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What explains the community acceptance of wind energy? Exploring benefits, consultation, and livelihoods in coastal Brazil

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ABSTRACT

In the Global South, qualitative research has identified injustices arising from exclusionary community consultation, wide information gaps between host communities and decision makers, and high reliance among residents on land- and sea-based resources that may compete with renewable power infrastructure. Here we analyze results of a face-to-face survey applied in three communities hosting wind farms in Ceará state, northeastern Brazil. Results from three regression models for two dependent variables ("support wind farm" and "support more wind farms") are reported. The comparative case study shows wide variation in support for wind farms among host communities with Benefits as a consistently significant independent variable, followed by Consultation and Environment variables. High support was observed in a community where a flawed consultation and construction process may have been partly overcome by mitigation funds that paid for new houses in one sub-community. Lowest support was found in a community with contested land tenure and a polemic consultation process, but the Benefits variable predicted increased odds of supporting a proposed wind farm. Support for wind farms was highest in a community where the wind investors negotiated royalties with landholders. The findings suggest that perceived or real economic benefits generated support for wind farms, especially when those benefits strengthened livelihoods and land-tenure security of host communities where livelihoods depended on fishing and farming and few employment opportunities exist. The varying consultation processes indicate that need for wind investors and state officials to improve community consultations.

1. Introduction

For decades, social scientists have developed multidimensional understandings of host community acceptance of renewable power infrastructure that emphasize place attachment, fairness of siting process, ownership models, and economic benefits [1–11]. Predictors of host community responses to wind energy in North America [9,10,12–17] and Europe [18–23] increasingly focus on procedural and distributive justice concepts and variables, such as developer transparency, participation in decision making, and fair distribution of negative and positive impacts of wind energy. In the Global South, qualitative research in wind farm sites in Mexico, Brazil, and Kenya has identified injustices arising from exclusionary consultative processes, vast information asymmetries between host community members and decision makers, and high reliance on land- and sea-based resources that compete with renewable power infrastructure [24–32]. These studies show clear indications of host community opposition and procedural and distributive injustices, but quantitative analyses of variables predicting support for, or rejection of, wind energy are not as well developed as the qualitative research. It is not known, therefore, whether host communities support or reject wind energy or whether the same variables predict support in the Global South as in North America and Europe.

Here we deploy a mixed-methods approach to identify predictors of host community responses to wind energy in a comparative case study of

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three locations in coastal Ceará, Brazil. We explain responses to two dependent variables ("I support the wind farm in my community" and "I support more wind farms in my community") with composite independent variables (Benefits, Consultation, Community, Environment, Social Problems, and Discomfort). We interpret regression results with qualitative data from respondents obtained through in-person surveys. We find that the Benefits variable predicted support for wind energy in all three communities. In one community, we found low support for a proposed wind farm with only the Benefits variable predicting support. In two communities, we found high support with Benefits, Consultation, and Environment as significant variables, suggesting different pathways to supporting wind energy. We conclude that tangible benefits aligned with livelihoods, supplemented by transparent siting processes, predict wind farm support in host communities.

2. Background

For nearly two decades, social scientists have analyzed host community acceptance and rejection of renewable power infrastructure according to perceived fairness of siting processes, distribution of benefits and harms, and place attachment. Studies in North America indicate the importance of benefits, siting process fairness, and trust as correlates for wind power acceptance, while demographic variables have little explanatory power and NIMBY ("not in my backyard") explanations are invalid [9]. Other syntheses have emphasized skewed financial compensation, socially mediated health impacts, opaque decision-making processes, and place attachment as reasons for host community opposition to wind energy [10]. In Europe, scholars consistently have determined the importance of siting process fairness, perceived and actual benefits, and landscape considerations in explaining acceptance of wind energy [1,2,4–8,33]. Community-based wind energy is associated with high host community acceptance [22,23], although the underlying reasons are not well understood [34]. Grashof [35] argued that a move to auction models in Germany would deter community wind and possibly undermine procedural and distributive justice indicators.

One important area of this multidimensional understanding estimates the influence of distributive and procedural justice on forming attitudes of host communities toward renewable power infrastructure. Part of a broader turn to justice approaches in energy studies [36–38], justice concerns as applied to host communities near wind farms include procedural justice, such as information sharing, participation in decision making opportunities, the ability to influence outcomes, and relations with project developers, and distributive justice, which refers to the perceived fairness of the introduction and distribution of benefits such as tax revenues and lease payments, and negative outcomes of the wind farm [16,17,24,39–41].

Important advances have translated procedural and distributive justice concepts into variables that predict host community support in North America and Europe. Based on a U.S.-wide sample of residents near wind farms, scholars report that process fairness and place attachment explain support for wind energy [9,42]. In the central U.S., support for wind power was associated with perceived increased employment and economic activity [43–45]. Reporting on the eastern U.S., scholars have argued for the importance of "fair, transparent and just decision-making processes" in determining host community responses to offshore wind [13, p.1]. The perceived fairness of decision-making processes was "an important determinant of local attitudes." Based on these findings, "jurisdictions should consider developing procedures that ensure citizens are consulted and heard and establish benchmarks or best practices for developer interaction with communities and citizens" [42, p. 382].

In Canada, fair distribution and amount of local benefits were key predictors for support of wind energy [16]. Measures of the planning process were such strong predictors of support for wind energy that the authors concluded that "lack of procedural justice elements–particularly the ability to affect facility outcomes—are important drivers of local views of wind energy siting processes and facility support" [17, p. 166]. Fairness in decision making and the distribution of positive and negative outcomes within host communities "can contribute to the overall local acceptability of turbine development" [46].

In Europe, several researchers have estimated effects of participatory and distributive justice using stated or discrete choice and vignette experiments [19]. A choice experiment with hypothetical wind farms found that respondents preferred information more than financial compensation [20]. Another study found higher acceptance of wind farms with increased participation in decision making processes and noted that participatory justice was more important than distributive justice outcomes [18]. Lienhoop [21] found that 90% of respondents to a choice experiment in Germany would "trade off financial and procedural participation against changes to their electricity bill." Respondents in Ireland supported (hypothetical) wind farms for power exports if the wind farms provided jobs, information, reduced electricity tariffs, and allowed for participation in the siting process [47].

In the Global South, procedural and distributive injustices have been described in host communities near wind farms, which have been built as large commercial operations rather than community-based projects owing to policy preferences for an auction-based approach that favors large firms. Auctions outside Europe are "actor neutral" and therefore favor large firms that offer attractive bids [48]. In southern Mexico, elites secured access to land desired by wind investors at the expense of small farmers [24–26,49]. In Kenya, Achiba [27] reported that investors obtained thousands of hectares to build wind farms and dispossessed resource users. Reporting on Ethiopia, Gebreslassie [50] found support exceeding 90% among respondents, but with concerns regarding opaque consultative processes and unsatisfactory land compensation. In Brazil, we have described flaws and biases in the licensing process [28,29] and indications of land-tenure fraud in land acquisitions for wind farms [31], while other researchers have reported poor relations between wind farm investors and host communities [51] and over-inflated employment benefits to host community residents [30,32]. Hochstetler [52, p. 207] found that 25% of Brazil's 600 wind farm sites had some type of oppositional mobilization, primarily in the northeastern region. Host community members mobilized through "diverse allies" within a political opportunity structure including judicial actors, non-governmental organizations, media, and elected officials.

However, the determinants of host community acceptance or rejection of wind farms in Brazil have not been described quantitatively, nor do we have comparisons between or among communities near wind farms. It is not known whether participatory justice variables, observed in North America and Europe to be significant predictors of support for wind, hold similar explanatory power in Brazil or, more broadly, in other sites of renewable power infrastructure in the Global South. It is important to address this knowledge gap given existing and planned wind power investments in the Global South and that fact that qualitative research has indicated that livelihoods, educational attainment, information asymmetries, and power differentials in Brazil and Mexico appear to influence acceptance or rejection of wind energy [24,26,28,29,31,51,53]. For example, high information and power differentials between host communities and regional elites, who support wind investors, may increase procedural injustices. Livelihoods that are highly dependent on agriculture and fishing, in a context of low employment opportunities, may be especially vulnerable to disruptions caused by wind farms.

We developed three quasi-hypotheses from the relevant international and Brazilian literature: indicators of strong procedural and distributive justice actions predict support for wind energy; procedural justice is a stronger predictor of support of support than distributive justice; and low support for wind energy in Brazil's traditional communities results from poor indicators of procedural and distributive justice actions.

Since 2005, installed capacity of wind power in Brazil increased from 29 MW to nearly 16 GW, or 9% of the total electricity generation

capacity, in 2020, with expectations for 27 GW by 2027. Approximately half of Brazil's wind capacity has been installed on land with native vegetation [54], especially in the Caatinga ecoregion of northeastern Brazil, which hosts more than 70% of installed capacity [55]. Wind power is a key element to Brazil's commitments to the country's Nationally Determined Contributions (NDC) goals for the Paris Climate Agreement even though transmission bottlenecks forced cancellation of some wind farms and a drop in renewable investments in 2017 and 2018 [56].

The increase in installed wind capacity in Brazil resulted from investor responses to government subsidies, auctions, planning efforts, and the spatio-temporal compatibility between hydropower, Brazil's leading power source, and wind power [57–59]. Brazil's wind market is dominated by large firms [60] that represent a "repositioning of business players" already influential in Brazil's energy and infrastructure [61, p. 6]. Brazil used wind policy to advance industrialization through local content requirements on wind turbine components, rather than encourage community ownership. The auction system and other institutional choices favored large firms. As a result, "community choices are situated within regulatory frameworks that have discouraged community ownership" of wind farms [52, p. 181]. Notably, "concrete benefits" for host communities "are at best unpredictable and may be minimal" in Brazil [52, p. 212].

3. Material and methods

We selected three host communities, Amarelas, Maceió, and Patos in the west coast of Ceará (Fig. 1), as units of analysis for comparative case study [62]. Selection criteria included prior contact between community leaders and the research team because of the complicated relationships between the host communities and outside groups, which have used the apparent "invisibility" of communities to usurp land and resources [63]. Efficient, safe, reliable, valid, and ethical data collection is possible only with prior trust-building with community leaders and residents. We needed to prioritize the safety of our enumerators, make efficient use of limited financial resources available to our team, and follow high ethical standards, such as the need to respect research subjects, avoid raising suspicion and anxiety, and allow for conditions for future researchers to collect data. Therefore, we held preliminary meetings with community leaders in several potential host communities to explain our research goals, building on the reputation of geographers at the Universidade Federal do Ceará in extension work benefiting rural communities, particularly with regard to participatory mapping [64].

In addition to prior contact between community leaders and the research team, selection criteria for host communities included a nearby proposed or constructed wind farm; similar apparent socio-demographic characteristics; and high reliance upon land and sea-based resources for livelihoods (Table 1). The communities we selected varied in terms of land-tenure security, information links with external groups, relationships with wind farm investors, consultation processes, and distribution of positive benefits [28–31,51]. The wind farms proposed or constructed were not in the community ownership model [34], but rather proposed, built, and managed by large firms that presented successful bids in Brazil's auction process [52,60].

The logic of our selection of host communities was as follows: we first selected Amarelas as a unit of analysis because our preliminary work

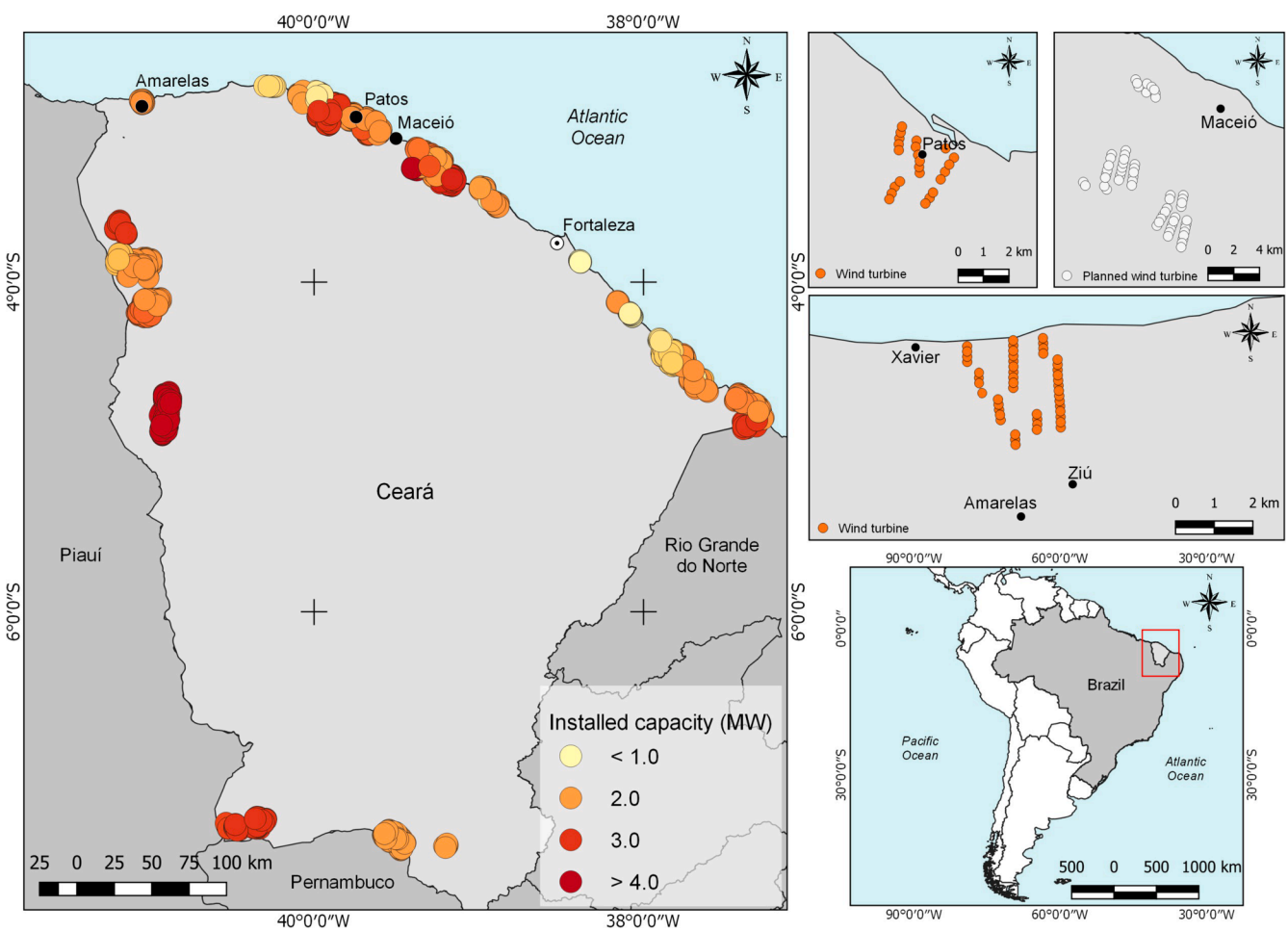

Fig. 1. Distribution of installed wind capacity in Ceará state, Brazil, and location of study communities in Amarelas, Patos, and Maceió. Wind turbines in Maceió were proposed but not constructed.

Table 1
Characteristics of host communities in coastal Ceará, Brazil. Key challenges and strengths were reported during focus groups.

	Amarelas	Maceió	Patos
Wind Farm Characteristics	50 turbines, 104 MW (Praia Formosa), built 2009	58 turbines, 116 MW, under review (Baleia)	23 turbines, 48 MW, built 2017 (Pedra Cheirosa)
Municipality (Population; HDI)	Camocim (63,900; 0.62)	Itapipoca (130,540; 0.64)	Itarema (37,471; 0.60)
No. residents in community	369	415	1,049
Key Challenges	lack of employment, health care, technical school; degradation of mangrove, rivers, lakes, and dunes	departure of young people; lack of support for traditional fishing; exploitative intermediaries; illicit drugs; land disputes	lack of employment, transport, medicine
Key Strengths	subsistence resource zones; school; churches; festivals; beach football tournament	solidarity; associations; history of struggle (*luta*) for land; algae processing; natural resources; festivals; sport	tranquility; subsistence resource zones; irrigated coconut fields; manioc processing; festivals; collective lands; associations
Focus Groups	March 2017 (11 participants)	March 2017 (12 participants)	June 2018 (17 participants)

indicated antipathy to the wind farm owing to poor procedural and distributive justice aspects [65,66], in line with theory; the second unit of analysis (Maceió) was selected owing to preliminary work that showed conflict owing to mistrust of a planned wind farm; and the third unit of analysis (Patos) was selected because preliminary fieldwork showed high support for the wind farm among community leaders who described practices commensurate with concepts of participatory and distributive justice.

With approval of community leaders, we conducted focus groups in each community to define problems and strengths (Table 1). Our interactions with community leaders and focus groups generated qualitative data that informed how we translated justice concepts and constructs into variables for a questionnaire and, eventually, interpreted responses. We based our questionnaire on work conducted in Canada [67] but made adjustments by including questions about truck traffic damage to houses [51] and the role of the influx of male workers during the construction phase encouraging unwanted pregnancies among women in the host community [28,29]. We used a five-point Likert scale ranging from total agreement (1) to total disagreement (5) for dependent variables ("I support the wind farm in (or planned for) my community" and "I support more wind farms in my community") and several independent variables (Tables 2 and 3).

In preparation for in-person data collection with the survey instrument, we obtained population estimates from local health workers. Each community presented different challenges for determining the sample size that would reach 90% confidence. In Amarelas, we relied on local health workers to estimate 131 families, leading to a goal of 89 responses. We stratified this desired sample size among three sub-communities recognized by residents and health workers. Owing to approximately 10 refusals and 24 houses without occupants in the Amarelas district, we obtained 78 responses. In Maceió, we estimated 110 families, determined a desired sample of 79 responses, and obtained 85 with six refusals. There were no coherent sub-communities in Maceió. In Patos, we estimated 285 families and a desired sample of 142 responses. We stratified this sample between two sub-communities and exceeded the desired sample size, achieving 147 responses while recording approximately 5 refusals.

We applied the survey through in-person interviews, by reading questions to respondents and recording answers, because internet or mail-out/drop off surveys are ineffective in traditional communities with illiteracy, marginalization, and poor internet. If we had randomly selected traditional communities hosting wind farms, we would have data validity problems and safety concerns for enumerators. We trained and supervised enumerators, mainly geography undergraduate and graduate students from the Universidade Federal do Ceará, then deployed the survey among randomly sampled heads of household identified in aerial imagery showing built structures in the community. We secured approval of our protocols by the Universidade Federal do Ceará. The enumerators were deployed to Amarelas in May 2017 and February 2018, to Maceió in May 2018, and to Patos in April and May 2019. We obtained qualitative data after the survey questions from respondents who wished to comment further on their responses or share an experience. Respondents authorized audio recordings lasting between five and 10 min, which we later transcribed. We organized the qualitative data according to questionnaire section and community. We did not deploy a detailed coding protocol owing to lack of human and financial resources.

We recognize the two-year period between the start and completion of data collection. During this time, Brazil elected a new president (October 2018), in addition to new municipal mayors and state governors. We did not collect data during the electoral campaign. We are not aware of intervening events that would have influenced how respondents answered the survey. This period resulted from the lengthy process of obtaining cooperation from host community leaders, which is essential to the safety of enumerators and the validity of the data.

In preparation for regression analysis, we combined independent variables into composites with reliability estimates. Benefits (Cronbach's $\alpha = 0.872$) included distributive justice variables and Consultation (Cronbach's $\alpha = 0.831$) included variables measuring aspects of procedural justice. Discomfort (Cronbach's $\alpha = 0.715$) was based on variables regarding perceived noise, flicker, and human health. Environment (Cronbach's $\alpha = 0.750$) included variables measuring perceived environmental impacts included impacts on the surrounding environment. Community (Cronbach's $\alpha = 0.642$) included measures of place attachment and community organization. Social Problems (Cronbach's $\alpha = 0.676$) included questions on increased conflict, problems, and accidents. We recognize that variables addressing landscape issues are included in different composites, but we did not design the survey to measure variables associated with the landscape construct [11,33,68].

We also conducted correlation analyses between the two dependent variables ("support wind farm in my community" and "support more wind farms in my community") and all other Likert-scale item responses used to develop the composite independent variables in the regression models (Table 4). Correlations between the dependent variables and age, gender, and educational attainment were not significant. Benefits, Consultation, and Environment variables were consistently significant for all communities.

Next, we conducted regression analyses for each host community. For the ordinary least squares regression (OLS) and generalized ordered logistic regression (gologit), we included all responses to the Likert-scale dependent variables, including "neutral." Effect metrics for the OLS and gologit models are omega-squared (ω^2) and Wald chi-square, respectively. For the binary logistic model, "neutral" responses were treated as missing and we created a binary category (1 = support wind, from Likert scores 1 and 2; 0 = not support wind, from Likert scores 4 and 5). No binary logistic model is reported for Maceió because results were "unstable" owing to low occurrence (5 of 85 respondents supported wind) but we found significant relationships in binary logistic models that excluded gender, age, and educational attainment. We used JMP version 15 to conduct the regression analyses.

Table 2
Description of dependent and indepedent variables.

Dependent Variables	
I support the wind farm in my community	1 = strongly agree, 5 = strongly disagree
I support more wind farms in my community	
Independent Variables	
Community (Cronbach's α = 0.642)	
I participate in my community's association.	1 = strongly agree, 5 = strongly disagree
I support the demands of the community association	
The community association is important in solving problems of the community	
I participate in a group (church, association, school, fishers) in my community	
Communities have the ability/power to stop wind energy projects	
My community is a good place to live	
I'm interested in living somewhere else (R)	1 = strongly disagree, 5 = strongly agree
Benefits (Cronbach's α = 0.872)	
Wind power is essential to create a sustainable future in Ceará	1 = strongly disagree, 5 = strongly agree
Wind farms brought/will bring benefits to my community	
The benefits of wind power are/will be distributed evenly in my community	
I think wind turbines are beautiful on the landscape	
Residents who live near wind turbines received/will receive financial benefits	
Residents were/will be properly compensated for the negative impacts of the wind power project.	
The value of properties and/or houses increased/will increase owing to the presence of the wind farm in my community	
Wind power contributed/will contribute to the generation of employment in my community	
There was/there will be new jobs in my community during the construction of the wind farm	
The installation of wind turbines improved/will improve the community	
In general, the wind farm had/will have more positives than negatives in my community	
Consultation (Cronbach's α = 0.831)	
My community was consulted about the wind energy project	1 = strongly disagree, 5 = strongly agree
I participated in a public hearing for approval of the wind farm	
Information about the wind farm (existing or proposed) is/was reliable.	
I approve how the government of Ceará is treating the wind energy project in the community	
Wind energy projects are distributed equitably among Ceará's communities.	
I am/was able to express my concerns and clear up doubts regarding the proposed/approved wind farm	
The community consultation process was transparent for local residents	
The municipal government helped answer queries and concerns about wind farms in my community	
The wind firm clarified doubts and concerns about the wind farm in my community	
Discomfort (Cronbach's α = 0.715)	
Noise [from the wind farm] causes discomfort when I am trying to rest	1 = strongly agree, 5 = strongly disagree
I have difficulty adjusting to the noise from the wind turbines	
I sleep in a different place in my house to reduce the noise of the wind turbines	
The wind firm has done an excellent job to protect the community from accidents	1 = strongly disagree, 5 = strongly agree
Shade from wind turbines causes discomfort	1 = strongly agree, 5 = strongly disagree
I am worried that wind turbines may have a negative impact on human health	
I have a health problem caused by the wind farm	
Environment (Cronbach's α = 0.750)	
The wind farm caused/will cause environmental problems in my community	1 = strongly agree, 5 = strongly disagree
Change in the landscape was/will be a problem caused by the wind farm	
I am worried that the wind farm may have negative impacts on groundwater	
Social Problems Cronbach's α = 0.676	
The wind farm brought/will bring problems to my community	1 = strongly agree, 5 = strongly disagree
The wind farm contributed/will contribute to increasing conflicts in my community	
I am afraid that the wind farm may cause accidents in my community	
Problems arising from the wind farm were/will be equally felt by all residents of my community	
Socio-Demographic Variables	
Gender	1 if female, 0 if male
Age	Age in years
Educational attainment	1 = illiterate or literacy achieved, 2 = primary complete, 3 = secondary complete, 4 = some higher education

4. Results

4.1. Amarelas

Amarelas, comprised of a district center (also known as Amarelas), Xavier, and Ziú, has approximately 131 families and 369 people, according to local health authorities. Xavier and Ziú lack paved roads, public lighting, schools, and health clinics. The Amarelas district center is connected by paved and gravel roads to the municipal capital, Camocim, approximately 29 km away. Xavier, which lacked electricity until 2010, is closest to the 104 MW wind farm. Built in 2009 on a dune field (Fig. 2), the wind farm created considerable controversy in part because the community lacked legal title to the dunes and wind farm investors prohibited residents from traversing the dunes to access the district center. Moreover, construction of the wind farm destroyed an interdunal lake important for livelihoods in Xavier [65,66]. With the help of public prosecutors and religious leaders, a legal challenge encouraged investors to make a mitigation payment of ~$130,000 to the Xavier community association, which oversaw the construction of 22 brick houses in 2013 that replaced wattle-daub structures [28].

The Amarelas sample (n = 78) had a mean age of 43.5 and was highly dependent on fishing, agriculture, and public benefits (Table 5). Approximately 9% of the sample was illiterate and 10% achieved only literacy. Nearly half of respondents participated in some type of organization. Strong attachment to the community was observed, as more than 90% of respondents agreed that "my community is a good place to live" and 70% indicated that they were not interested in living somewhere else (Supplemental Table S1). Nearly two-thirds of respondents believed that communities have the ability to stop wind farm projects.

Table 3
Responses (%) to dependent variables (1 = strongly agree, 5 = strongly disagree).

	Amarelas					Maceió					Patos				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Support wind farm in my community	50.0	26.9	9.0	6.4	7.7	4.7	1.2	8.2	3.5	82.4	54.4	29.3	5.4	3.4	7.5
Support more wind farms in my community	41.0	12.8	10.3	5.1	30.8	3.5	4.7	4.7	3.5	83.5	49.7	11.6	6.8	6.1	25.9

Table 4
Correlations between dependent variables and independent variables in three host communities.

	"Support wind in my community"						"Support more wind in my community"					
	Amarelas		Maceió		Patos		Amarelas		Maceió		Patos	
Variable	Spearman ρ	p value	Spearman ρ	p value	Spearman ρ	p value	Spearman ρ	p value	Spearman ρ	p value	Spearman ρ	p value
Age	−0.067	0.558	0.030	0.784	0.071	0.391	−0.050	0.661	0.047	0.671	−0.006	0.944
Gender	−0.147	0.199	0.059	0.592	−0.063	0.448	−0.019	0.867	0.088	0.424	−0.010	0.901
Educ Attain	0.072	0.529	−0.143	0.190	−0.025	0.770	−0.066	0.564	−0.087	0.429	0.082	0.325
Benefits	−0.425	0.000	−0.545	0.000	−0.551	0.000	−0.438	0.000	−0.563	0.000	−0.535	0.000
Community	−0.245	0.031	−0.310	0.004	0.185	0.025	−0.161	0.158	−0.251	0.021	0.004	0.964
Consultation	−0.376	0.001	−0.241	0.026	−0.450	0.000	−0.412	0.000	−0.231	0.033	−0.358	0.000
Discomfort	−0.157	0.169	−0.245	0.024	−0.422	0.000	−0.139	0.224	−0.361	0.001	−0.504	0.000
Environment	−0.478	0.000	−0.266	0.014	−0.408	0.000	−0.482	0.000	−0.385	0.000	−0.380	0.000
Social Problems	−0.379	0.001	−0.293	0.007	−0.316	0.000	−0.299	0.008	−0.341	0.001	−0.343	0.000

Fig. 2. Wind farm near the Xavier village in Amarelas. (Credit: Christian Brannstrom, August 2015.)

Table 5
Sample characteristics of host communities in coastal Ceará, Brazil.

		Amarelas	Maceió	Patos
Sample	Number (% female)	78 (46.2)	85 (60.0)	147 (49.7)
	Mean age	43.5	42.5	47.5
Educational Attainment (% respondents)	No formal schooling	9.0	10.6	9.5
	Literacy achieved	10.3	10.6	21.8
	Primary	43.6	38.8	40.8
	Secondary	33.3	23.5	20.4
	Some post-secondary	3.8	16.5	6.1
Most Important Income or Activity	Fishing	24.4	38.8	25.9
	Agriculture	43.6	74.1	59.9
	Livestock	16.7	25.9	17.7
	Public sector	16.7	10.6	10.9
	Private sector	21.8	23.5	27.2
	Pension	34.6	32.9	33.3
	Bolsa Família (conditional cash transfer)	42.3	42.4	58.5

Strong support for the "wind in my community" dependent variable was observed (77%), but when asked about support for "more wind farms in my community," 54% responded positively (Table 3). Explanatory variables of support for wind farms differed according to regression model but Environment and Consultation were the most consistent significant predictors (Tables 6 and 7). For "support wind in my community," Benefits was significant for the OLS models ($p = 0.052$). Consultation was significant for the binary logistic models ($p = 0.0499$), with a one-point increase in the Consultation variable predicting a ten-fold increase in support for the wind farm. Environment was significant for the "support more wind" dependent variable. Fewer environmental concerns predicted more likelihood of support in the gologit ($p = 0.0016$) and in the binary logistic ($p = 0.0296$) models. Benefits was significant ($p = 0.0179$) in the gologit model. Consultation was significant ($p = 0.050$) in the binary logistic model. A one-point increase in the Consultation variable predicted a 4.5-fold increase in support for more wind farms.

Responses to the Environment variables show that nearly two-thirds of respondents agreed that the wind farm caused environmental problems in the community (Supplemental Table S5). One-quarter of the sample agreed that the wind farm harmed groundwater. Preliminary work on possible groundwater impacts from wind turbine construction indicated high natural vulnerability for Xavier, the Amarelas subcommunity close to the wind farm, and suggested potential for the wind farm to lower groundwater levels [69]. Residents of Xavier had previously described the destruction of an interdunal lagoon that had been used for fishing and a wind turbine that suddenly exploded, frightening residents [28,65,66]. During the survey, one respondent from the Amarelas district noted that the "dunes are burying the forest, and I think that when they move sand back and forth the entire dune will advance into the forest." Another respondent worried that the earth-moving equipment used to keep sand off the roads and away from turbine pads was causing the entire dune field to shift: "in the future, our community could be buried by sand."

Responses to questions comprising the Consultation composite showed that Amarelas had little engagement with the wind farm siting process. One-quarter of respondents (the lowest percentage among the three host communities) were consulted about the wind farm, 30% indicated that the wind firm clarified doubts and concerns, 20% believed the consultation process was transparent, and only 4% indicated that they had participated in a public hearing (Supplemental Table S3). Moreover, only 6%, the lowest among host communities, had an

Table 6
Regression models for "support wind" dependent variable in host communities. ***$p < 0.001$ **$p < 0.01$, *$p < 0.05$.

	Support wind in my community: Amarelas								Support wind in my community: Maceio						Support wind in my community: Patos							
Model	OLS			Gologit			Binary Logistic		OLS			Gologit			OLS			Gologit			Binary Logistic	
R-Square	0.40			0.40			0.48		0.5			0.67			0.39			0.43			0.42	
N	78			78			71		85			85			147			147			137	
	Coef.	p-value	ω^2	Coef.	p-value	Wald chi sq	p-value	OR	Coef.	p-value	ω^2	Coef.	p-value	Wald chi sq	Coef.	p-value	ω^2	Coef.	p-value	Wald chi sq	p-value	OR
Intercept	4.54	0.0002*		−5.21	0.0303*	4.690	0.25		7.88	<0.0001*		−27.71	0.0002*	13.65	6.26	<0.0001*		−8.33	0.0003*	13.20	0.0026*	
Age	0.00	0.73	0.00	0.00	0.94	0.01	0.56	0.97	−0.01	0.17	0.01	0.08	0.17	1.90	0.00	0.77	0.00	0.00	0.98	0.00	0.17	1.05
Gender[0]	0.12	0.39	0.00	−0.42	0.41	0.67	0.49	0.46	0.09	0.38	0.00	−0.79	0.49	0.47	0.01	0.88	0.00	−0.18	0.63	0.23	0.58	1.49
Educ Attain[1–0]	0.04	0.95	0.00	0.08	0.95	0.00	0.71	2.50	−0.39	0.32	0.03	3.88	0.09	2.84	0.06	0.85	0.00	−0.57	0.43	0.61	0.81	1.52
Educ Attain[2–1]	0.04	0.94	0.00	−0.40	0.70	0.15	0.87	0.75	−0.26	0.45	0.03	−1.08	0.66	0.19	−0.02	0.93	0.00	0.08	0.87	0.03	0.99	1.49
Educ Attain[3–2]	0.33	0.38	0.00	−0.61	0.41	0.68	0.18	0.12	−0.16	0.55	0.03	1.97	0.14	2.22	−0.33	0.14	0.00	1.26	0.0316*	4.62	0.10	6.51
Educ Attain[4–3]	−1.09	0.12	0.00	2.16	0.13	2.35	1.00	NV	−0.45	0.12	0.03	3.22	0.0274*	4.86	0.49	0.21	0.00	−1.26	0.15	2.10	0.74	1.59
Benefits	−0.39	0.05	0.03	0.69	0.08	3.08	0.17	3.86	−0.57	<0.0001***	0.120	4.42	0.0004***	12.70	−0.51	0.0012***	0.05	0.96	0.0048**	7.96	0.0255*	5.35
Community	−0.01	0.94	0.00	0.11	0.73	0.12	0.77	0.80	0.00	0.99	0.00	0.30	0.74	0.11	−0.07	0.53	0.00	−0.04	0.86	0.03	0.56	1.40
Consultation	−0.34	0.09	0.02	0.66	0.14	2.18	0.0499*	10.41	−0.01	0.93	0.00	0.05	0.95	0.00	−0.32	0.0365*	0.02	0.74	0.0285*	4.80	0.091	3.52
Discomfort	0.10	0.64	0.00	−0.14	0.75	0.10	0.78	0.79	−0.10	0.44	0.00	0.26	0.71	0.14	−0.18	0.21	0.03	0.33	0.29	1.10	0.69	1.26
Environment	−0.24	0.11	0.02	0.50	0.08	3.02	0.44	1.54	−0.31	0.06	0.02	0.57	0.47	0.51	−0.04	0.65	0.00	0.19	0.38	0.77	0.92	1.05
Social Problems	−0.16	0.38	0.00	0.23	0.52	0.41	0.93	1.06	−0.04	0.81	0.00	0.36	0.73	0.12	−0.06	0.60	0.00	0.18	0.51	0.43	0.29	1.91

Table 7
Regression models for "support more wind" dependent variable in host communities. ***$p < 0.001$ **$p < 0.01$, *$p < 0.05$.

	Support more wind in my community: Amarelas								Support more wind in my community: Maceio						Support more wind in my community: Patos							
Model	OLS			Gologit			Binary Logistic		OLS			Gologit			OLS			Gologit			Binary Logistic	
R-Square	0.41			0.46			0.41		0.62			0.75			0.4			0.43			0.37	
N	78			78			70		85			85			147			147			135	
	Coef.	p-value	ω^2	Coef.	p-value	Wald chi sq	p-value	OR	Coef.	p-value	ω^2	Coef.	p-value	Wald chi sq	Coef.	p-value	ω^2	Coef.	p-value	Wald chi sq	p-value	OR
Intercept	7.55	<0.0001*		−8.27	0.0016*	9.96	0.0125*		7.46	<0.0001*		−30.51	0.0003*	13.30	9.41	<0.0001*		−11.16	<0.0001*	22.70	0.0001*	
Age	−0.03	0.08	0.02	0.04	0.11	2.50	0.0362*	1.08	−0.01	0.146	0.01	0.03	0.68	0.17	0.00	0.734	0.00	0.00	0.93	0.01	0.704	0.99
Gender[0]	−0.07	0.72	0.00	0.40	0.48	0.50	0.60	1.49	0.14	0.101	0.01	−2.21	0.14	2.14	0.02	0.856	0.00	−0.07	0.84	0.04	0.741	0.85
Educ Attain[1–0]	1.00	0.20	0.04	−1.63	0.17	1.87	0.40	0.24	−0.32	0.349	0.02	4.05	0.12	2.41	0.73	0.134	0.00	−1.51	0.067	3.35	0.175	0.15
Educ Attain[2–1]	−1.53	0.0166*	0.04	2.58	0.0095**	6.74	0.0465*	23.06	−0.30	0.317	0.02	−4.26	0.20	1.63	0.01	0.971	0.00	−0.05	0.93	0.01	0.827	0.85
Educ Attain[3–2]	−0.36	0.48	0.04	0.51	0.51	0.43	0.44	2.40	−0.31	0.182	0.02	2.98	0.0495*	3.86	−0.09	0.790	0.00	0.33	0.53	0.39	0.469	1.64
Educ Attain[4–3]	−0.56	0.56	0.04	0.42	0.73	0.12	1.00	NV	−0.15	0.559	0.02	3.84	0.057	3.63	−0.04	0.944	0.00	−0.13	0.89	0.02	0.499	2.10
Benefits	−0.46	0.10	0.02	0.98	0.0179*	5.61	0.85	1.14	−0.50	<0.0001***	0.10	6.67	0.0023**	9.31	−0.84	0.0003***	0.06	1.32	0.0005***	12.00	0.0007***	5.98
Community	0.00	0.99	0.00	−0.09	0.78	0.08	0.88	1.08	0.16	0.298	0.00	−1.34	0.26	1.27	−0.45	0.0080**	0.03	0.71	0.0076**	7.13	0.0047**	3.45
Consultation	−0.43	0.12	0.01	0.41	0.27	1.21	0.050	4.50	0.11	0.378	0.00	−1.45	0.15	2.05	−0.29	0.200	0.00	0.52	0.14	2.20	0.215	1.82
Discomfort	0.26	0.39	0.00	−0.39	0.42	0.66	0.15	0.34	−0.17	0.127	0.01	1.56	0.078	3.12	−0.58	0.0050**	0.03	0.93	0.0042**	8.20	0.0308*	2.59
Environment	−0.58	0.0053*	0.07	1.03	0.0016**	10.00	0.0296*	3.13	−0.47	0.0009***	0.06	1.25	0.16	1.98	0.00	0.986	0.00	−0.05	0.79	0.07	0.668	1.21
Social Problems	−0.01	0.97	0.00	−0.10	0.81	0.06	0.67	1.28	0.00	0.975	0.00	0.44	0.70	0.14	−0.05	0.782	0.00	0.12	0.66	0.20	0.637	1.19

opportunity to clarify doubts regarding the wind farm. The consultation process in Amarelas was exclusionary and opaque, with little information offered to residents, unlike the process in Patos (4.3). Responses to questions about the wind firm may reflect post-construction negotiations, when the wind firm settled a legal dispute by offering funds to construct houses in Xavier.

Although the Benefits composite was a significant predictor of support for wind farms only in the OLS model, the responses are instructive for comparison with the two other host communities. 70% of respondents agreed that the wind farm generated new jobs during construction, 68% agreed that the wind farm would "have more positive than negative" impacts, and 60% agreed that the wind farm would bring benefits (Supplemental Table S2). However, the unequal distribution of benefits within the community was confirmed by 25% of respondents even though 54% agreed that the wind farm would "improve" the community. 87% of respondents believed that wind farm was "beautiful on the landscape." Respondents understood benefits in terms of economic impacts and improved roads. A respondent in Amarelas told us that "yes, [the wind farm] is good, because it generated a lot of jobs for my community…we rented our houses, got jobs, and now it's easier to get to the beach" by the paved road through the wind farm. But another respondent in Amarelas noted that the "jobs were only during the start [construction], and later they threw everyone out, so now we can't find work" at the wind farm.

Concern with discomfort in Amarelas was highest with regard to negative impacts on human health (35% agreement), but 4% reported a health problem caused by the wind farm (Supplemental Table S4). One-quarter of respondents felt discomfort when resting and 22% had difficulty adjusting to the noise from the wind farm. 17% of respondents agreed that the wind firm protected the community from accidents.

Amarelas respondents were divided in regard to a questions about conflict and problems caused by the wind farm (Supplemental Table S6). Approximately half agreed that the wind farm brought problems to the community and nearly one-third agreed that the wind farm increased conflicts in the community, but 45% believed that problems would be felt equally in the community. On the issue of sexual relations, 48% of respondents agreed that this was a problem, suggesting the seriousness of the "children of the wind" concern reported previously with qualitative data [28,29].

4.2. Maceió

The Maceió community (~110 families and 415 residents) is an agrarian reform settlement created in 1985 by Brazil's National Institute for Colonization and Agrarian Reform (INCRA). The community association is well connected to the Landless Workers Movement (MST), a group that was Latin America's most influential rural social movement during the 1990s and 2000s and is known for confrontational strategies for obtaining land [70]. Community leaders pride themselves on their history of *luta* or struggle for land, which they obtained after decades of sharecropping in abusive and miserable conditions [71]. The formation of the agrarian reform settlement opened the way for state support for agricultural grants and links with non-governmental organizations. The land struggle is not over in Maceió, as community leaders continue to defend their territory from fraudsters, speculators, and shrimp farm investors.

The 116 MW Baleia ("whale") wind farm was proposed in this contentious land-tenure context. In 2018, after survey deployment, the wind developer postponed indefinitely plans for the wind farm; however, at the time of our survey, the developer was pursuing a license to clear land for the wind turbines. Mobilization against wind farms began at least in 2012, as community leaders displayed a poster from a workshop highlighting injustice caused by wind farms (Fig. 3). As this poster suggests, Maceió is well connected with social movements, including the MST, which helps coordinate a school, in addition to community tourism groups and other non-governmental organizations that provide information and resources. Maceió's leaders have relatively high knowledge of disputes regarding wind farms and other land and-sea

Fig. 3. Poster in the Maceió community organization headquarters. The poster describes a 2012 workshop on "Wind energy, injustices, and environmental impacts in the coastal zone." Note the design emphasizing large wind turbines and warning signs intruding on the space occupied by simple houses. (Credit: Christian Brannstrom, June 2016).

based resources in the state. Overall, Maceió's partners represent an example of what Hochstetler [52, p. 207] refers to as the "diverse allies" that support mobilization against wind farms and other perceived external threats.

The Maceió sample (mean age = 42.5) had higher educational attainment than the other two communities. The community was highly dependent on agriculture, fishing, livestock, and state benefits (Table 5). Respondents had high attachment to the community, with nearly 100% agreement with "my community is a good place to live." The community association was seen in highly favorable terms (Supplemental Table S1).

Maceió strongly opposed the proposed wind farm, with only 9% of respondents supportive and approximately 85% opposed to both planned and additional wind farm scenarios (Table 3). The Benefits composite was significant in the OLS ($p < 0.0001$) and gologit ($p = 0.0004$) models (Table 6). For the "support more wind" dependent variable, the Benefits composite was also significant in the OLS ($p < 0.0001$) and gologit models ($p = 0.0023$) (Table 7). Environment was significant for the OLS model ($p = 0.0009$).

Responses to Benefits questions in Maceió indicate the contours of how this concept is understood. 32% believed the wind farm would bring benefits to the community, 9% believed the benefits would be evenly distributed in the community, 12% believed residents would be properly compensated from the wind farm's negative impacts, and only 6% believed the wind farm would have more positive than negative impacts (Supplemental Table S2). Only 21% believed wind turbines were "beautiful on the landscape." Responses to employment questions show how respondents interpreted the question of benefits with 75% in agreement that there would be new jobs in the construction phase while 42% believed that the wind farm would contribute to the generation of employment in the community.

Respondents were aware of the limited employment boost from wind farms. One respondent noted that "most jobs will be in construction, and after that there will be very little work." Another told us, "yes, there will be work for a lot of people, but then after construction, these workers will leave and others, with skills [*cargo de estudo*] will arrive" for the work in the wind farm. But one respondent in Maceió noted that "the wind farm isn't so bad, and I think it's good [because] it brings jobs." More broadly, Maceió's concerns may be summarized by one respondent who told us that "the community won't get anything from this [wind farm], only losing tranquility. And, they will fence off [enclosed] areas where we walk, and put guards there. How will fishers get to their boats [from the village]? This [wind farm] doesn't provide anything good to our community."

The Consultation variable was not significant in the regression models, but responses illustrate how community members viewed the process. <12% participated in a public hearing but 61% had been consulted about the planned wind farm. Only 8% believed the information about the wind farm was reliable (Supplemental Table S3). 32% of respondents in Maceió could express concerns, even if they distrusted information. Respondents told us that wind farm investors had stacked the public hearing with "their people" recruited from other communities who allegedly were paid to show their support for the proposed wind farm. Another Maceió respondent faulted the municipal government for not providing information about the wind farm: "they should be concerned about us, give us information about it, answer our questions, but we see that they don't care about us."

Neither Discomfort, Environment, nor Social Problems was significant in regression models, but the responses illustrate how Maceió differed from the other two host communities. Three-quarters of respondents were worried about noise and negative human health impacts, far higher than Amarelas or Patos (Supplemental Table S4). Approximately 85% of respondents believed that the proposed wind farm would cause environmental problems, harm groundwater, or result in negative landscape changes (Supplemental Table S5). Groundwater concerns, which are highly relevant to the communities because of reliance on shallow wells for household water in a semi-arid climate, were highest in Maceió, where a resident noted that "reports from a neighboring community…indicate that their water supply was reduced" because of excavations to support the wind turbines. This respondent asked, "what will this be like in 10 years? There won't be [potable] water, there won't be fish to eat, it will be difficult for fishers to go fishing." Finally, responses to Social Problems variables were less optimistic than Amarelas and Patos (Supplemental Table S6). 76% of respondents believed that the proposed wind farm would contribute to an increase in conflicts and 80% believed the wind farm would bring problems to the community.

4.3. Patos

The Patos community includes approximately 279 families (1,049 residents). The developers of the 48 MW wind farm, constructed in 2017, paid for the construction of a bridge (Fig. 4), which shortened a 5 km trip to a nearby village, and negotiated with community organizations. The Patos community includes a main village (Patos) and two subcommunities. These communities are organized, in part, into three groups owing to past land-tenure struggles that, in turn, influence the ways in which financial benefits from wind turbines are distributed among landholders. One group (Associação Comunitária dos Produtores Rurais da Fazenda Patos) secured its status in 1998 as an agrarian reform settlement by negotiating with local elites and state authorities (Ceará's Institute for Agrarian Development; IDACE), and hosts 9 turbines that provide 1.5% of monthly gross electricity sales as a royalty to the association's members; in addition, the wind farm investor helped settle a debt owed to a bank for the land purchase that helped establish the settlement.

Two other associations represent groups of farmers who secured land from the municipality rather than the state agency. One of these hosts 4 turbines, receives royalties, and accepted funds from wind firm to remodel a manioc flour processing plant and professionalize the workforce (Associação Comunitária dos Pequenos Agricultores de Patos). The third group does not have wind turbines within its settlement perimeter owing to the layout of the wind farm. Therefore, the spatial distribution of turbines within the agrarian-reform context favored some landholders over others in terms of royalty payments.

The Patos sample was slightly older than Amarelas and Maceió, but had similar educational and livelihood profiles (Table 5). The Bolsa Família conditional cash transfer program was especially important. More respondents reported private sector employment than the other two communities. Attachment to the community was similarly high,

Fig. 4. Bridge constructed to improve travel between sub-communities in Patos (Credit: Christian Brannstrom, July 2018). The sign reads, "this passage was built for you [Patos communities]."

with 95% reporting that the community was a good place to live and nearly 80% not interested in living somewhere else. Support for the community organizations was higher than Amarelas but lower than in Maceió (Supplemental Table S1).

Support for the wind farm was high in Patos compared to Amarelas and Maceió (83% agreement with support for "wind in my community"), but when asked about support for "more wind farms in my community," agreement was 61%, a decrease in support similar to Amarelas (Table 3). For the "support wind in my community" dependent variable, Benefits and Consultation composites were significant in all regression models. Benefits was significant for OLS ($p = 0.0012$) and gologit ($p = 0.0048$), and binary logistic ($p = 0.0255$) models. A one-unit increase in Benefits predicted a 5-fold increase in support for the wind farm. Consultation was also significant for OLS ($p = 0.0365$) and gologit models ($p = 0.285$).

Considering predictors of support for "more wind farms" in Patos, Benefits was also significant for OLS ($p = 0.0003$), gologit ($p = 0.0005$), and binary logistic models ($p = 0.0007$). A one-unit increase in Benefits predicted a 6-fold increase in support for more wind farms. Consultation was not significant in any model. Community and Discomfort composites were also consistently significant. Community was significant for OLS ($p = 0.008$), gologit ($p = 0.0076$), and binary logistic models ($p = 0.0047$). Discomfort was significant for OLS ($p = 0.0050$), gologit ($p = 0.0042$), and binary logistic models ($p = 0.0308$). In the binary logistic model, Community and Discomfort had odds ratios of 3.5 and 2.6, indicating that a strong sense of community and lack of perceived discomfort increased odds of supporting more wind farms.

Viewing the Benefits responses in more detail reveals that 80% of the community believed that the wind farm brought benefits to the community, 83% responded that the wind farms had more positives than negatives for the community, and 71% believed the wind turbines improved the community; however, 45% believed the benefits were evenly distributed, an indication that the royalty payment system limited benefits to a subset of the community (Supplemental Table S2). 95% agreed that the wind farm would generate "new jobs" during construction and 88% agreed that the wind farm would generate employment. Regarding the aesthetic presence of wind turbines, high approval (86%) was observed.

Respondents noted some important details that revealed how they interpreted benefits in their community. One community leader emphasized that royalty from power generation sales was a superior institution compared to a rental agreement because "they [wind farm owners] could set up a deal and then abandon it, saying 'I'm not going to pay rent anymore.'" Respondents in Patos noted that employment was short term because the firms only hired trained workers. Many young people were not hired because they lacked skills and required documents. Moreover, one respondent described the unequal distribution of benefits: "When the wind farm arrived, the job openings appeared, and who benefited? The association's [Fazenda Patos] people. Why? Because the turbines were located precisely on the lands that belonged to the association."

Consultation, another significant variable, differed markedly compared to Amarelas and Maceió (Supplemental Table S3). 90% of respondents indicated that they were consulted about the wind farm, 35% participated in a public hearing, and 83% agreed that the process was transparent and that the information about the wind farm was reliable. 67% reported that they could express concerns. High level of support for the process in Patos was indicated by responses such as, "the company is concerned with having a dialogue with us, explaining, understanding what we experience…in other words, a partnership." Another respondent told us, "the company comes here every year to ask us about how their workers are treating us, whether we experience negative impacts."

Discomfort and Environment responses show how Patos viewed this issue compared to Amarelas and Maceió. 54% of respondents agreed that the wind farm would cause environmental problems (less than Amarelas or Maceió) and 34% of respondents worried about groundwater impacts (more than Amarelas but less than Maceió) (Supplemental Table S5). With regard to Discomfort, 43% agreed that noise caused discomfort during sleep and 44% had difficulty adjusting, far higher than Amarelas (Supplemental Table S4). Patos had few reports of health problems experienced (4%), but 34% of respondents worried about negative health impacts, similar to Amarelas but far lower than Maceió. In interviews, one respondent placed discomfort from turbine noise into the context of benefits, telling us that "people who don't get any benefits hear the noise…at the start, it caused discomfort but now it sounds like the sound of the sea." Another respondent made a similar connection, arguing that "more noise means greater [financial] returns…it's producing more." A third respondent noted, "I'm worried when they [turbines] aren't moving" in reference to the royalties.

Responses to Social Problems variables reveal that only 14% believed the wind farm contributed to conflicts in the community but 39% believed the wind farm brought problems (Supplemental Table S6). Problems relating to sexual relations between male workers and female residents were reported by only 4% of respondents, far less than the 48% in Amarelas.

5. Discussion

The comparative case study of three host communities with similar livelihood profiles indicates wide variation in support for wind farms. Benefits, consultation process, and environmental harms were the main explanatory variables explaining support for wind farms. Support for wind farms was highest in Patos, where the wind investors negotiated royalties with landholders. In Patos, Benefits and Consultation were significant independent variables explaining support. In Maceió, where a wind farm was planned, support was low owing to a contested consultation process, but the Benefits variable predicted increased odds of supporting the wind farm. In Amarelas, mitigation funds that paid for new houses in one sub-community may have partly overcome a flawed consultation and construction process. Relatively high support was found, with Consultation and Environment identified as significant variables predicting support for the wind farm.

The findings support the first quasi-hypothesis (indicators of strong procedural and distributive justice actions predict support for wind farms), but the findings are uneven across the host communities studied. Amarelas is strongly supportive even though justice actions were poor, while Patos provides a case of strong justice actions leading to increased likelihood of supporting the wind farm. Weak justice actions in Maceió support a reverse version of this hypothesis.

Regarding the second quasi-hypothesis (procedural justice is a stronger predictor of support of support than distributive justice), our findings offer mixed support. The strength and significance of the Consultation composite, which includes variables in the procedural justice construct, and Benefits, which includes distributive justice variables, demonstrate how procedural and distributive justice actions significantly increase the odds of supporting wind farms. The evidence for Consultation as an explanatory variable adds to the growing empirical and experimental evidence that fair and transparent siting processes and perceived benefits are strong and reliable predictors of wind farm support among host communities [13,16–21,47]. The strength of the Benefits composite suggests the importance of perceived employment, royalties, and other benefits in determining support for wind energy similar to previous work in the Global North [43–45]. It is premature to suggest that employment and royalties are more important than process fairness and transparency; however, it seems possible that predictions of procedural justice variables as the strongest determining factor of support [13,18,46] may not apply in all host communities, especially in areas of economic decline or marginalization. Future research may help disentangle the relative influence of participatory and distributive justice processes in determining host community acceptance of wind energy. In host communities where livelihoods depend on fishing and farming, with low educational attainment and few

employment opportunities, perceived or real economic benefits may generate support, especially when those benefits strengthen livelihoods and land-tenure security.

It is important to consider the possible meanings of benefits and participation among the host communities. In North America and Europe, benefits may flow directly from community ownership of wind turbines [34] or may result from employment in the operation and maintenance of wind farms [13,43]. Benefits in traditional communities reliant upon fishing and agriculture, struggling to find opportunities for young people, may be understood by respondents as specific improvements to difficult livelihoods with limited options. But there are additional dynamics to consider. In Patos, participation and benefits were interconnected in terms of how residents experienced these phenomena. Negotiations with wind investors helped secure royalties and other benefits linked directly to livelihoods—land and manioc, specifically. The idea of benefits in Patos has clear meaning owing to tangible benefits, such as the bridge (Fig. 3), land debt, and assistance to manioc processing, which in turn may help explain why Patos respondents did not perceive wind farms to cause discomfort. In Maceió, the predictive power of benefits indicates the desire for economic opportunities in a context of deep skepticism toward the wind farm. Employment in the wind farm seems a hollow promise, as it does in other cases in northeastern Brazil, because employment in wind farm operation and maintenance is nearly exclusively for outsiders with skills [30,32]. In a context of high unemployment, respondents may have viewed any employment positively. Benefits that support agriculture and fishing, such as we observed in Patos, will likely resonate in host communities, while wind farms that intrude on, threaten, or enclose livelihood resources will face resistance.

What does consultation mean to host communities? In other studies, consultation variables included the ability to affect outcomes, access to information, and participation in public hearings [13,16]. Consultation in Amarelas was poor, yet the odds of support for the wind farm increased with positive consultation indicators. Perhaps any dialogue or information sharing in Amarelas would be a welcome improvement on several years without information. In Maceió, a public hearing attracted some community residents, but they distrusted the information and believed the meeting was stacked with paid supporters. In Patos, the consultation process included the negotiation of tangible benefits, even if the benefits were not well distributed among all residents. In host communities deprived of information and skeptical of municipal officials, consultation could mean one public hearing led by regional elites, but this is hardly sufficient for dialogue among host community residents, state officials, and wind investors. Municipal and state authorities were absent in disseminating information about planned wind farms, so community organizations filled this gap in Maceió and Patos, but not in Amarelas.

Focusing on the third quasi-hypothesis (low support for wind farms in Brazil's traditional communities results from poor indicators of procedural and distributive justice actions), we note that previous research suggested more opposition than we found in Amarelas and Patos. The finding of strong opposition in Maceió is congruent with earlier work [28–31,51] and with Hochstetler's [52] description of mobilization against wind farms. But support in Amarelas and Patos suggests that the researchers may be attracted to cases in which the host community challenged the wind farm and community leaders were eager to discuss their resistance [52].

Similar to previous work, our findings highlight the complex and heterogeneous conditions in apparently similar communities involving land struggles, experiences with wind investors, and the perceptions of participation and benefits relating to wind farms. Maceió, strongly opposed to a proposed wind farm, was defined by a land struggle that drew upon social-political networks opposed to wind farms. Although support for the proposed wind farm in Maceió was low, perceiving indicators of benefits increased the odds for supporting wind. By contrast, Amarelas and Patos showed high acceptance of wind farms, even though both communities arrived at that high acceptance through different processes. In Amarelas, the consultation process was weak; moreover, a dispute centering on the Xavier families resulted in a court-mediated settlement between the wind farm investors and Xavier. In Patos, the relationship between wind investors and community leaders underscores the predictive power of the Benefits variable. Actions by the wind investors in Patos were proactive, rather than reactive as in Amarelas. The land-tenure struggle in Patos relied on less confrontational means than in Maceió, which may have encouraged Patos community leaders to work collaboratively with wind farm owners. These differences in the meaning of benefits and consultation regarding wind farms parallel findings emphasizing different ways that host communities perceive wind farms, in the sense of what Bates and Firestone [12] noted as clean energy or industrializing the sea, and which Ellis et al. [72] and Fast [40] described as differences between supporting and opposing discourses regarding wind farms.

The comparative case study revealed widely varying community consultation practices and benefits, confirming Hochstetler's [52] findings. Future work could focus on the reasons for variation in how wind farm owners approach consultation and benefits regarding in host communities. It is not known which ideas guided the actions of individuals charged with community relations. Implications for wind farm investors include the need to work collaboratively with community organizations [31], following the emphasis placed on community engagement plans [13]. Given the absence of municipal and state authorities, who are likely complicit with fraudulent land deals that will alienate host community residents [28], investors need to negotiate carefully the local political environment to ensure successful projects. In addition, investors need to better understand the meaning of benefits and desist from hollow promises of employment. Host community residents understand that local employment is temporary and limited to the construction phase. Benefits may generate strong support if they strengthen, rather than undermine, land- and sea-based livelihoods.

Future research should aim for more consistent variables aligned to justice concepts and constructs, especially the issues regarding perceived problems caused by wind energy. Future work could also more precisely delineate the relative importance of procedural and distributive justice variables in determining support and opposition and use participatory techniques in host communities to better understand the meaning of justice concepts [53]. Landscape constructs could be better linked to variables in future refinement of the survey instrument. A balanced sampling approach may have reached additional respondents that could have improved the regression model for the Maceió community. Our comparative case study also illustrates issues that could be investigated with a large randomized study [15,42], although significant challenges would confront researchers in defining the sample owing to the nature of marginalized host communities and obtaining valid responses because of mistrust of outsiders resulting from land-tenure insecurity. Future work also could focus on whether corporate ownership of wind farms in Brazil influences community engagement as a way to deploy insights from studies of community wind [34]. Our study did not explore the institutional choices leading to corporate ownership of wind farms, which may help explain how communities view wind energy. Limitations to our study include the two-year period involved in data collection and lack of first-hand information, from wind farm managers, about how they approached host communities. Finally, we caution against experimental approaches, which might generate distrust and confusion because hypothetical wind farm scenarios could be interpreted as actual proposals in communities starved of information and lacking employment options for young people.

6. Conclusion

In the Global South, qualitative research has identified injustices arising from exclusionary consultative processes, information asymmetries between host community members and decision makers, and high

reliance on land- and sea-based resources that may compete with renewable power infrastructure. Findings from our comparative case study revealed varying levels of support for wind farms in three host communities. Benefits and Consultation independent variables explained support for wind farms, similar to host communities in North America and Europe. Host communities differed in terms of responses to procedural justice variables such as information and participation in public hearings, and regarding distributive justice concerns such as increase in conflict and employment increases. The findings suggest that host communities will support wind farms when they perceive benefits and a transparent consultation process, and without perceiving discomfort or environmental problems from the wind farm. Perceived or real economic benefits generate support for wind farms, especially when those benefits strengthen livelihoods and land-tenure security of host communities where livelihoods depend on fishing and farming and few employment opportunities exist. Wind energy investors and state officials have abundant opportunities for improvement in providing tangible benefits and conducting transparent community consultations.

CRediT authorship contribution statement

Christian Brannstrom: Conceptualization, Data curation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Nicolly Santos Leite:** Data curation, Investigation, Methodology, Project administration, Visualization. **Anna Lavoie:** Formal analysis, Validation, Writing – original draft. **Adryane Gorayeb:** Funding acquisition, Project administration, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.erss.2021.102344.

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