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Sustainability Challenges of Wind Power Deployment in Coastal Ceará State, Brazil

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Abstract: Sustainable and socially just decarbonization faces numerous challenges, owing to high land demands for wind farms and weak economic and political institutions. In Brazil, a leader in the Global South in terms of rapid installation of wind power capacity since the 2001 electricity crisis, firms have built wind farms near host communities that are politically and economically marginalized, giving rise to numerous forms of subtle contention and overt opposition. We aimed to better understand the licensing materials for wind farms and the content of the host communities' concerns about wind farms. We analyzed 18 "simplified" environmental impact reports, which created a legal path for wind farm construction, and conducted qualitative interviews in host communities in coastal Ceará state in northeastern Brazil. Our analysis reveals how firms appropriated and manipulated "crisis" in their environmental impact reports. Interviews with host community members reveal themes of ecological damage, fear, privatized land, employment, migrant workers and noise, in addition to evidence of active resistance to wind farms. These findings corroborate previous work on the overall nature of host community perceptions, add additional insight on the content of the licensing materials and expand the number of host communities analyzed for emerging sustainability challenges. More rigorous licensing procedures are needed to reduce corrupt practices, as well as the offering of avenues for community participation in the decision-making processes and eventual benefits of the wind farms.

Keywords: wind power; discourse; community; conflict; resources; crisis; Brazil

1. Introduction

Land demands for wind power are high owing to a low power density [1,2], creating major challenges for territorialization and landscapes dimensions [3–5] given the possible energy transition from fossil fuels to renewable power. The demand for land, when coupled with "green grabbing" processes that marginalize host communities and lead to forms of accumulation by dispossession [6], present significant challenges for sustainable and just decarbonization through renewable power generation [7–9].

Recently, wind energy science has been characterized as focusing on atmospheric dynamics, materials, and grid integration [10]. However, this approach ignores the social and institutional dimensions of wind energy science, such as social acceptance of renewable power [11–14]; place attachment [15–17]; employment and agglomeration economies [18]; institutional arrangements for rents, royalties and ownership [19]; justice principles; and the environmental impacts of wind farms. Here, we analyze the licensing documents for wind farms in the coastal region of Ceará state, Brazil, showing how firms

appropriated sustainability discourses in their paths towards implementation, and report qualitative data from host communities on the negative environmental and social impacts of wind farms. Previous work in Brazil has analyzed the environmental impacts of wind farms on coastal systems [20], problematic relationships between wind farms and fishing communities [21,22], corruption in licensing procedures [23] and, most recently, conflict negotiation in a coastal community in Rio Grande do Norte [24,25]. Collectively, this work has investigated some emerging conflicts owing to high land demands for wind farms in settings characterized by land-tenure insecurity, judicial dysfunctionality and extreme power imbalances between the local or regional elites and host communities.

The novel feature of this paper is the analysis of a large volume of licensing documents, beyond the single document analyzed in [23], with the use of a reproducible and theory-informed coding framework; moreover, we add to earlier work by reporting qualitative results from additional coastal communities near wind farms showing specific perceived impacts, adding both additional sites and qualitative depth to work previously reported in coastal Ceará [21,22] and coastal Rio Grande do Norte [24,25]. Recent ethnographic work in southern Mexico [8,26,27] describes a more violent and conflict-ridden assessment of the impact of wind farms compared to the situation we analyze here. Generalizations about host community responses to wind farms in the Global South are not yet possible, but the present paper offers additional insight regarding licensing procedures and specific challenges in host communities, with the aim of developing detailed and comprehensive knowledge to inform socially just decarbonization and climate change policies.

In the remainder of the paper, we first describe the conceptual framework for data collection and analysis. We combine “green grabbing” insights, which have recently been applied to critical studies of renewable power, with a critical reading of low-carbon pathways for meeting climate change goals. The Brazilian renewable power context is described next, emphasizing the policies that helped encourage wind farms (Section 1.2). Data sources and analytical approaches are described in Section 2, indicating how we coded ~4200 pages of Simplified Environmental Reports and conducted participatory research and qualitative interviews in host communities. Section 3 reports the main findings in two subsections, one focusing on the coding results, showing how the reports describe “crisis”, and the other synthesizing the interview results, using the words of the host community members to show the type of problem that people have experienced. Section 4 situates the findings within a critical appraisal of climate change and low-carbon energy pathways. Conclusions, including study limitations, are offered in Section 5.

1.1. Conceptual Framework

Our research is informed by critical perspectives on renewable power aiming to identify socially just decarbonization pathways. The “green grabbing” literature offers a complementary approach as it aims to illuminate the economic and political processes by which elites appropriate land for environmental purposes as a form of primitive accumulation [6]. Recent applications of “green grabbing” to renewable energy include important work in India on large-scale land acquisitions for solar photovoltaic (PV) installations, which not only strip access rights long held by villagers but also create a precarious workforce [28]. Several scholars have described “green grabbing” processes in the Tehuantepec region of Mexico, where elites have secured access to land highly desired by wind firms and the Mexican state, which devised particular institutions that favored transnational corporations to operate in the electricity market and negotiate directly with host communities with minimal state oversight [8,26,27]. In Greece, “green grabbing” processes include close linkages with the financial crisis and institutional reforms that allowed transfer of land [29]. McCarthy and Thatcher [30] analyzed the mapping of wind resources, funded by the World Bank and other financial institutions, aimed at finding suitable locations in the Global South for global investors [30]. We add to this body of work by focusing on one key dimension of “green grabbing”—the processes by which “crisis” is produced as justification for land appropriation through analysis of licensing documents.

A second and compatible literature informing our work is built upon critical perspectives of renewable power in pursuit of climate change goals, which reveal the discursive elements upon which “green grabbing” relies. A foundational premise of this critical perspective is that effective policies to combat climate change must be offered for a “treatable” and politically “administrable” problem [31]. The transformation of climatic evidence into a political objective allowed the expected environmental benefits to be associated simultaneously with economic benefits, providing the “economic incentives” necessary for the energy companies to change their practices. Consensus on the concept of “clean energy” is an important element of this process. This concept has been evoked within the scope of the climate negotiations, based on the reports of the Intergovernmental Panel on Climate Change (IPCC) by referring a reductionist manner only to the sources of energy that do not generate greenhouse gases, such as wind, solar, hydroelectric and nuclear power [32–34]. This concept includes a moral dimension, given that “clean” energy is considered to be a “good”, “better” or “adequate” alternative, irrespective of its uses and social contexts, in contrast with “dirty” energy, which is considered to be “bad”, “worse” or “inadequate”.

In Acselrad’s view, different social actors define the climate problem in different ways, based on the reasoning and practices derived from a given paradigm, through the creation of new concepts filled with meanings and intentionalities that become dominant in the public sphere [31]. Furtado believes that the dominant argument supports the reductionism of the climate problem by “denying, appropriating, and transforming the more structural perspectives on climate change to promote reductionist actions”, restricting more general environmental problems to the perspective of climate change and carbon emissions, while ignoring social and environmental inequalities and questions related to the access of different groups to natural resources, in addition to limiting the potential for the construction of a new society that is no longer dependent on fossil fuels [35] (p. 306). Based on this premise, “clean” energy has expanded in Brazil through “greenhouse effect blackmail” [31], which justifies the growth of the different types of clean energy through the threat of the alternative scenario—new sources of fossil energy would otherwise be needed to satisfy demand. The installation of sources of so-called clean energy is inserted into the public debate as the “lesser evil” or a “necessary evil”; that is, the best option among a limited set of alternatives.

In this interpretation, the Brazilian state re-frames the “blackmail” issues by exploiting the logic of “infernal” or “diabolical alternatives” using mechanisms such as relaxing environmental legislation, which we discuss below, and issuing public declarations that refer to a range of options or alternatives that are all invariably inferior [36]. This discursive performance suggests that one source of energy has been substituted by another in the national grid through the exhaustive search for solutions and alternatives that are fair, technically adequate and, above all, democratic. Discursively, then, the Brazilian state constructed wind power as superior to other competing “solutions” to a climate change debate with a narrow set of possible solutions. The application of the adjective “clean” to wind power refers only to the lack of greenhouse gas emissions, while ignoring the broader social and environmental parameters. Different versions of this critical view of decarbonization appears in other studies, such as the recent analysis of decarbonization efforts according to macro-, meso- and micro-scale injustices [9].

1.2. Brazilian Wind Power Context

Brazilian public policy has played a decisive role in the expansion and consolidation of wind power in the Brazilian national grid, through incentives and financing that have created a market sector that is attractive to new investments. In particular, the Brazilian Program of Incentives for Alternative Sources of Electrical Energy (PROINFA) has contributed to the creation of 53 wind farms in the country since 2014, as reported by the Brazil wind energy trade group [37] and scholars analyzing the incentives [38] and technical–institutional dimensions of wind power [39–41]. In the specific case of Ceará, similar incentives were established by a decree creating the Program for the Development of the Productive Chain of Wind Power Production (PROEÓLICA). This program guarantees the allocation

of 75% of the value of the state value-added tax to the businesses that intend to participate in the wind power sector [42].

One of the arguments used to support the inclusion of wind power in the Brazilian national grid is the country's voluntary aim of adhering to the target of the United Nation Paris Conference on Climate Change (COP 21); that is, a reduction of 36.1–38.9% in total greenhouse gas emissions by 2020. Nevertheless, the Brazilian Panel on Climate Change [43] reported that, in 2012, the principal source of greenhouse gas emissions in Brazil was not the production and use of electrical energy, but rather, the deforestation occurring on the country's agricultural frontiers, in particular in the Amazon region, which was responsible for 61% of the country's emissions, followed by agriculture, with 19%, and the energy sector, with 15%.

These institutional reforms have permitted the accelerated expansion of the wind power sector in recent years, in particular, from 2010 onward. The restructuring of the energy sector and the new auctions of energy concessions organized by Brazil's National Electricity Agency (Agência Nacional de Energia Elétrica, ANEEL), which has become the most important mechanism for the establishment of energy concessions in Brazil, also contributed not only to the growth of the sector, but also to its increasing competitiveness in relation to other sources of energy [38,40,41]. By 2014, wind power was already the second cheapest option at auction, behind only hydroelectric power. As of January 2019, auctions (for new, reserve and alternative power) accounted for 15.5 GW (609 wind farms), PROINFA supported 1.3 GW (52 projects) and free-market protocols covered 2.6 GW (106 projects) of the wind capacity [44,45]. Overall, these reforms encouraged investments resulting in a dramatic increase in the installed capacity of wind power in Brazil, from 29 MW in 2005 to nearly 16,000 MW, or 9% of the total capacity, in 2020. (Table 1).

Table 1. Installed capacity (MW) of Brazilian electricity generation ¹.

Generation Type	2000	2005	2010	2015	2020
Hydropower	61,063	71,060	80,703	91,650	111,312
Thermal	10,623	19,770	29,689	39,563	42,958
Nuclear	1966	2007	2007	1990	1990
Wind	19	29	927	7633	15,705
Solar	0	0	1	21	2927
Total	73,671	92,866	113,327	140,858	174,892

¹ Includes self-producers, independent producers and public service producers of electricity. Data for 2000–2015 obtained from [46]. Data for 2020 obtained from [47]. Brazil's electricity grid is interconnected; therefore, wind power generated in Ceará could be consumed internally or sent out of the state [48].

Another important institutional reform occurred in 2014, when the Brazilian National Environment Council (CONAMA) published a resolution that defined the specific norms that govern the procedures for the environmental licensing of land-based wind power projects. The resolution defines these projects as having a “low polluting potential” and providing an important contribution to “a cleaner national power grid” [49], used to justify the simplification of the environmental licensing of wind farms. In this case, only a Simplified Environmental Report (Relatório Ambiental Simplificado (RAS)), is required, without the need for a Study of Environmental Impact (EIA) or its respective Environmental Impact Report (RIMA), except in some specific cases, including locations in dune formations, mangroves and the coastal zone [49]. In Ceará, the state's environmental council required complete environmental impact reporting in 2018 for wind farms planned in sensitive areas, including dune and beach systems and mangrove systems; however, there are still numerous pathways for wind farm developers to build wind farms on sensitive coastal systems.

Our study focuses on the Ceará state, Brazil, where nearly 70% of installed wind capacity has been located within 5 km of the shoreline [50], as well as near or on dune fields and mangrove ecosystems [20]. Wind farms in Ceará are located primarily on the Atlantic coast; that is, on the coastal plain and coastal tablelands (*tabuleiros*), located either partially or completely within areas

of permanent preservation (APPs), including fixed or mobile dunes, estuaries and mangrove forest, as well as areas of wind diffusion and seasonal interdune lagoons [20] (Figure 1a,b). The implantation of wind farms in the coastal zone has significantly altered the ecological and morphological characteristics of these ecosystems [20,22,23]. The installation of a wind farm results in the following alterations to the environmental systems that are earmarked for common use by the local communities: (i) the removal of large amounts of sand, which results in deforestation and the burying of fixed dunes; (ii) the suppression of habitats and the fragmentation of the local ecosystems; (iii) excavation and landfills in fixed and mobile dunes; (iv) the artificial fixation of mobile dunes; (v) the impermeabilization and compacting of dunes; and (vi) the burial and fragmentation of interdune lagoons [20]. These impacts resulted from the construction of the access roads necessary for the installation of the foundations of the wind turbines, the preparation of land for the construction site, the implantation of the service roads that link the turbine towers, and the installation of the subterranean conduits for the electric cables (Figure 2c).



Figure 1. Location of the wind farms and host communities in (a) Amontada and (b) Aracati, both in the Ceará state, Brazil.



Figure 2. Examples of contested interactions between the wind farms and host communities in the coastal Ceará state, Brazil: (a) roads interfering with an interdune lagoon; (b) heavy truck traffic for wind farm construction through a host community; (c) warning signs in wind farms near host communities.

2. Materials and Methods

We analyzed the text of 18 Simplified Environmental Reports (Relatório Ambiental Simplificado (RAS)) held in the library of the Ceará State Superintendency for the Environment (Superintendência Estadual do Meio Ambiente do Ceará, SEMACE) following rigorous qualitative procedures. We decided to analyze RAS because until January 2020, when SEMACE published licensing materials and conditional requirements, they were the only textual material available to researchers studying the licensing process for wind farms. These RAS have not been held to analytical scrutiny on this scale, although preliminary work [23] indicated the need to analyze several RAS in the same analytical

framework. We have opted to not disclose the names of the individual wind farms, nor the firms that authored the RAS, because of possible legal exposure of the author team to the consultancies and investors involved. The RAS were used for SEMACE's evaluation of the environmental viability of wind farms in Ceará. However, not all wind farms represented by these RAS were constructed owing to various reasons. For example, interested parties withdrew interest, the project changed locations or the projects were not submitted to the energy auctions. We deployed the ATLAS.ti qualitative software functions of autocoding with confirmed matches using codes (Table 2) to ~4200 digitized pages of RAS. This function allowed us to identify words that matched our search terms (Table 3) but also required us to "confirm" the match. We discarded hundreds of apparent matches that did not meet the definition of the intended code. For example, we used the "instability" code to seek mentions of instability of the Brazilian electricity grid. ATLAS.ti found many references to "instability" that were outside of the electricity context; therefore, we did not confirm these mentions.

Table 2. Summary of the Simplified Environmental Reports (RAS) analyzed in this study.

RAS No. (Year) ¹	Municipality	MW Capacity	No. Turbines	Environmental Context ²	Status
1 (2013)	Acaraú	24.0	12	<i>Tabuleiro</i>	License obtained; not constructed
2 (2014)	Itarema	29.7	11	Mobile dunes	License obtained; not constructed
3 (2014)	Itarema	29.7	11	<i>Tabuleiro</i>	License obtained; not constructed
4 (2008)	Paraipaba	12.6	6	<i>Tabuleiro</i>	License obtained; not constructed
5 (2002)	Acaraú	28.8	32	Beach and dunes	Operational (13 turbines)
6 (2002)	S.G. do Amarante	13.5	15	Mobile dunes	No license obtained; not constructed
7 (2003)	Acarati	3.3	18	Mobile dunes	Operational (2 turbines)
8 (2014)	Acaraú	16.8	8	<i>Tabuleiro</i>	License obtained; not constructed
9 (2014)	Acaraú	18.9	9	<i>Tabuleiro</i>	License obtained; not constructed
10 (2014)	Acaraú	23.1	11	<i>Tabuleiro</i>	License obtained; not constructed
11 (2014)	Acaraú	18.9	9	<i>Tabuleiro</i>	License obtained; not constructed
12 (2014)	Acaraú	23.1	11	<i>Tabuleiro</i>	License obtained; not constructed
13 (2014)	Itarema	29.7	11	<i>Tabuleiro</i> and floodplain	License obtained; not constructed
14 (2002)	Camocim	105.5	50	Mobile dunes	Operational (48 turbines)
15 (2008)	Aracati	31.5	15	Mobile dunes	Operational
16 (2008)	Aracati	45.6	24	Mobile dunes	Operational
17 (2003)	Aracati	57.0	57	Mobile dunes	License obtained; not constructed
18 (2008)	Aracati	57.0	57	Mobile dunes	Operational (28 turbines)

¹ RAS No. (Column 1) refers to our number system for the RAS materials. ² *Tabuleiro* is translated as coastal tableland.

Table 3. Codes used in analysis of RAS materials for the “crisis” aspect of green grabbing.

“Crisis” Theme	Codes Used	Number of Mentions	Number of RAS
Electrical or energy crisis, rationing, and self-sufficiency	Crisis; Rationing; Self-sufficiency; Independence	47	14
Alternative, clean, and sustainable energy responding to environmental and energy crises	Alternative; Complementary; Clean; Sustainable Emissions	421	18
National grid instability and reliability	Instability; Reliability	64	18
Reduction in hydropower	Hydropower; Water	69	13
Government alternative during crisis	PROINFA ¹ ; Incentive; Expansion	71	13

¹ PROINFA is the 2002 Brazilian Program of Incentives for Alternative Sources of Electrical Energy (Programa de Incentivo às Fontes Alternativas de Energia Elétrica).

After confirming text that belonged in the category of “crisis”, these sections were included in the ATLAS.ti project, where they were separated from other “green grabbing” codes we deployed but do not report here. We noted total mentions and page numbers so we could return to the original materials for checking.

RAS are highly relevant to wind power deployment because they represent a key part of the licensing phase for wind farms in Ceará, which was an early leader in Brazil’s wind power deployment. RAS created a legal path for wind farm construction. The legal basis for RAS appeared in 2002, when the federal government created PROINFA, as discussed above. The fact that wind farms were constructed based on the RAS established precedent and showed the economic and political viability of wind farms in coastal Brazil.

Fieldwork was conducted during 2013 and 2014 within the area influenced directly by the wind farms to verify the alterations of the landscape and the way-of-life of the host communities. Based on the configuration of the geo-environmental processes that govern the fluxes of energy and material within the highly fragile coastal systems [51], 25 representatives of the host community were interviewed directly and about 60 other representatives were interviewed indirectly through observation and participation in seminars to determine the degree of intervention of wind farm projects in the ancestral territories that play a fundamental role in local food and water sovereignty. We participated in events in the communities and applied semi-structured interviews to understand the meanings that the local populations attributed to the installation of wind farms in their territories and the effects on their lives.

Semi-structured interviews were conducted with the aid of a portable voice recorder (with consent of each informant) and a field diary for additional information. We conducted interviews with guiding questions (“What do you think of the wind farm in your territory?”; “What are the positive impacts?”; and “What are the negative impacts?”). During the interview, we asked other questions following up on the particular responses offered by the respondents, following normal procedures described by Longhurst [52]. Representatives from the communities were interviewed in the following cities: Aracati (Cumbe), Acaraú (Curral Velho), Amontada (Sabiaguaba settlement and Moitas) and Itapipoca (Maceió Settlement, São José e Buriti Indigenous Land, Pau D’Arco, Zé do Lago and Lagoa das Mercês) (Table 4). We did not select sites for fieldwork based on locations represented by Simplified Environmental Reports (Table 2); rather, selection of the host community sites was purposive, based on previous relationships of trust between community leaders and the author team. Fieldwork was conducted in an ethical manner consistent with the standards of informed consent and respect for individuals, although formal authorization was not required at the time of field work by the institution of the first author.

Table 4. Summary and characteristics of sites visited for the semi-structured interviews.

Community	No. Direct Interviews	City	Wind Farm Year, MW Capacity
Cumbe	2	Aracati	2010, 50 MW
Curral Velho	3	Acarauá	2010, 70.8 MW
Sabiaguaba Settlement	3	Amontada	2009, 54.6 MW
Moitas	3	Amontada	2009, 54.6 MW
Maceió Settlement	8	Itapipoca	2014, 116 MW ¹
São José and Buriti indigenous land	1	Itapipoca	2014, 116 MW
Pau D'Arco	1	Itapipoca	2014, 116 MW
Zé do Lago	2	Itapipoca	2014, 116 MW
Lagoa das Mercês	2	Itapipoca	2014, 116 MW

¹ Licensed with RAS but full environmental impact statement and report were required before construction.

3. Results

3.1. Green Grabbing in Environmental Impact Reports: Creation and Solution of “Crisis”

Our analysis of RAS materials indicates numerous ways in which authors created justifications for wind farms based on a “crisis” discourse developed through claims about electricity supply, global climate change and local sustainability benefits. The analysis shows how RAS authors appropriated the state discourse and incorporated “crisis” in numerous ways to justify particular wind farms. RAS authors justified wind farms as alternatives to electricity and environmental crises with arguments emphasizing clean, sustainable and alternative power.

One major discursive thread was the idea that wind power would help surmount Brazil’s electricity crisis by avoiding electricity brownouts and rationing. This discourse tapped a highly politicized and polemic issue because of Brazil’s electricity crisis [40,41,53], which began in 2000 and culminated in blackouts in May 2001, with the lingering threat of new supply crises and electricity rationing through February 2002 mandated by the national government. The RAS texts analyzed indicate that authors used the 2001 Brazilian electricity crisis to justify wind farms. RAS authors noted that wind farms would help Ceará state face the nationwide crisis and made dubious claims that wind farms would make Ceará self-sufficient in electricity, and therefore reduce dependency on the national grid. The idea of crisis was emphasized to demonstrate the importance of the wind farm as contributing to solving the electricity crisis and ameliorating the possible negative social and economic consequences of the electricity crisis.

RAS authors reminded readers that, in 2002, Brazil’s federal government had committed to incentivize alternative electricity sources through PROINFA and “diversify energy supply and guarantee electricity for economic development and environmental protection” (RAS 2, 3, 8, 9, 10, 11, 12 and 13). For example, RAS authors noted that wind farms would “allow Ceará state to survive energy crises that sometimes affect Brazil without facing large economic and social costs” (RAS 4, 5, 6, 8, 9, 10, 11, 12 and 14). Other RAS authors argued that wind farms “would be of fundamental importance” to facing the “great electricity crisis that has damaged some Brazilian regions, particularly the northeast” (RAS 4, 5, 9, 10, 11, 12 and 14). For another RAS, the “viability” of the wind farm was “perfectly justified by the lack of electricity supply in Ceará and Brazil and the risk of electricity rationing” (RAS 1). In four RAS, the authors argued that the wind farms were essential given that “electricity rationing has harmed not only the people, but also industry and irrigated agriculture” (RAS 15, 16, 17 and 18).

RAS authors played on the dubious claim that wind farms would help Ceará’s electricity self-sufficiency and reduce imports and dependency on electricity produced in other states. For example, some authors argued that Ceará’s “local energy distribution” suffered diminished “quality and quantity, which destabilized productive sectors and reduced quality of life for the population” (RAS 1, 4, 5, 7, 8, 9, 10, 11 and 12). Authors also argued that the particular wind farm they analyzed would “help

reach the goal of self-sufficiency” in terms of electricity generation (RAS 4 and 7) and “independence” in electricity production (RAS 14), and would “incentivize technological and energy development in Ceará” (RAS 1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13 and 14). Another group of authors argued for wind farms by blaming Ceará’s allegedly high dependency on hydropower as a cause for “destabilization of productive sectors and reduction in quality of life”, suggesting, therefore, that wind farms could restore stability to the state’s electricity supply with positive impacts on the lives of its citizens.

These are highly suspect claims, not least because of Brazil’s national and interconnected electricity grid [40,41]. “Imports” and “exports” between states happen automatically and instantly. The idea that Ceará could choose between hydropower and wind power is also a false choice because the state lacks hydrological features for any substantive power generation. Finally, the idea that one particular wind farm could offer a meaning contribution to the state’s electricity supply, and by extension improve the lives of the state’s residents, is highly suspect.

Another element of the “crisis” discourse was to situate wind farms as an alternative to hydropower investments. RAS authors argued that Ceará had highly unstable hydropower supply, making wind power investments essential for the state to cope with the fluctuating nature of hydropower. Authors seized on the emerging consensus that wind farms were complementary to hydropower seasonality. For example, RAS authors argued that wind farms could supply power “during periods of low capacity among hydropower units” (RAS 2, 3, 4, 8, 9, 10, 11, 12 and 13) and that it was normal, in terms of the “current global context”, for governments to “seek clean energy production through alternative and complementary sources that offer minimal impact on the environment” (RAS 8, 9, 10, 11 and 12). RAS authors offered a technical basis for these claims by highlighting the “magnificent coincidence” that that wind quality increases during the same period that stream runoff declines (RAS 4 and 7). Unlike the dubious claims regarding Ceará’s self-sufficiency in power production through wind, the claim of wind and hydropower complementarity in northeast Brazil has been confirmed [54].

A second major discourse identified in our analysis of RAS texts was justification of wind farms through the global environmental frames of sustainability, climate change and avoiding the emissions of greenhouse gases. This discourse used wind power as the only solution to deal with the electricity and environmental crises, arguing that wind farms were the best alternative, clean and sustainable electricity solution. A common argument was to reinforce how “in today’s global context, environmental concerns are present in all realms” and “alternatives to fossil fuels” are sought by all governments seeking to “minimize impacts on the environment” (RAS 2, 3, 8, 9, 10, 11, 12 and 13). One RAS argued that a wind farm would offer “essential increase in present and future electricity supply” to the northeast region “without aggression to the environment” (RAS 1). A commonly used claim among RAS authors was that wind power produced “clean” electricity that “directly and indirectly helped Ceará’s sustainable development” (RAS 2, 3 and 13), and that wind farms produced renewable power “without consuming natural resources and without producing pollutants” (RAS 2, 3, 8, 9, 10, 11, 12 and 13) and without producing “atmospheric emissions or waste” (RAS 2, 3 and 13). For some authors, wind farms produce “clean energy because they do not generate solid or gaseous waste because the wind stream enters and leaves [the wind farm] with the same qualitative and quantitative characteristics” (RAS 2, 3, 8, 9, 10, 11, 12, 13 and 14).

RAS authors were not so optimistic that they denied negative environmental impacts. One RAS argued that its wind farm would be “an environmentally correct or ‘clean’ project” that would nevertheless have modest negative impacts (RAS 1), while others argued that wind farms were “clean” and with “low potential for negative impacts” that nevertheless required “compensation and/or attenuation” of “anthropogenic interventions” (RAS 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13 and 14).

Several RAS presented the same “alternative” energy comparative table (Table 5) that highlighted the apparent advantages of wind power relative to other renewable sources (RAS 2, 3, 4, 7, 8, 9, 10, 11, 12, 13 and 17) without mention of power density (MW per unit area) [1,2], and offering very low figures for photovoltaic systems, therefore indicating the inevitability of wind farms as a “sustainable” solution to Brazil’s energy crisis. The particular context of Ceará was also important, as the RAS authors

argued that Ceará did not have the ability to generate hydropower owing to its semi-arid climate, so “investment in alternative energy tapping natural conditions is essential, especially wind and solar” (RAS 2, 3, 7, 8, 9, 10, 11, 12 and 13).

Table 5. Summary of comparative table for “alternative energy” used in RAS for Ceará wind farms ¹.

Criterion or Variable	Solar Thermal	Photovoltaic	Wind	Biomass
State of Technology	Very few commercial	Some commercial	Many commercial	Many commercial
Power (MW)	Variable	0.1–1	100–750	<100
Efficiency (%)	15–17	9–12	20–30	15–50
Initial Investment	High	Very high	Medium	Low medium
Energy Cost for Construction	Medium	High	Low medium	Low
Energy Cost for Operation	Minimal	Minimal	Minimal	Medium
Operational Time (hours)	Variable	800–1900	1000–3000	4000–7000

¹ This table was reproduced in RAS 2, 3, 4, 7, 8, 9, 10, 11, 12, 13 and 17.

Climate change also figured into the discourse on the economic viability of the proposed wind farms. Nearly all RAS authors argued, verbatim, that it was “undeniable” that wind farms were highly competitive because of cost reductions and “simple and rapid installation that permits the participation of a new and wide set of investors in electricity production”, who were attracted to wind because of “environmental cleanliness, without future economic risks, generating benefits that were commensurate with global efforts to stabilize global atmospheric warming” (RAS 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12 and 13).

A third discourse on the “crisis” theme focused on justification of wind farms through positive local sustainability impacts. RAS authors framed this discourse somewhat differently in arguing that wind farms offered the ability to increase the value of sites through “employment and worker training, creating the opportunity to promote regional development in a sustainable manner.” “Sustainability” figured, in this case, in increasing the quality of life among people “benefited by clean power”, “contributing to the sustainable use of natural resources” in a regional planning context and “conserving nature and biodiversity” (RAS 2, 3 and 13). RAS authors emphasized wind power as not only clean and alternative, but also as a means to strengthen economic and social activity in surrounding areas. Several RAS argued, verbatim, that “the production of alternative power from a clean and safe source, available to the region, will result in continued economic and social development” (RAS 2, 3, 4, 7, 8, 9, 10, 11, 12, 13 and 14). Tourism was also highlighted in the RAS for a 57 MW wind farm, which was described as “fundamental in producing energy in renewable and non-polluting way, using state-of-art technology, that make possible the attraction of new large investments in isolated areas of the [Ceará] coastline where ecological tourism could be established” (RAS 17). The wind farm would “generate electricity from one of the world’s cleanest sources, contribute to ecological tourism, and to Ceará’s sustainable social-economic development” (RAS 17). Another RAS argued that the wind farm “allowed for other productive activities in parallel with power generation and maintenance of large areas of preserved vegetation in addition to ‘clean’ energy production” (RAS 7). For other RAS authors, the wind farm would be an “alternative and clean” means to stimulate economic activities while avoiding emission of effluent into the environment (RAS 6, 7, 8, 9, 10, 11 and 12).

3.2. Host Community Responses to Wind Farms

Analysis of semi-structured interviews in host communities revealed six major themes. First, the ecological functions impacted by wind farms include alterations of the availability of freshwater in the water table, which is one of the principal preoccupations of the local populations. The local residents reported that, previously, even during periods of prolonged drought, the levels of the water available for human consumption have never been as low as they have been in recent years. One resident in the municipality of Amontada expressed concerns derived from the suspicion that this process has

been aggravated by the installation of wind farms in the region: “Our water comes from Cavalos lagoon, and it is brackish, it was diverted to the sea. It never dried up before, but it is drying up now. We believe that this is the result of the impact of the enormous foundations of the wind towers on the water table” (interview, female farmer, 50 years old, from the municipality of Amontada, 2 May 2014).

The wind farms have not only had an impact on the dune fields and interdune lagoons, but the construction of access roads, along which heavy machinery and other vehicles pass, have also had undesired effects on the local traditional populations and indigenous groups [55]. The traffic on these roads results in clouds of sand and dust that are blown by the wind into residential areas and public schools, where they have permanent effects, in particular by provoking respiratory diseases (Figure 1b).

Another theme raised by residents of the host communities is the establishment of what they refer to as a “territory of fear” through the installation of signs that indicate the “risk of death” and “escape routes” (Figure 1c) within the limits of the wind farms themselves and in the surrounding area. The environmental licensing requires the installation of warning signs at locations where high tension electric cables are buried under the dunes. However, cables were clearly visible in many places, including areas with access trails and in common areas, as well as in the dunes, lagoons, plantations and fishing grounds. One resident of Aracati stated that “they built the wind turbines where a spring feeds into the lagoons. The wind farm administrators tell us that, if we bathe in the lagoon, we could be electrocuted” (interview, 45-year-old fisher from the Cumbe quilombo community, on 25 October 2013). It was also possible to verify that natural dune movements have led to the exposure of the cables, which has also increased the risk of accidents.

Third, residents of host communities referred to “privatization of the land” as a result of the wind farms. This process has been established and enforced through the frequent use of armed security, watchtowers and the installation of fences and gates in areas that were previously part of the common space of the population. Most of the wind farms are located on land rented from local elites by the operator [22], and is thus private property, although the infrastructure constructed in the area, such as the access roads, and many of the fences and gates, are not limited to these properties. Fourth, interviews in host communities revealed how wind farms manipulated the promise of job creation, which is one of the arguments most used by the wind power companies to legitimize their projects. While local jobs are created during the construction of the installations, this involves temporary employment, which typically lasts approximately six months. During the operational phase, the number of jobs is greatly reduced, with only 10 employees being required for maintenance and security, as reported by an employee of a wind farm in Amontada. In neighboring Rio Grande do Norte state, Dantas and co-authors identified similar challenges for local employment in wind farms [25] and Frate and co-authors found that employment was highly contested among supporters and opponents of wind farms [24].

A fifth theme identified was the influx of migrant workers during the installation phase and the impacts of this process. This scenario is typical of wind power projects and other major energy, mining and infrastructure schemes, where the number of jobs during the initial phase is much greater than that available during the subsequent steps. Generally, the local workforce is unable to satisfy the initial demand for employees, which attracts the interest of workers from other regions of the country. These employees are lodged near the construction site, in areas adjacent to the local communities, and once the initial installation phase has ended, most of the migrants return to their homes, although a number do often set up residence in the region [56].

The reports of the local residents indicate that wind farm construction has overstretched public services, such as health, education and security, which are outdated and are unable to adapt to the growing demand. This process has also aggravated social problems in the communities, such as illicit drug use in young people and an increase in sexual exploitation, violence against women and unwanted adolescent pregnancies, as previous work has suggested [23]. One resident in Aracati declared “Can you imagine a community of 600 people dealing with an influx of 1500 visitors? The outside workers arrive here and have a big impression on the young girls. They have sexual relations . . . some of the

girls that get pregnant don't even know who the father of the child is, due to the constant turnover of the workforce" (interview, 45-year-old fisher from the Cumbe quilombo community, on 25 October 2013). The children resulting from the relationships between local women and the company employees are referred to as "children of the wind" by the residents of the fisher communities, alluding to both the type of project and the fact that the temporary workers return to their home towns "like the wind", without taking responsibility for the pregnancies. This theme even became the subject of a play presented by the Sementes da Arte ("Seeds of the Art") theatre group, in 2012, at the Nazaré Flor State Middle School in Itapipoca. One of the six students that established the group explained that the choice of the theme of the wind farms was due to its importance in the community, given that it was the topic that is most commented on locally, but it was also something that people knew little about. The first play focused on the theme of undesired pregnancies, a prominent byproduct of the wind farms, based on the experiences of the neighboring communities. In the opinion of this student, undesired pregnancies were the most prominent of the many impacts both reported by local residents and also observed by the students, given that "many of the girls from the other communities got pregnant, and some of them were my friends" (interview, 16-year-old student, resident of the Maceió settlement in Itapipoca, 5 March 2015).

Noise produced by the turbines in Amontada and Cumbe was a sixth theme that emerged from interviews in host communities. The residents report that the "noise is unending" and is similar to a "helicopter that never lands". At some sites, such as Amontada, the towers are less than 100 m away from the nearest houses, with obvious consequences. In Aracati, the towers are close to the houses too, as reported by an interviewed resident: "some residents are complaining about the noise coming from the wind towers, which is very disturbing, given their proximity to our houses" (interview, 35-year-old cockler from the Cumbe quilombo community, 2 May 2014).

Host communities have not accepted the issues arising from wind power without resistance. Residents of host communities are not simply passive victims of the process of wind power imposition; rather, they participate actively on the unequal stage of power, where political strategies and debate against the hegemony of the state have been implemented permanently to guarantee the affirmation of the community's way-of-life, its lands, as well as access to the material and symbolic conditions necessary for the reproduction of its traditional practices [57,58].

Fieldwork revealed a general strategy adopted by the companies to occupy the lands of the traditional communities and ethnic groups. The companies often allege that the wind farms were installed on "empty land", on which little or no social or cultural activity takes place, while the local "disadvantaged" populations will benefit from the development that the projects can provide to allow the community to overcome its "outdated" conditions. Although these communities are, in fact, characterized by a lack of social policies, this does not reflect any kind of "outdated" condition, but rather, the historic condition of having been made vulnerable [59] by the state.

In this context, a number of strategies have been shown to be relevant to the deconstruction of the "empty land" myth. These strategies include community-based tourism, seminars, the traditional regattas and the creation of resistance camps. One of these camps, the "Nossa Terra" (Our Land) camp in Itapipoca, which has been in existence for seven years, was created by residents of the rural settlement as a means of defending their ancestral lands from conflicts involving real estate speculation.

Residents of host communities reported a set of other strategies that are used to potentialize their direct action and their challenges to the companies. One of these actions was the road block established by a community in Aracati in 2009 (see Figure 1) to impede the passage of trucks transporting heavy machinery to the wind farms located on the land of a local community of fishers and cocklers (Figure 2b), described previously by Brown [21]. One of the most important of these direct actions is the self-monitoring of the environmental systems by the populations affected by the wind farms. Faced with the threat of the implantation of a wind farm and complaints of alterations in the hydrostatic dynamics of lagoons in other localities, the residents of a community in Amontada mobilized themselves

and established the continuous monitoring of their water resources, with the aim of impeding the inadequate exploitation of these resources by the wind power companies.

Host community residents also highlighted the importance of strategies that involved the articulation of partnerships with university researchers, social movements and other entities. In addition to the strategies mentioned above, observations conducted during the fieldwork revealed at least 14 other types of activity that involve interchanges among coastal zone communities, at the local, national and even international levels. These activities consist of the exchange of information and experiences between individuals that reside in the vicinity of wind farms, in situations of conflict, as well as those that reside in localities where the installation of wind farms is still at the planning stage.

4. Discussion

The term “clean energy” encompasses processes of power generation which, while reducing the emission of greenhouse gases, have provoked a series of socio-environmental conflicts, including those described in the present study. The territorial implications of these so-called clean energy options are routinely overlooked when they are classified as such in the public sphere. The clean energy label clearly does not embrace the economic, political and cultural dimensions, the unequal power relationships, nor the inequalities of the access to and use of natural resources.

We found that the discursive creation of a “crisis” shows evidence of “green grabbing” characteristics in the environmental licensing documents that provided the legal basis for the approval of the wind farms in the coastal Ceará state. Exaggerated claims regarding the “sustainability” of wind farms were common in RAS documents, which established precedent for procedures to implement wind farms in Brazil. Residents of host communities reported several themes, evidencing dissatisfaction with the wind farms. These concerns ranged from noise to the workforce influx and damage to environmental services that support livelihoods. Qualitative interviews revealed not only expropriations, but also social resistance and collective struggle. These social groups were not passive victims of the process, but participate actively on the unequal stage of power, adopting different strategies, actions and practices in an attempt to guarantee the persistence of their traditional way-of-life, their lands, as well as the material and symbolic conditions necessary for the reproduction of their traditional practices [57].

The rapid growth of the wind power sector, together with public investment, “clean energy” publicity campaigns and the superficial RAS licensing processes, have contributed to the consolidation of socio-environmental conflicts and the articulation of the communities affected by the wind farms [60]. In recent years, the “legitimacy” of this source of energy has been questioned increasingly by the social groups that occupy the land adjacent to the wind farms, especially in the Tehuantepec isthmus of southern Mexico [8,26,27].

Agents of the Brazilian state and the entrepreneurial sector have prioritized the application of the concept of “clean energy” in institutional climate negotiations and in licensing documents to legitimize the implementation of new wind power projects in the Brazilian state of Ceará, exploiting the idea of the “infernal alternative” [36] or “greenhouse effect blackmail” [31] in their approaches. The use of these arguments determines the acceptance by the public of these new and so-called clean projects as the only possible alternative for the avoidance of the need for the addition of projects powered by the so-called dirty energy sources.

However, there is a clear contradiction between this justification and the results of the political actions of the agents, given that both types of energy have been implemented permanently, through an approach that can be denominated the “hell with no alternatives” and the adoption of more than one option, which is invariably bad. The incorporation of wind power in Brazil has occurred as a complement to non-renewable sources of energy (Table 1), rather than as a substitute, as both the agents and the companies involved in the process have argued.

Numerous approaches and metrics may be used to evaluate sustainability owing to the multiple dimensions of sustainability [61]; here, we prioritized the discursive use of sustainability terms

deployed in the RAS texts as defined through the “green grabbing” literature. This reflects a partial understanding of sustainability, which could be approached for wind farms through other means. RAS texts, owing to their status as “simplified” reports, are insufficient to evaluate the full suite of environmental impact of wind farms. More complete environmental analysis is needed, perhaps using full environmental impact reports, if required by state authorities, although it is possible that “green grabbing” concepts will permeate those reports as they do the RAS. More broadly, it is possible that more rigorous environmental analysis at the licensing stage could improve the sustainability outcomes for the wind farms, especially in cases of land-tenure insecurity in dynamic coastal systems, as Gorayeb and others have argued [23], and if justice principles [9,24] are included in the review and approval process.

We also emphasize that we are not suggesting that the pre-wind farm situation was somehow superior to the present, nor are we offering specific suggestions for resolution of the presentation situation; this is because we have only begun a diagnosis of the situation through study of the justification of the wind farm construction (through analysis of RAS texts) and some social-environmental outcomes (through analysis of interviews), which suggest sustainability challenges that should be addressed in future wind farm expansion in Brazil and elsewhere in the Global South. Attention to the concerns of the host communities, a well-established research area [11,16,17], must be added to notions of wind power science’s “grand challenges” [10].

Overall, then, the findings of the present study indicate the need to question how low-carbon energy should be produced, through the incorporation of a set of values and interests that go beyond the strictly technical perspective of the process, to guarantee fair and democratic processes for the production of energy. However, this alone will not be sufficient, given that the energy question cannot be resolved in terms of the best technique but rather involves a wider discussion of the prevailing model of development and the characteristics of the power grid. There is also clearly an urgent need for the questioning and politicization of questions with regard to the priorities and objectives of the Brazilian national grid, in addition to the territorial implications and resulting environmental impacts and conflicts.

5. Conclusions

We analyzed the sustainability challenges arising from wind farm construction in the coastal Ceará state, Brazil, showing that wind farm licensing documents manipulated sustainability discourses in simplified licensing protocols to offer exaggerated claims regarding the “sustainability” of wind farms. Analysis of simplified environmental reports indicated numerous ways in which authors created justifications for wind farms based on a “crisis” discourse developed through claims about electricity supply, global climate change and local sustainability benefits. We found that the simplified environmental reports made many dubious claims to justify wind farms that would eventually generate negative reactions from the host community members. Clearly, “green grabbing” operated discursively in the permitting realm. We also described some negative environmental and social aspects of wind farms experienced by the host community members in Brazil, using their own words to give voice to sustainability challenges. Decarbonization and climate change efforts need to carefully consider the procedures used to implement renewable power and the site-specific environmental and social outcomes that the host communities experience.

A more rigorous licensing procedure may reduce corrupt practices and offer avenues for community participation in the benefits of the wind farms, but we lack knowledge on how well firms comply with the stipulations made during the licensing process. Moreover, we do not know the criteria and nature of the stipulations and mitigation measures required by the state authorities for approved wind farms. Future research should investigate possible non-compliance of mitigation actions required of wind farms with respect to reducing the impacts on the host communities and environments. We also recognize the partial nature of the 18 simplified environmental impact reports, noting that many other licensing reports could be analyzed with similar protocols using qualitative software to make the

volume of data manageable with a theory-informed coding procedure. We also recognize the small sample size supporting the qualitative work, but the claims made by the respondents describe widely held views similar to findings reported in other coastal communities in the states of Ceará [21–23] and Rio Grande do Norte [24,25] in Brazil. These qualitative data should be used to help construct questionnaires relevant to host communities that could be deployed in randomized large-*n* surveys to offer generalizable findings.

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