, fairness of the process, and compensation. The data show that the development of policies that do not include the direct participation of society generates conflicts between the different institutional levels and significant local environmental and social problems.

**Keywords:** Social impacts. Wind energy. Procedural justice and Distributive justice. Perception.

## RESUMO

A expansão da energia eólica no Brasil trouxe benefícios, mas surgiram muitos conflitos no entorno de comunidades rurais. A pesquisa consistiu em entender as respostas da comunidade em relação à aceitação/rejeição da implantação de parques eólicos na ótica da justiça processual e distributiva, na comunidade Serra dos Pereiros no Piauí. Aplicou-se um questionário com dez respostas que somaram juntas 31 variáveis. Nas análises estatísticas, com amostra populacional de 69 pessoas, utilizou-se a escala de Likert, o coeficiente alfa de Cronbach e o coeficiente de correlação de Spearman (rs).

*Dos resultados, cinco respostas apresentaram correlações moderadas positivas ou fortes positivas: mudança na paisagem, opinião sobre os parques eólicos, processo político de implantação dos parques eólicos, justiça do processo e compensação. Os dados mostram que o desenvolvimento de políticas que não incluam a participação direta da sociedade gera conflitos entre os diferentes níveis institucionais e problemas de ordem ambiental e social local graves.*

*Palavras-chave: Impactos sociais. Energia eólica. Justiça processual e Justiça distributiva. Percepção.*

## 1 INTRODUCTION

Since the Industrial Revolution, the economic disputes of countries and the quality of life of their inhabitants have been influenced by several factors, including energy. Clean energy production is a dynamic concept in which new procedures and technologies constantly emerge, searching methods and practices to prevent environmental damage (Giannetti *et al.*, 2020).

Brazil is part of the Global South Countries, which stand out in the generation of renewable energy. Among them, wind energy stands out as an alternative plan to non-renewable sources (of fossil origin), helping to reduce the greenhouse effect and global warming while preserving the planet's natural resources (Montefusco; Santos; Santos, 2020).

Social and political responses to wind energy development are highly variable globally. Numerous cases of opposition to wind energy in North America and Europe provide evidence of the persistence of the social gap, defined as the difference between national public opinion in favour of wind energy in contradiction to local perception opposition (Bell *et al.*, 2005; Bell *et al.*, 2013). The conflict often results from "imposition" (Pasqualetti, 2011a; Pasqualetti, 2011b), when entrepreneurs and the government prioritise technical issues of efficiency and wind quality above social impacts. Rand and Hoen (2017) argue that, in North America, issues related to justice, participation and trust between parties during the development of a wind farm are determining factors in the social acceptance of the project. The authors summarise several factors that the bibliography points to as "acceptance" or "rejection".

However, the topic of social opposition is little discussed in the Brazilian context, despite wind energy having environmental impacts, especially at the community level, from implementation to operation. Gorayeb and Brannstrom (2016) suggest measures to manage wind farm implementation policies better. These measures provide goals and directions related to the implementation of wind energy projects through municipal planning plans, including establishing, in more detail, the suitability of the location of the turbines, the number of projects and the relevance of the visual impact on the landscapes. To this end, it is important to consider the population that lives in the location with regard to information about projects and negotiations regarding their geographic location and the size of the enterprise.

That implies that the planners and the population should decide if the Project is compatible with the existent use of the land and if it negatively modifies the global character of the area, harming established communities since residents are the most impacted (Gorayeb; Brannstrom, 2019).

Even with the impacts of the increase in wind power, it is necessary to rethink parks that work from a win-win perspective, a "situation where everyone wins" in the sense of benefiting their owners, the consumer population and the population residing close to the parks (Juárez *et al.*, 2014, p. 833). That is, the installation of wind farms must consider issues relating to procedural justice and distributive justice.

It is noticed that the development of politics that does not include the direct participation of Society generates conflicts between the different institutional levels and major environmental and social order problems, a proportion of which we may only have an exact idea of in a few decades (Gorayeb; Brannstrom, 2016).

The present research is part of this discussion, considering that few academic works address fair energy social justice from the perspective of the vision of residents who live close to wind turbines installed in the Northeast of Brazil, specifically in the interior of Piauí.

Piauí, a federal state in Brazil, stands out in the wind generation scenario. According to data released by the Brazilian Wind Energy Association (Abeeólica, 2021), Piauí was the third state that produced the most wind energy in Brazil in 2022 (10.29 TWh), behind Bahia (24.17 TWh) and Rio Grande do Norte (23.20 TWh) (Abeeólica, 2022). The State of Piauí stands out today in the wind generation scenario. According to data from SIGA (Aneel) from June 2023, the state occupied the third position in the number of wind farms (173) and also in supervised power (3,526.5 MW).

The objective of the research was to understand the community's responses in relation to the acceptance/rejection of the implementation of wind farms from the perspective of procedural and distributive justice. Here, the results of a face-to-face survey carried out in the Serra dos Pereiros community in the municipality of Caldeirão Grande do Piauí – PI were analysed. The results are presented from the 31 questions referring to the answers to the variables impact on daily life, landscape changes, visibility, opinion on wind farms, political process of implementing wind farms, fairness of the process, compensation, noise nuisance, sensitivity to noise and perception of background noise. Results with moderate and strong correlations with statistical significance were discussed. These correlations are carried out between two variables with the same response, or in cases where the response has a single variable, correlation is carried out between variables with different responses that are identical to each other.

## 2 ENERGETIC SOCIAL JUSTICE

Procedural justice in the renewable energy project location is achieved by sharing information, participating in decision-making opportunities, and having the capacity to influence results and relations with project developers (Frate *et al.*, 2019). Information strongly influences feelings of procedural justice and local acceptance of renewable energy. For Walker (2017), procedural justice tends to concentrate on the participation of the residents in wind energy planning and the conditions of this participation, and for justice in these processes to be considered fair, the meetings must be accessible, the decision makers must recognise the legitimate contributions of local citizens, and the public opinion must have some influence on the final decisions.

People's participation is the main axis for achieving procedural justice. It refers to the representation and decision-making power of the local population, which will be satisfactory only through dialogue, transparency in actions and transfer of information and, mainly, the starting from the construction of a relationship of trust between the parties (Leite, 2019).

Corroborating the idea of Hall *et al.* (2013) and Leite (2019) demonstrate that three principles emerged from participants about how the wind company could maintain procedural fairness during its engagement with the local community: honesty and transparency, complete and unbiased information, and ensuring that donations of funds for infrastructure or community programs do not were perceived as tacit support.

To facilitate the development of these principles, Frate *et al.* (2019) observe the inclusion of defenders and opponents of wind energy in the decision-making process. This permanently improves local and regional acceptance.

As noted by several authors, the acceptance of wind energy must be directly linked to people's participation in the decision-making process. Yun *et al.* (2022) argue that the involvement of local communities in the development process is a key component in leading communities to have

positive attitudes towards wind farms. Hall *et al.* (2013) observed that public consultations following announcements about the implementation of wind farms are more of a trigger for opposition than an incentive for the adequate design of acceptable projects. In summary, Byrne *et al.* (2017, p.48) argue that community members want "partnership in decision-making processes" rather than being treated as "consumers at the end of the line".

For Simcock (2016), procedural justice has multiple 'dimensions', where the basic criteria by which the fairness of a decision-making process is judged must be understood. The general evaluations of a decision process are shaped by the fact that justice should be reached in these different dimensions, which for him are: inclusion, influence and information, as shown in Board 1.

**Board 1 | Multiple Dimensions**

<i>Dimension</i>	<i>Concept</i>	<i>Description</i>	<i>Application</i>
Inclusion	It refers to the question of who is present and has a voice in decision-making.	Everyone affected by a decision must be involved to some degree in that decision. Also pertinent are questions about the responsibility to ensure presence and participation while people may have a 'right' to be included and to what extent different actors are responsible for ensuring this right is exercised.	Call the community in a wide manner, democratic and universal way, to dialogue with the company, including residents and people interested in the process.
Influence	It is related to the extent to which different participants' opinions, suggestions and concerns shape the outcomes of decisions.	A person or collective can exercise different degrees of influence in a decision-making process, which broadly categorises here as "listening as a spectator", "consultative influence", and "direct authority". "Bystander listening" refers to a situation in which a stakeholder receives information about a decision but has no influence. If a stakeholder has "consultative influence," they can give their opinion on an issue, but others make the final decision. Finally, "direct authority" refers to the situation in which a stakeholder can formally shape the outcome of the decision, either by making the decision individually or by sharing power with others in a democratic process (such as voting).	Open the possibility for residents' associations to have their resolutions in a 'deliberative' and not just 'consultative' character, that is, to be able to give their opinion and intervene in the projects from the first moment.
Information	Adequate, sufficient and accurate information for all participants in a decision-making process is often considered crucial to procedural justice, helping to ensure transparency, participation and informed consent.	Constitutes 'adequate', 'sufficient' and 'accurate' information, such as how much detail should be included and how it should be communicated (e.g. in writing or verbally?) – so it is not evasive or disputed.	Proceed with well-planned protocols and the idea of revealing the truth about issues relating to the project, especially concerning negative aspects, and not a version that the community can easily approve.

*Source: Adapted from Simcock (2016).*

Distributive justice focuses on the local community's perception of equity in the distribution of costs, risks and benefits associated with the wind farm. Besides that, distributive justice also considers conflicts created within communities due to the distribution of benefits (Leite, 2019).

Endorsing Leite (2019) and Walker and Baxter (2017b), distributive justice is the perception of equity in relation to the introduction and benefit distribution, such as tax revenues, lease payments, and compensation for negative results from the wind farm. Brannstrom (2022) comments based on studies focused on concepts of distributive justice (Bell *et al.*, 2005, 2013; Devine-Wright, 2005, 2011; Gross, 2007; Wolsink, 2000, 2007; Wustenhagen *et al.*, 2007) that these authors aim to understand how the distribution of costs and benefits of wind farms influence acceptance and opposition. This

understanding builds on the analytical turn to the multidimensional understanding of the host community's acceptance of renewable energy infrastructure.

According to Anchustegui (2020), the responsible company for implementing the wind farm offers some form of retribution for the externalities imposed on the host Community, such as noise or visual impact, and brings direct benefits in addition to the positive effects of renewable energy benefits play a key role when it comes to fostering the acceptance and, ultimately, approval of renewable energy projects, serving a utilitarian purpose that goes beyond pure financial compensation to specific individuals, such as those arising from tort or non-contractual liability.

Distributive justice approaches how the benefits (primarily financial) are introduced and shared within communities; that is to say, distributive justice in renewable energy is defined as the perceived justice of the introduction and distribution of benefits such as tax revenues and individualised lease payments or shared (Frate *et al.*, 2019; Walker, 2017). Supporting these authors, Brannstrom and Gorayeb (2022) refer to distributive justice as a damage distribution and benefits between the affected people, focusing on the energetical Injustice location.

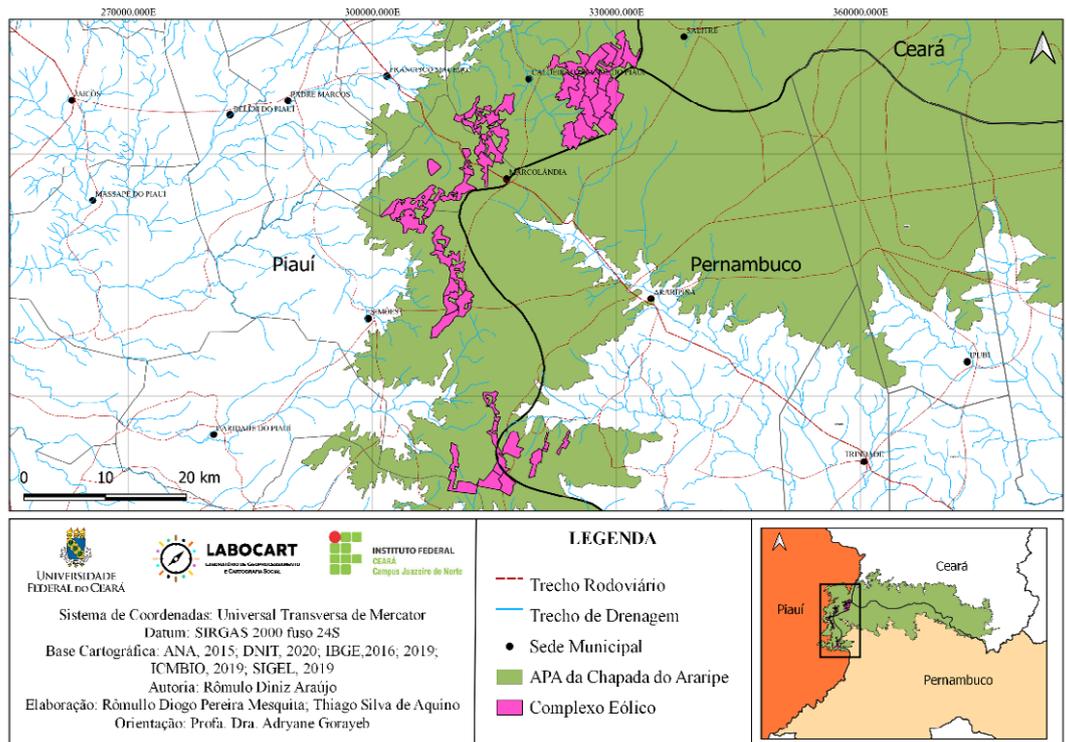
The absence of processes that meet these justices often creates economic inequalities and power asymmetries in the communities hosting wind farms, causing economic losses and disruptions in the routine of a significant portion of the population (Frate *et al.*, 2019).

### 3 METHODOLOGY

This chapter presents the work methodology and the adopted phases of the research development.

#### 3.1 LOCATION OF THE STUDY AREA

Piauí stands out in the onshore wind Generation scenario. One of the largest wind complexes in Latin America is located in an Environmental Protection Area (APA) in the west of "Chapada do Araripe" (an area of elevated land with a relatively flat top, located in the interior of the State of Ceará) on the border between the states of Pernambuco and Piauí (Abeeólica, 2017). The wind complex has 585 wind turbines, distributed over 14,543.2 há with a total installed power of 1,212.5 MW (Sigel, 2022). It was installed in 2015 with 50 parks, of which 45 are in the state of Piauí and 5 in Pernambuco, according to Figure 1.



**Figure 1 | Wind farms installed in the Chapada do Araripe region**

*Source: Prepared by the authors (2022).*

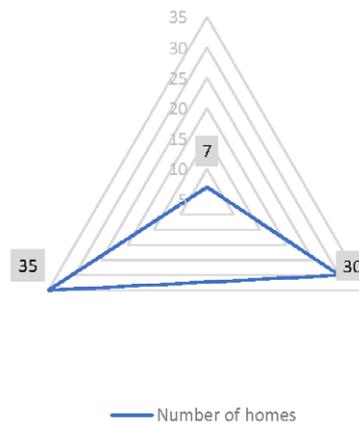
Given the large number of wind farms in this complex, there was a need to select parks with many residences close to the wind turbines. So, parks were chosen in Caldeirão Grande do Piauí, in the Serra dos Pereiros Community, as they have these characteristics.

In this community, there are 149 families, distributed in 144 residences, totalising 433 residents, according to the data of the Health Secretary of the city of Caldeirão Grande do Piauí of 2022, August, obtained through community health agents in Serra dos Pereiros.

### 3.2 PREPARATION OF THEMATIC CARTOGRAPHY

For the study, it was made a mapping of the residences of Serra dos Pereiros community using the Google Earth Pro software. The information was collected in images from August 9, 2020. A bibliographical survey was also carried out to acquire data relating to wind turbines via the Sigel platform - Georeferenced Information System for the Electrical Sector.

Based on these data, it was observed that 7 residences are located at a distance between 150 and 200m, 30 residences are located between 200 and 300m, and 35 residences are between 300 and 400m away from the wind turbine tower (Figure 2), verifying densification of residences within the perimeter of up to 400m from the wind turbine towers, that is, around 50% of residences are within this perimeter, which justifies the choice of the community for the study under Conama resolution 462 (Brasil, 2014), which establishes procedures for the environmental licensing of projects generating electricity from wind sources.



**Figure 2 |** Residential quantity and distances, in meters, in relation to wind turbine towers

Source: Prepared by the authors (2023).

The research has an *ex-post-facto* research nature; in other words, it investigates the hosts' perception of the impacts of a wind farm installed in the community since 2015. Primary data collection took place through four field activities, February/2021, June/2021, August/2022 and June/2023, in order to get to know the study area through conversations with community members, health agents and associations to diagnose the interviewees' perceptions regarding the acceptance/rejection of the implementation of wind farms from the perspective of procedural and distributive justice.

### 3.3 DEVELOPMENT AND APPLICATION OF THE QUESTIONNAIRE

The objective of the research was to understand the community's responses in relation to the acceptance/rejection of the implementation of wind farms from the perspective of procedural and distributive justice. Here, the results of a face-to-face survey carried out in the Serra dos Pereiros community in the municipality of Caldeirão Grande do Piauí – PI were analysed. The results are presented from the 31 questions referring to the variables for the answers: impact on daily life, landscape change, visibility, opinion on wind farms, political process of implementing wind farms, fairness of the process, compensation, noise nuisance and noise sensitivity.

Questionnaires were adapted from research carried out in Brazil and South Korea, based on Brannstrom *et al.* (2022), Leite (2019), and Yun *et al.* (2022). This questionnaire consists of identifying the interviewee and 10 answers that add up to 31 variables that measure the factors used for the analysis. Board 2 presents the objectives of the responses and the number of questions used in the questionnaire.

**Board 2 |** Description of responses

Nº	Responses	Objective	Number of questions
1	Impact on daily life	Understand the day-to-day relationships of the community with wind farms.	3
2	Change in the landscape	Understanding the relationships established between individuals and the environment experienced over time which can contribute to understanding the idea of protecting the landscape and the relationship with the territory.	3
3	Visibility	Understand the relationships established between individuals and wind turbines.	1
4	Opinion about wind farms	Effectively present participants' views regarding implementing and expanding wind energy projects at local, state and national levels.	4

Nº	Responses	Objective	Number of questions
5	Political process for implementing wind farms	Understand community participation with governmental and non-governmental bodies regarding implementing wind farms.	10
6	Fairness of the process	Understand whether there was any community influence in the wind farm design stage.	4
7	Compensation	Understand the positive and negative impacts of installing a wind farm in terms of financial and economic compensation.	3
8	Noise nuisance	Understand the impacts of noise on the community	1
9	Noise sensitivity	Understanding the impacts of noise on the community	1
10	Background noise perception	Understand the impacts of noise on the community	1

Source: Prepared by the first author (2023).

As this research used subjective data collection through interviews with human beings, it was necessary to submit it for consideration by the Research Ethics Committee – CEP, through Plataforma Brasil (Brazilian Base of Data of the registry of research involving human beings). The CEP's consolidated opinion confirmed the ethical approval of the research under opinion number 6,034,815 on May 2, 2023.

### 3.4 STATISTICAL ANALYSIS AND DATA PROCESSING

Population data were provided by health agents from the Serra dos Pereiros community. The sample was calculated considering the total number of inhabitants: 433 people.

The following statistical formula was applied to calculate the sample (Devore, 2018).

$$n = \frac{Z^2 \cdot p \cdot q \cdot N}{e^2(N-1) + Z^2 \cdot p \cdot q} \quad (1)$$

Where:

- n: is the sample value;
- Z: adopted a significance level of 10% (1.64), which gives a confidence of 90%;
- p: proportional value of the population analysed in relation to the municipality, where the population of the community (433) was divided in relation to the population of the municipality (5671), resulting in  $p = 0.0763$ ;
- q: complementary value,  $q = 1 - p$ , which resulted in the value 0.9236;
- N: population size;
- e: the non-sampling error was adopted at 5%.

The sample size calculated according to equation 1 to apply the questionnaire was 65 ( $n = 64.6$ ) people, men and women over 18 years old.

To measure the level of agreement with each statement, the participant chose a response according to the gradient of the Likert scale of satisfaction with 5 levels: completely disagree (1), disagree (2), indifferent (3), agree (4) and totally agree (5). This scale consists of taking a construct and developing

a set of statements related to its definition to which respondents express their degree of agreement (Júnior; Costa, 2014).

To measure the degree of relationship between the variables, a correlation test was conducted with a reliability degree of 95% and, consequently, a statistical significance level of 5%.

Data tabulation was carried out using the Microsoft Excel program. The information in the questionnaire was entered into Excel, calculating the percentages of each response obtained through the agreement used on the Likert scale.

After, the software R (*Language and Environment for Statistical Computing*) was used. The data were imported from Microsoft Excel to perform the statistical analyses. In R, Cronbach's alpha coefficient was calculated to evaluate the reliability and internal consistency of measuring instruments. It is a statistical tool that quantifies, on a scale from 0 to 1, the reliability of a questionnaire, with the minimum acceptable value being 0.70 (Almeida; Santos; Costa, 2010; Gaspar; Shimoya, 2017).

Next, another statistical method, the Spearman correlation coefficient ( $r_s$ ), was applied. This coefficient indicates the intensity degree of the correlation between two variables with the same response or, in cases where the response has a single variable, performs there is a correlation between different response variables, but they identify with each other.

The direction of the correlation can be positive or negative. If the correlation between two variables is perfect and positive, then  $r_s = (+1)$ . If  $r_s = (-1)$ , there is a perfect and negative correlation between the variables, and if there is no correlation between the variables, then  $r_s = (0)$ .

Results with moderate and strong correlations with statistical significance were discussed. In the research, the proposal by Santos (2007) was used to indicate the degree of intensity of the correlation between two variables. According to the author, moderate correlation has a correlation coefficient between  $(0.5 \leq r_s < 0.8)$ , and strong correlation has a correlation coefficient between  $(0.8 \leq r_s < 1)$ .

## **4 RESULTS**

This chapter summarises the results obtained from the questionnaires applied in the Serra dos Pereiros community.

### **4.1 COMMUNITY OPINION ABOUT THE INSTALLATION OF WIND TURBINES IN SERRA DOS PEREIRO**

According to the data processing analysis procedure determined in the methodology, the results presented in Tables 1, 2, 3 and 4 express the percentages of each response obtained through the agreement used on the Likert scale.

Table 1 presents the results of the variables' impact on daily life, landscape change and visibility.



**Table 1 | Responses about impact on daily life, change in landscape and visibility**

Response	q	Variable	Level of agreement				
			1	2	3	4	5
Impact on daily life	1.1	I have good feelings about the wind farms in my community.	11,59%	17,39%	20,29%	39,13%	11,59%
	1.2	The community where I live is a good place to live	0,00%	0,00%	0,00%	55,07%	44,93%
	1.3	My life was affected by the installation of the wind farm	14,49%	30,43%	17,39%	11,59%	26,09%
Change in the landscape	2.1	The changing landscape caused by wind turbines around my community affects my daily life.	7,25%	27,54%	43,48%	15,94%	5,80%
	2.2	I consider the presence of wind turbines in the landscape to be beautiful.	7,25%	30,43%	10,14%	43,48%	8,70%
	2.3	I like the landscape of my community with wind farms	2,90%	24,64%	15,94%	47,83%	8,70%
Visibility	3.1	I can see the wind turbines from my house	1,45%	0,00%	0,00%	26,09%	72,46%

*Source: Prepared by the authors (2023).*

Regarding the variables' impact on daily life (1.1 – 1.3), for the existence of wind farms in the community, just over 50% reported that they had a good feeling about them. All residents interviewed stated that the community is a good place to live, and around 37% reported that their lives were negatively affected by the installation of the park. Half of the community was in favour of the existing wind energy project in the community. Concerning the feeling of belonging, all interviewees stated that the community is a good place to live, even considering that around 37% had their lives negatively affected by the wind farm installation.

As for the variables relating to the feeling of changing the landscape (2.1 – 2.3), almost half of the residents interviewed (43.5%) were indifferent to the change in the landscape caused by the installation of wind farms, 43.5% of those interviewed they consider the presence of wind turbines to be beautiful and 47.8% agree that they like the landscape with wind farms. In addition, the variable visibility (3.1) of wind turbines shows that almost 99% of residents interviewed can see the wind turbines from their homes. This demonstrates that the community does not consider the change in the landscape to be a problem caused by the wind energy project. In general, these results are in line with those presented by Leite (2019), who reports that the population's responses possibly did not consider this interrelationship (environmental dynamics and landscape), which can be explained by the educational level and superficial provision of information about this renewable energy, or even the short time during an interview to interpret information in depth.

The results of the variables about opinions on wind farms and the political process for implementing wind farms are presented in Table 2.

**Table 2 | Responses about opinion and political process for implementing wind farms**

Response	q	Variable	Level of agreement				
			1	2	3	4	5
Opinion about wind farms	4.1	I support the existing wind energy project in my community	13,04%	20,29%	5,80%	53,62%	7,25%
	4.2	I support installing more wind turbines in my community	18,84%	18,84%	13,04%	26,09%	23,19%
	4.3	I support wind energy projects in other locations in Piauí	1,45%	4,35%	30,43%	34,78%	28,99%
	4.4	I support the use of wind energy to meet Brazil's energy needs	1,45%	4,35%	23,19%	33,33%	37,68%
Political process for implementing wind farms	5.1	My community was consulted on the wind farm implementation project	5,80%	33,33%	5,80%	46,38%	8,70%
	5.2	I have knowledge about the wind energy project in my community	33,33%	49,28%	5,80%	8,70%	2,90%
	5.3	I participated in the public hearings for approval of the wind farm	86,96%	10,14%	0,00%	0,00%	2,90%
	5.4	I had a great opportunity to express my concerns and clarify doubts before the project was approved	88,41%	8,70%	0,00%	0,00%	2,90%
	5.5	The community consultation process was transparent to local residents	62,32%	24,64%	0,00%	11,59%	1,45%
	5.6	The municipal government helps clarify doubts and concerns about wind farms in the community	94,20%	2,90%	1,45%	0,00%	1,45%
	5.7	The wind company clarifies doubts and concerns about wind energy in the community	44,93%	34,78%	2,90%	17,39%	0,00%
	5.8	The Public Prosecution helps clarify doubts and concerns about wind farms in the community	92,75%	4,35%	1,45%	1,45%	0,00%
	5.9	The land title (land ownership document) facilitated the installation of the wind farm	2,90%	8,70%	43,48%	36,23%	8,70%
	5.10	The land title (ownership document) helped define the wind farm installation areas	4,35%	10,14%	40,58%	33,33%	11,59%

Source: Prepared by the authors (2023).

Regarding the variables related to the opinion on wind farms (4.1 – 4.4), just over 60.0% of those interviewed agreed or completely agreed with the existing wind farm project in the community, and

approximately 50.0% support the installation of more wind turbines on site. The community expressed acceptance of the wind farm project, and similarly, there was support for this energy generation projects at the state (64.8%) and national (71%) levels

Concerning the variables related to the political process (5.1 – 5.10) of implementing wind farms, around 55% of those interviewed expressed that the community was consulted about the installation of the park. However, 82.6% reported that they did not know about the project. In the variable "I participated in the public hearings to approve the wind farm", only 2.9% of those interviewed stated that they participated, highlighting the lack of community involvement. This becomes clearer when analysing the percentage of people interviewed (97.1%) who could not express their concerns and clarify doubts before the project was approved.

Still, 86.9% stated there was no transparency for local residents regarding the community consultation process. 92.1% totally disagreed or disagreed with the possibility of collaboration with the municipal government to clarify doubts and concerns about wind farms in the community. Similarly, this same question was asked to clarify doubts and concerns about wind farms in the community for the company and the Public Prosecutor's Office, obtaining percentages of 79.7% and 97.1%, disagreeing completely or disagreeing, respectively. It is believed that these high percentages of disagreements in relation to these entities in clarifying doubts and concerns about wind farms in the community may be because, often, there is no direct contact with people in the community but instead with representatives and public bodies involved.

Regarding the land title, respondents responded that 44.93% agreed or completely agreed that the land ownership document facilitated the wind farm installation and that this title helped define the wind farm installation areas.

The results of the variables related to justice in the process and compensation are presented in Table 3.

**Table 3 | Responses about the fairness of the process and compensation**

Response	q	Variable	Level of agreement				
			1	2	3	4	5
Fairness of the process	6.1	The community development process after the installation of wind farms was fair	11,59%	26,09%	11,59%	49,28%	1,45%
	6.2	The wind project developer acted openly and transparently throughout the process	8,70%	60,87%	7,25%	23,19%	0,00%
	6.3	My community was able to influence the outcome of the wind project, for example, the location or number of turbines	42,03%	50,72%	1,45%	5,80%	0,00%
	6.4	During the development process of wind farms, the interests of residents were considered	30,43%	56,52%	4,35%	8,70%	0,00%

Response	q	Variable	Level of agreement				
			1	2	3	4	5
Compensation	7.1	I and/or my family received compensation for the wind farm implementation project	71,01%	7,25%	0,00%	15,94%	5,80%
	7.2	I am satisfied with the compensation for leasing the land for installing the turbine	82,61%	5,80%	0,00%	8,70%	2,90%
	7.3	I believe that the community is satisfied with the improvements made by the wind project developer	1,45%	20,29%	18,84%	59,42%	0,00%

Source: Prepared by the authors (2023).

Concerning the variables related to the fairness of the process (6.1 – 6.4) in the implementation of wind farms in the community, around 50% of those interviewed agreed or completely agreed that development occurred in the community after the installation of the parks. They cite, as an example, the construction and paving of roads. However, more than 70% reported that the project developer did not act transparently, the community could not influence the project and the interests of residents were not considered.

Regarding the variables related to financial compensation (7.1 – 7.3), more than 70% of the residents interviewed did not receive financial compensation with the implementation of the park. However, around 60% believe that the community is satisfied with the improvements made by the project.

The results of the variables related to noise annoyance, noise sensitivity and perception of background noise are presented in Table 4.

**Table 4 | Responses about the fairness of the process and compensation**

Response	q	Variable	Level of agreement				
			1	2	3	4	5
Noise nuisance variable	9.1	I am bothered by wind turbine noise in my community	5,80%	10,14%	55,07%	14,49%	14,49%
Variable Noise sensitivity	10.1	In general, I am sensitive to noise	1,45%	17,39%	43,48%	23,19%	14,49%
Variable Perception of background noise	11.1	The area where I'm living was initially quiet	0,00%	1,45%	0,00%	17,39%	81,16%

Source: Prepared by the authors (2023).

Regarding the variable related to noise nuisance (9.1), more than half of the residents interviewed are indifferent regarding noise nuisance. Regarding the noise sensitivity variable (10.1), around 37% of residents interviewed agree or completely agree that they are sensitive to noise. Regarding the variable perception of background noise (11.1), almost 100% of the residents reported that the community was quiet before installing the wind farms. These results show that wind farms can generate environmental problems, with noise incompatible with the local lifestyle.

## 4.2 CORRELATIONS BETWEEN VARIABLES REFERRING TO THE QUESTIONNAIRE APPLIED IN THE SERRA DOS PEREIRO COMMUNITY

From the data tabulation, results were identified where there were moderate or strong correlations with statistical significance, based on the 31 questions referring to the variables' impact on daily life, landscape change, visibility, opinion on wind farms, political process of implementation of wind farms, fairness of the process, compensation, noise nuisance, noise sensitivity and perception of background noise, collected when applying the questionnaire. The correlation matrix between the variables was analysed using the R software, which was also used to determine the level of reliability of the questionnaire with a sample of 69 people living in Serra dos Pereiros. The result obtained a Cronbach Coefficient of 0.805, representing high reliability.

In cases where the response has a single variable, such as visibility, a correlation was made between the variables visibility and change in the landscape, which are identified with each other. The variables noise annoyance, noise sensitivity and perception of background noise were also correlated with each other.

Only five presented moderate and strong correlations with statistical significance from ten analysed responses in Tables 1, 2, 3, and 4. Responses to landscape change have a moderate positive correlation between q2.2 and q2.3 ( $r_s = 0,74$ ;  $p < 0,001$ ). These data indicate a moderate tendency for those who consider the presence of wind turbines in the landscape beautiful and like the landscape of their community with wind farms to be more supportive of wind projects. These results corroborate the results of Leite (2019).

The variables related to the response to opinions about wind farms present moderately positive correlations between the variables q4.1 and q4.2 ( $r_s = 0,76$ ;  $p < 0,001$ ), q4.1 and q4.3 ( $r_s = 0,74$ ;  $p < 0,001$ ), q4.1 and q4.4 ( $r_s = 0,73$ ;  $p < 0,001$ ) and q4.2 and q4.4 ( $r_s = 0,70$ ;  $p < 0,001$ ). According to the data obtained through moderated correlations in relation to support for the existing wind farm project in the community, they indicate that there is a direct relationship between support for the installation of more turbines in the community and also in other locations in Piauí, with the purpose to satisfy the needs of wind energy in Brazil. Between the variables q4.2 and q4.3 ( $r_s = 0,86$ ;  $p < 0,001$ ), and q4.3 and q4.4 ( $r_s = 0,86$ ;  $p < 0,001$ ) there is a strong positive correlation. The same support relationship as the previous ones can be seen regarding these variables. However, they demonstrated greater support in installing more turbines in the community and other locations in Piauí to meet the needs of wind energy in Brazil.

The variables regarding responses to the political process of implementing wind farms have a moderate positive correlation between q5.3 and q5.6 ( $r_s = 0,64$ ;  $p < 0,001$ ) and q5.3 and q5.8 ( $r_s = 0,56$ ;  $p < 0,001$ ). These data suggest a direct trend in the responses among those who did not participate in the public hearings, stating that the municipal government and the Public Prosecution did not clarify doubts and concerns regarding wind farms in the community. The variables q5.3 and q5.4 ( $r_s = 0,94$ ;  $p < 0,001$ ) have a strong positive correlation. This trend is even stronger in the responses among those who did not participate in the public hearings and the opportunity to express concerns and clarify doubts before the project is approved.

Regarding the variables for the response fairness in the process, there is a moderate positive correlation between the variables q6.1 and q6.2 ( $r_s = 0,57$ ;  $p < 0,001$ ) and q6.3 and q6.4 ( $r_s = 0,63$ ;  $p < 0,001$ ). These data show, through moderate correlations, that the responses regarding justice in the community development process after the installation of the park and how the developer acted during this process are directly related, as well as the community's responses regarding the capacity to influence the outcome of the wind project and the interest of residents are directly related.

The variables relating to the compensation response have a moderate positive correlation between q7.1 and q7.2 ( $r_s = 0,64$ ;  $p < 0,001$ ). This data has a tendency in the answers directly between the compensation received by people and the compensation received regarding the land lease.

## 5 CONCLUSION

The analysis of the Serra dos Pereiros community's responses concerning wind farms shows that 50% of interviewees are in favour of the wind energy project. However, 37.0% were negatively impacted by the installation of the park.

These impacts are related to the visibility of wind turbines, considering that almost 99.0% of interviewed residents see the wind turbines in their homes, nor with the change in the landscape, considering that 78.27% agree or are indifferent to this statement.

Just over 60.0% of respondents expressed acceptance of the wind farm project in the community, and similarly, there was also support for energy generation projects at the state (64.8%) and national (71.0%) levels.

It was verified that for 55% of those interviewed, there was an initial consultation about the wind energy project in the community; however, 82.6% reported that they did not have knowledge about the project, and 97.1% were unable to express their concerns and clarify doubts before the approving of the project. Only 2.9% participated in a public hearing, confirming the community's low participation and ability to interfere in the local project. These data show that according to Gorayeb and Brannstrom (2016), the development of policies that do not include the direct participation of society generates conflicts between different institutional levels and severe environmental and social problems, the proportion of which we may only have an accurate idea only in some decades.

Regarding procedural justice, about 50% of the interviewed stated that development occurred in the community after the installation of the parks. It is quoted, as an example, the construction and paving of the roads. However, more than 70% reported that the project developer did not act transparently, did not consider the community's interests, and did not allow the community to influence the project development. Regarding distributive justice, 70% of the interviewees did not receive financial compensation for the park implantation. However, about 60% believe that the community is satisfied with the improvements made by the project. Even carrying the conception that the wind parks could generate environmental issues, noise being the main one, it is clear when almost 100% of the interviewed residents informed that the community used to be quiet before the installation of wind farms.

Through the Spearman Correlation Coefficient, it was possible to confirm that the related variables to the referred answers to changes in the landscape, the opinion about the wind farms, the political process of implanting the wind farms, the fairness of the process and compensation have a moderate positive correlation and also the variables related to the responses referred to the opinion about wind farms and the political process of the implementation of wind farms have a strong positive correlation, which always shows a directly proportional relationship between these variables.

Walker and Baxter's research (2017 a, b) reveals that accepting wind energy projects raises when people have a role in the decision-making, which would be procedural justice. The question about justice in the planning and licensing (procedural justice) and the benefits and harms distribution (distributive justice) are essential in this process.

Gorayeb and Brannstrom (2016) bring proposals to adequate the implementation of wind energy parks in the Northeast, such as payment of monthly amounts related to productivity and rents to community associations, reduction of energy bills for residents, creation of permanent education programs and promotion of good practices aimed at the local community; construction of legal provisions that

regulate the implementation of wind energy at the state and municipal level, based on the drafting of municipal laws and plans; preparation of environmental impact studies that are based on public awareness, broad information and communication strategies about the benefits and possible damages to the natural and social environment and human health; and construction of a state zoning that identifies levels of compatibility of the state's regions with the implementation of wind farms, with broad social participation.

The research has limitations related to the sample size, which, when presented in a small number, allows for considering the results found only for the population in question. Another limitation was the low education level of the interviewees, who often did not fully understand the questions in the questionnaire.

Therefore, new research is suggested to deepen these discussions, which aims to understand the criteria for installing new wind farms and enabling a fairer distribution of benefits.

Based on these guidelines, the research contributed to developing more detailed normative instruments that preserve the well-being of local communities in or around wind farms, assisting in policies linked to fair energy and social justice.

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