



Environmental and climate impacts of implementing wind farms: Systematic review

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CARVALHO, Lucas Talvane Ferreira⁽¹⁾; ANDRADE, Luciano Pires⁽²⁾; SILVA, Luiz Rafael Silva da⁽³⁾

⁽¹⁾ 0000-0002-3752-9835; Bacharel em Ciências da Natureza, Centro Universitário Estácio de Ribeirão Preto, Brasil. E-mail: lucas.talvane.carvalho1@gmail.com.

⁽²⁾ 0000-0001-5818-711X; Dr. em Agronomia e Prof. nos cursos de Ciências Agrárias, Universidade Federal do Agreste de Pernambuco. Brasil. E-mail: luciano.andrade@ufape.edu.br.

⁽³⁾ 0000-0000-0000-0000; Me. em Ciências Biológicas, Prof. no curso de Ciências da Natureza, Centro Universitário Estácio de Ribeirão Preto, Brasil. E-mail: luiz.ssilva@estacio.br.

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ABSTRACT

Environmental impacts provided by the implementation of wind farms in Brazil. In this sense, the objective of this article is to evaluate the impacts caused by the implementation of wind farms, described in the literature. Bearing in mind, above all, that wind farms are one of the most important alternatives for clean energy generation, and the high growth in the number of projects in operation and in the implementation phase in the Northeast region of Brazil. The material used for the systematic review of the literature was the result of searches on the CAPES/MEC Journals portal. Through the inclusion criteria, articles were reached that led to discussions about the environmental impacts caused by the implementation of wind farms. The study showed that there should be a more in-depth assessment of the environmental impacts, which should be carried out with the support of resources from the energy sector itself, in order to promote sustainable growth in the contribution of this alternative energy source in the national energy matrix market.

RESUME

Impactos ambientais proporcionados pela implantação de parques eólicos, no Brasil. Nesse sentido, o objetivo deste artigo, é avaliar os impactos causados pela implantação de parques eólicos, descritos pela literatura. Tendo em vista, sobretudo, que os parques eólicos como uma das mais importantes alternativas de geração de energia limpa, e pelo elevado crescimento do número de projetos em operação e em fase de implantação na região do Nordeste do Brasil. O material utilizado para a análise de revisão sistemática da literatura foi resultado de buscas no portal de Periódicos CAPES/MEC. Por meio do critério de inclusão, foram alcançados artigos que levaram a discussões sobre os impactos ambientais causados pela implantação de parques eólicos. O estudo mostrou que deve haver uma avaliação mais aprofundada dos impactos ambientais, que deve ser realizada com o apoio de recursos do próprio setor energético, a fim de promover um crescimento sustentável na contribuição desta fonte de energia alternativa no mercado nacional da matriz energética.

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Introduction

Climate change is becoming more and more noticeable and, over the decades, we have witnessed various political, economic and social agendas, since its impacts are projected both in the present and in the future. The United Nations Development Programme (UNDP) and the Intergovernmental Panel on Climate Change (IPCC) recognize that climate change is becoming progressively more evident, proportional to the increase in greenhouse gas (GHG) emissions and, consequently, global warming (IPCC, 2021).

On the other hand, there has been a significant increase in investment in various countries to implement renewable energy sources. This is mostly due to the fact that nonrenewable energy sources release gases that contribute to global warming, along with other anthropogenic activities such as deforestation. These factors, combined with the depletion of natural resources such as fertile land, forests and fresh water, make the transition to renewable energies a crucial measure for reducing the impact of the greenhouse effect (Santos & Shayni, 2022).

In Brazil, by September 6th, 2022, 12.02% of the energy matrix of a total installed capacity in operation of 184.75 GW will come from wind farms, with approximately 751 wind farms and more than 8,800 wind turbines installed in Brazil. The trend is for this energy matrix to increase over the next few years. Currently, there are 36.76% of licensed projects under implementation that will reinforce the energy matrix; the projection is that by the end of 2025 the installed power will reach 35 GW, which will correspond to the energy power equivalent to 2.5 Itaipu plants (MME, 2022).

With the idea that wind energy is a “clean” source, environmental legislation describes this energy source as less impactful, thus exempting entrepreneurs from submitting an Environmental Impact Study (EIA) and an Environmental Impact Report (RIMA) for the environmental licensing process. In this way, the entrepreneur only has to present the Simplified Environmental Report (RAS). As the name suggests, this is “simplified”. In the absence of the EIA/RIMA, wind projects are left with “open gates” for undertakings that do not follow the care that should be taken with socio-environmental issues, at all stages of the implementation of wind farms (Costa, 2022).

But just like other natural elements, air currents are very irregular, which means that energy generation is often unpredictable. This makes it necessary to create a large wind farm to accommodate the wind turbine towers. Great visual impact and noise pollution are evident for those who live in the vicinity of the park, but these are not the only impacts, given that the

implementation can cause biotic and abiotic problems, affecting all those who are inserted in the parks or on their route (Farias et al., 2021).

And like any other economic activity, they cause environmental impacts, however small they may be; therefore, they must be analyzed and mitigated. Such as impacts on the biosphere, interfering with biological and chemical cycles in the natural environment (Pinto et al., 2017).

The aim of this study is to evaluate scientific research on the environmental impacts on the biosphere caused by the construction of wind farms.

Methodology

The aim of this type of scientific study is to integrate references in the literature related to wind energy farms and their environmental impacts (Gil, 2008). All the studies identified were indexed by consulting one of the largest virtual scientific collections in the country: SciELO Journal Portal, Web of Science, Digital Repository of universities: UFPB, UNESP, UFU, UFERSA, UNEAL, through CAFE access, which provides unlimited access to the collection.

Systematic review studies are important because they significantly help to analyze the research carried out in a specific area of knowledge over time. Good quality systematic reviews are generally considered to be the best indication for deliberation, thus facilitating access for researchers who need to carry out an agile review, which can also lead to future research.

This review included articles with abstracts and full texts available, in Portuguese and English, published between 2017 and 2022 and which responded to the study's guiding question. The period chosen was because it was possible to obtain more recent and up-to-date work, given that in recent years there has been a significant percentage of wind farms built, in compliance with the commitment made by some countries during the United Nations Conference on Climate Change in 2015 (COP 21) (CARVALHO, 2016). Initially, in an advanced search using the keywords "environmental impacts" and "wind farms", 33 articles were selected, available on the CAPES journals portal with unlimited access to the SciELO, Web of Science and Digital Repository of Universities collections, which had keywords related to the topic. They were then evaluated according to the relevant information: inclusion criteria were established for articles with theoretical and empirical knowledge and which were within the scope of the research.

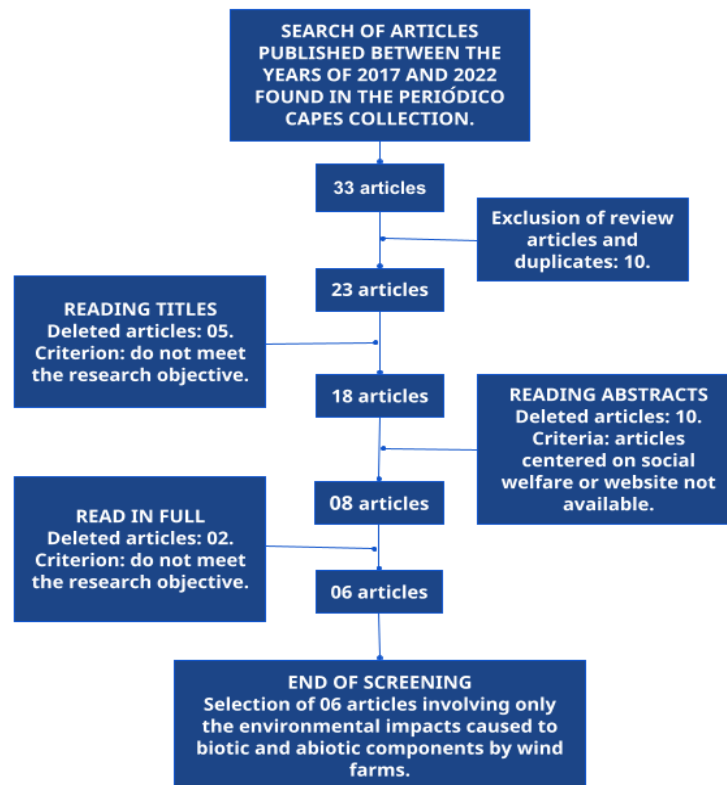
Therefore, the exclusion criteria were: review articles that do not use sophisticated search strategies and random choices, such as narrative reviews. This led to the analysis using searches for scientific articles with field, exploratory, descriptive and qualitative studies. Another exclusion criterion was the elimination of repeated studies that did not answer the research objective. These criteria aim to answer the following question: What are the environmental impacts caused by the implementation of wind power plants on the soil, local

flora and wildlife, including avifauna, terrestrial fauna and ichthyology. At the end of the analysis, only seven articles remained (Figure 1).

The papers were carefully read, then categorized according to the content of the study objectives, which were used in this review. The Google Spreadsheet Program was used to help analyze the qualitative data, which made it possible to manage the bibliographical references.

Figure 1.

Search procedures and article exclusion criteria.



Source: Research data (2022).

Results and Discussion

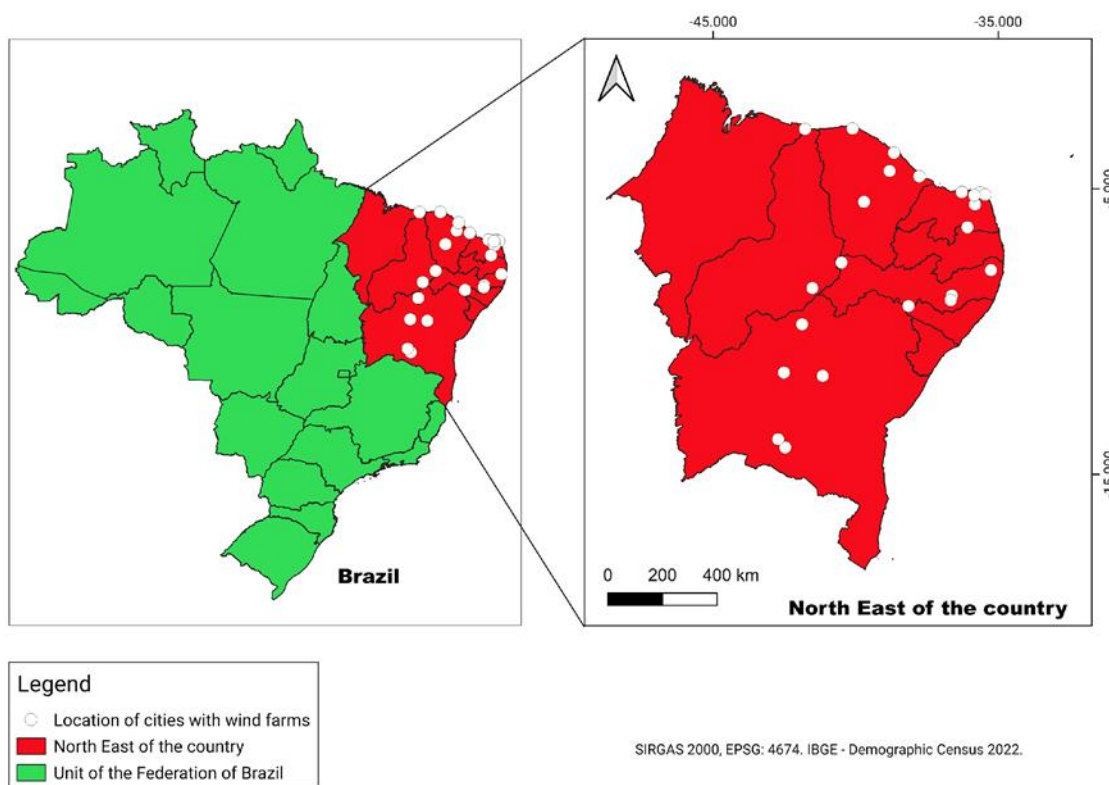
Based on the analysis of the studies, it was possible to trace a path on the environmental impacts caused by the implementation of wind power plants, through the research carried out on the journals portal. It is worth noting that it was difficult to find more studies on the subject because it is a current issue and environmental changes can be observed over time. Six complete papers were selected with the search terms defined, as shown in Table 1, in which the objects of study are located in the Northeast region of Brazil (Figure 2) and their respective cities with parks in operation in the states of Bahia: Caetit , Gentio do Ouro, Igapor , Morro do Chap u, Sento S ; Cear : Aracati, Aracoiaba, Caucaia, Pedra Branca, Acara ; Piaui: Delta do Parna ba, Lagoa do Barro do Piaui; Pernambuco: Araripina, Caet s, Carpina, Tacaratu,

Paranatama; Rio Grande do Norte: São Miguel do Gostoso, Touros, Galinhos, Jandaíra, João Câmara, Parazinho, São Bento do Norte.

Regions characterized by the *Cerrado*, *Caatinga* and Coastal biomes (sandbanks, dunes, mangroves, beaches and the sea) where the intense incidence of winds is caused by various factors, including local temperature variation and the presence of high and low atmospheric pressure systems. Caused by the topography and latitude, the region is a differential for implementing this energy generation system when compared to the Central-West, North, Southeast and South regions of Brazil.

Figure 2.

Map of the Brazilian Northeast with markers representing the geographical location of cities with wind farms in operation.



Source: Personal archive (2023).

Table 1.

Distribution of articles according to title, authors and year of publication.

Author/year	Title	Type of study	Aspects addressed
BEZERRA, A. S. et al., 2021.	Local climate change after the installation of wind farms in the Brazilian semi-arid region (<i>Mudanças climáticas locais após instalação de parques eólicos no Semiárido brasileiro</i>).	Field research - Full article.	Impacts on fauna and flora, noise, reduced rainfall, changes in thermal sensation and possible alteration of the local climate over the years.
COSTA, M. A. S. et al., 2019.	<i>Socioeconomic, Environmental and Technological Impacts Caused by the Installation of Wind Farms in Ceará (Impactos Socioeconômicos, Ambientais e Tecnológicos Causados pela Instalação dos Parques Eólicos no Ceará)</i> .	Descriptive and Exploratory research - Full article.	The main socio-environmental impacts of this work are: The reduction of fauna and flora, noise emissions, decharacterization of the natural landscape, limitation of the right to “come and go”, cracks in houses and deterioration of access roads.
FIRMINO, C. B., 2017.	Environmental impact assessment for the installation of a wind farm in Pereiro-CE (<i>Avaliação de impactos ambientais na instalação de um parque eólico em Pereiro-CE</i>).	Field research - TCC.	Relationship between wind farms and activities that could alter the physical and Chemical characteristics of the site.
GÊ, D. R. F. et al., 2022.	Socio-environmental analysis of the wind farm implementation/operation process in the ponta do tubarão state sustainable development reserve, Macau/Guamaré, Rio Grande do Norte - Brazil (<i>Análise socioambiental do processo de implantação/operação de usinas eólicas na reserva de desenvolvimento sustentável estadual ponta do tubarão, Macau/Guamaré, Rio Grande do Norte – Brasil</i>).	Qualitative research - Full article.	The developments have caused environmental impacts and socio-environmental conflicts, damaging the environment and traditional ways of life.

SOUZA, N. et al., 2020.	Integrated analysis of the environmental aspects and impacts of operational activity at a wind farm in southwest Bahia / Brazil (<u><i>Análise integrada dos aspectos e impactos ambientais da atividade operacional em parque eólico no sudoeste da Bahia / Brasil</i></u>).	Field and exploratory research through Interaction network and weighting matrix - Dissertation.	The study proposal was drawn up using two environmental impact assessment methods: a weighting matrix and a network interaction.
PEREIRA, O. A. et al., 2019.	Bird diversity in wind farms in the APA Delta do Parnaíba, Northeast, Brazil (<u><i>Diversidade de aves em Parques Eólicos na APA Delta do Parnaíba, Nordeste, Brasil</i></u>).	Field and exploratory research - Full article.	The impacts of the loss of the natural environment due to the establishment of wind farms on the composition and dynamics of the bird species present in the area.

Source: Research data (2022).

The environmental issue that Gê et al. (2022) report involved problems in the environmental licensing process for the project installed between 2010 and 2012 in the Ponta do Tubarão State Sustainable Development Reserve (RDSEPT) (Management Council). There was resistance on the part of the council members, who did not have the opportunity to study the issue in greater depth and understand how the RDSEPT would be affected by the Conservation Units (UCs).

On the other hand, the managing councillor accuses the Institute for the Defense of the Environment in Natal (IDEMA) (Managing Body) of agreeing to release environmental licenses for the installation of the project in the reserve without the express agreement of the Managing Council and without having meeting minutes authorizing the implementation of the project. There were energy auctions run by the federal government, as well as a conflict between the wind farm and the community over dubious contracts between the developers and landowners in the RDSEPT area (GÊ et al., 2022).

Gê et al. (2022) state in their study that, with the leveling of dunes, the construction of access roads, the burying of a lagoon and deforestation, the exploitation of groundwater has resulted in damage to the water table and native vegetation. The narrative mentions the existence of different levels of impact, since there is a park on the pre-littoral plateau, a more stable environmental unit recommended for this type of activity.

There are two other more impactful areas: one part of the plant is located in the mobile dunes, considered by National Environmental Council Resolution (CONAMA) No. 303/2002 to be a permanent preservation area, and the other part is installed in an even more fragile

area, the restinga, an environmental unit that exhibits intense sediment movement due to marine influence, which can show processes of erosion and/or accumulation of sediments in a short time, thus enabling tidal advances and retreats (GÊ et al., 2022).

As a result, part of the problem is due to the lack of a Management Plan and Ecological-Economic Zoning at that time, which would have served as more pertinent instruments to guide the licensing body and entrepreneurs. Gê et al. (2022) point out that there was only economic interest and no responsibility for environmental sustainability. (2019), there are impacts (primary, secondary and tertiary) which, in their study, highlighted the integration networks between each positive and negative factor present in the operation stage, the phase of operation of the wind turbines, whose direct impacts are more noticeable, describable and quantifiable, while the indirect impacts are more difficult to identify and control.

However, Souza et al., (2019) identified that as developments reduce their direct impact, they can be analyzed through a network of interactions that cooperate to reduce the indirect environmental impact that occurs at the beginning of the activity. Therefore, a project can be developed to prioritize the reduction of indirect environmental impacts (primary, secondary and tertiary) that may arise from subsequent impacts. There are many aspects of direct and indirect environmental impacts related to the operation phase of wind farms.

As every operating process is linked to indirect and direct environmental impacts that can be positive and negative, the positive ones include the production of less impacting energy and the movement of the local economy. On the negative side, there is the stroboscopic effect (an effect that occurs when a pulsating light source illuminates a moving object, which can be compared to wind turbine propellers and the moving shadow) decharacterization of the landscape, electromagnetic interference, modification of the migratory route of fauna, noise pollution and optimization of land use (SOUZA et al., 2019).

Costa et al. (2019) identified a number of impacts caused by the implementation of wind farms. These include impacts on flora, fauna and soil, which are in line with the focus of the review in question. In their study, the authors highlighted the type of vegetation present in the affected area, which includes mangroves and the transition between tabuleiros and Caatinga. According to the interviews conducted with the local population, it was found that native vegetation had been suspended only around the towers and on the access roads, which are used for passing cars and machinery for erecting and maintaining the towers. However, this suspension occurs in specific places within the parks, without there being any endangered species of flora.

As far as terrestrial and winged fauna are concerned, impacts were perceived due to the disturbances caused by the movement of machinery, the opening of access roads and earthworks, which leave the animals' habitat. However, as time goes by, they return to their natural environment, and there is a perception of a slight impact, either in terms of mortality or a decrease in the number of birds and the Calango (*Tropidurus hispidus*), which are species

of terrestrial fauna. With regard to the soil, it was found to be compacted by machine and vehicle traffic, which was noticeable during the rainy season, which presented problems with water infiltration into the soil (COSTA et al., 2019).

On the other hand, Bezerra et al. (2021) carried out a rainfall, fauna and flora study before and after the wind farm was set up. Between 2005 and 2010, the average rainfall was 2,990.2 mm; between 2015 and 2018, after implementation, the average was 2,459.2 mm, showing a reduction in rainfall in the area. No data was collected for the years 2011 to 2014 due to the dynamics of atmospheric circulation influenced by the *El Niño* phenomenon. In the years prior to implementation, which had higher rainfall rates, there was a high rate of vegetation, as shown by satellite images comparing the vegetation index of the site before and after implementation of the park.

In addition to the impacts already mentioned, other relevant impacts can be mentioned, such as changes to the landscape, electromagnetic disturbance (which interferes with the birds' sense of direction and flight), noise pollution, changes in weather conditions and damage to fauna. Wild animals are not seen as often in the park area and domestic animals, such as pets and production animals, are less efficient due to noise pollution, variations in the weather and deaths due to collisions with turbines, propellers or other park structures (BEZERRA et al., 2021).

Pereira et al. (2019) then reports that their study object is located near an Environmental Protection Area (APA). He points out that certain groups of fauna are among the most affected, such as birds. The purpose of the study was based on observation and a survey of the bird species present at the plant. A mist net was used to capture the birds. The most frequent species in the study area were large birds such as *Caracara plancus*, *Cathartes burrovianus*, *Coragyps atratus*, *Heterospizias meridionalis*, *Rostrhamus sociabilis*, *Rupornis magnirostris* and *Theristicus caudatus*.

Pereira et al. (2019) identified in their studies that large birds are more likely to suffer collisions and electrocutions with the artificial structures of exposed towers and transmission lines. Some of the peculiarities of this type of project are the size and arrangement of the turbines and the fleeting rotation of the wind turbines, conditions that can increase the impact of wind farms on birdlife. It is also important to note that the study area is located in a coastal region, which is conducive to the migration of multiple species of birds that migrate from the northern hemisphere in the run-up to the boreal winter. Their intention is to look for places in other seasons that provide food and to complete their biological cycle, which would not be possible in the northern hemisphere due to the extreme temperature during the winter.

In line with Bezerra et al. (2021), Souza et al. (2019) and Pereira et al. (2019), there are solutions that can prevent and reduce impacts on birdlife. One solution is to avoid placing towers in important habitat areas, such as resting, feeding and breeding areas. It is also

important to avoid bird migration corridors. Power plant designs should provide for towers to be strategically placed to avoid bird collisions. Another solution is to adopt tubular towers with blades made of synthetic materials, as opposed to towers made of metal blades. Finally, it is important to adopt an underground transmission system to reduce the impact of wind towers on birds.

Final Considerations

When analyzing the data, it can be seen that there are still few studies focused exclusively on environmental impacts (i.e. those related directly to the ecosystem), while there are a large number of studies focused on socio-environmental issues, such as the impact on the lives of residents who have received towers on their properties or in the vicinity of the wind farm. This includes problems with animal and plant production, noise produced by the towers, temperature and rainfall levels and psychological problems. Therefore, companies in the energy sector should carry out research into the prevention and mitigation of possible environmental impacts through Environmental Impact Studies (EIS) and Environmental Impact Reports (EIR), as well as more in-depth scientific studies, using their own resources or in partnership with higher education institutions. In addition, it is important that these studies are widely publicized so that there is transparency.

The studies indicated that there were changes in the physical-chemical factors of the soil and water, influences on the productive, reproductive and photosynthetic cycles of local native and exotic species, as well as problems with reproduction and feeding, thermal comfort and shelter for bird and reptile species. For the fish, problems were found with the level of oxygen in the water, which can harm the ecological relationship in a disharmonious way. Therefore, these ecological factors of population growth and balance are influenced by changes in the habitat and can be adaptable in the case of more resistant or disharmonious species.

REFERENCES

- Bezerra, A. S., Anjos, M. M. S., Farias, A. R. B., Andrade, L. P., & Andrade, H. M. L. (2021). Mudanças climáticas locais após instalação de parques eólicos no Semiárido brasileiro. *Diversitas Journal*, 6(3), pp. 3097-3114.
https://doi.org/10.48017/Diversitas_Journal-v6i3-1790.
- Carvalho, E. R. D. (2016). Estratégia para a redução da emissão de dióxido de carbono gerada pelo consumo de energia em segmentos industriais brasileiros.
- Costa, H. S. (2022). *Por que não discutir os impactos socioambientais dos negócios do vento?* Info São Francisco. Set. 2022.
<https://infosaofrancisco.canoadetolda.org.br/noticias/energia-eolica/por-que-nao-discutir-os-impactos-socioambientais-dos-negocios-do-vento/>.
- Costa, M. A. D. S., Costa, M. D. S., Costa, M. M. D. S., & Lira, M. A. T. (2019). Impactos socioeconômicos, ambientais e tecnológicos causados pela instalação dos parques eólicos no Ceará. *Revista Brasileira de Meteorologia*, v. (34), pp. 399-411.
<https://doi.org/10.1590/0102-7786343049>.
- Change, I. C. (2021). IPCC - Fourth Assessment Report: the physical science basis. Contribution of the Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Set. 2022.
<https://www.ipcc.ch/report/ar6/wg1/>.

- Chipindula, J., Botlaguduru, V. S. V., Du, H., Kommalapati, R. R., & Huque, Z. (2018). Life cycle environmental impact of onshore and offshore wind farms in Texas. *Sustainability*, v. 10(6), pp.2022.
- Farias, A. R. B., Calado Filho, M. A. L., Bezerra, A. S., Carvalho, L. T. F., Silva, R. N., Andrade, L. P., & Silva, H. M. D. L. (2021). Saúde Mental E Implantação De Parques Eólicos: Um Estudo De Caso No Semiárido Brasileiro. *Revista Saúde e Meio Ambiente*, v. 12(1), pp. 154-166. set. 2022. <https://periodicos.ufms.br/index.php/sameamb/article/view/12239>.
- Firmino, C. B. (2017). *Avaliação de impactos ambientais na instalação de um parque eólico em Pereiro-CE* [Trabalho de Conclusão de Curso, UFERSA]. Out. 2022. https://repositorio.ufersa.edu.br/bitstream/prefix/6223/1/CristianoBF_MONO.pdf.
- Gê, D. R. F., Carvalho, R. G., Brannstrom, C., Caetano, A. G. N., & Silva, M. R. F. 2022. *Análise Socioambiental Do Processo De Implantação/Operação De Usinas Eólicas Na Reserva De Desenvolvimento Sustentável Estadual Ponta Do Tubarão, Macau/Guamaré, Rio Grande Do Norte–Brasil. REVISTA CAMINHOS DE GEOGRAFIA*, v. 23(85), pp. 115–136. DOI: <http://doi.org/10.14393/RCG238557408>.
- Gil, A. C. (2008). Métodos e técnicas de pesquisa social. 6. ed. Editora Atlas SA.
- Ministério de Minas e Energia – MME. (2022). Brasil ultrapassa os 185 GW de potência instalada, Agência Nacional de Energia Elétrica - ANEEL. Set. 2022. <https://www.gov.br/aneel/pt-br/assuntos/noticias/brasil-ultrapassa-os-185-gw-de-potencia-instalada>.
- Pereira, O. A., Ribeiro, A. S. N., Santos, S. S., Siqueira, A. J. da S., Nascimento, M. dos S., Santos, F. das C. V., & Guzzi, A. (2019). Diversidade de aves em parques eólicos na APA Delta do Parnaíba, Nordeste, Brasil. *Gaia Scientia*, v. 13(4), pp. 109-129. <https://doi.org/10.22478/ufpb.1981-1268.2019v13n4.44698>
- Pinto, L. I. C., Martins, F. R., & Pereira, E. B. (2017). O mercado brasileiro da energia eólica, impactos sociais e ambientais. *Revista Ambiente & Água*, v. (12), pp. 1082-1100. <https://doi.org/10.4136/ambi-agua.2064>.
- Santos, L. H., & Shayani, R. A. (2022). Análise da precificação de carbono para geração de eletricidade a partir de termelétrica a gás natural e energia solar fotovoltaica: estudo de caso para escolas públicas do Distrito Federal. *X Encontro de Sustentabilidade em Projeto*, Marabá. Set. 2022. [https://repositorio.ufsc.br/bitstream/handle/123456789/238383/1%20\(2\).pdf?sequence=1](https://repositorio.ufsc.br/bitstream/handle/123456789/238383/1%20(2).pdf?sequence=1).
- Soares, T. O., Almeida, A. A., Morais, A. E. F., Sousa, M. C. B., & Leite, T. S. A. (2019). IMPACTOS AMBIENTAIS CAUSADOS PELO DESMATAMENTO: UMA REVISÃO SISTEMÁTICA DA LITERATURA. *Revista Saúde e Meio Ambiente*, v. 9(2), pp. 66-73. 2022. <https://desafioonline.ufms.br/index.php/sameamb/article/view/7675>.
- Souza, N. L. R., Ribeiro, A. Í., Medeiros, G. A., Martins, A. C. G., & Longo, R. M. (2020). Análise integrada dos aspectos e impactos ambientais da atividade operacional em parque eólico no sudoeste da Bahia/Brasil. *Revista Gestão & Sustentabilidade Ambiental*, 9(4), 40-63.