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Justice and risk perception in Chile's wind energy expansion

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The deployment of renewable energy infrastructures has intensified across Latin America as countries pursue decarbonization goals; however, these transformations often reproduce existing territorial inequalities, especially in rural areas that have been historically affected by extractive industries. In many rural areas, the expansion of wind energy has generated significant socio-environmental tensions linked to landscape transformation, informational asymmetries, and procedural deficits. This study evaluates the interaction between energy development and the ecosystem multifunctionality of rural landscapes, focusing on how local actors perceive and interpret socio-environmental risks, changes in Ecosystem Services, and dimensions of environmental justice. A constructivist framework was performed in addition to qualitative fieldwork in five administrative localities to connect conceptual trends with empirical narratives. Results show that wind energy projects have disrupted both physical and symbolic ecological landscape functions, revealing perceived risk functions associated with procedural injustice and an expression of territorial inequality. Risk perception emerged as a socially constructed and historically rooted phenomenon, shaped by lack of trust, uneven information access, and symbolic disconnection. The findings call for place-based, justice-oriented energy planning approaches that integrate community knowledge, territorial heterogeneity, and the affective dimensions of landscape.

KEYWORDS

ecosystem services, energy transition, environmental justice, landscape multifunctionality, windenergy

1 Introduction

Decarbonization agendas have accelerated renewable-energy deployment worldwide, generating socioenvironmental challenges in territories where participation is late or merely informative (Delcayre and Bourdin, 2025). The rapid expansion of wind energy has reconfigured rural landscapes and local identities, often through centralized, technocratic procedures that underplay territorial context (Cannon et al., 2023). Recent research has shown that even when framed through sustainability and participation discourses, renewable energy transitions may reproduce territorial inequalities if governance remains centralized and technocratic, incorporating justice claims without substantively redistributing procedural decision-making power (Wuebben et al., 2025). Early landscape change, weakened participation, and historically rooted inequalities converge to shape community interpretations of risk and justice, particularly in Chile,

where extractivist trajectories of energy related intervention (hydropower/water governance), have fostered mistrust and justice claims, especially in southern regions (Araújo and Gorayeb, 2023; Anderson and Johnson, 2024).

Energy-justice is commonly articulated around distributive, procedural and recognition dimensions (McCauley et al., 2013), later expanded to include cosmopolitan and restorative perspectives as a normative basis for evaluating the fairness of energy systems and decision-making processes (Sovacool et al., 2017; Heffron, 2022). Within this framework, energy justice has been shown to shape social acceptance of energy infrastructures, particularly through its emphasis on transparency, inclusiveness, and participatory quality (Walker et al., 2018; Kojo et al., 2022). More recent scholarship mobilizes energy justice as a critical lens to interrogate how technocratic and market-oriented energy transitions reproduce territorial inequalities and power asymmetries (van Uffelen, 2022). In this context, risk perception is understood as a socio-cognitive mechanism through which experiences of exclusion, injustice, and landscape transformation are articulated and amplified.

Extensive research demonstrates that evaluations of renewable-energy projects are not purely technical but deeply affective, identity-based, and situated: emotional bonds and symbolic meanings can foster acceptance when projects align with local place identities (Devine-Wright, 2011), while attachment mediates social and cognitive drivers of engagement (Fu and Dong, 2025). Shared belonging and collective identification enhance local agency in socio-ecological systems (Escalera-Reyes, 2020), and communicative processes of risk amplification shape how impacts are socially interpreted (Ram and Webler, 2022). These dynamics interact with the material implications of wind-energy expansion, which can create spatial trade-offs that strain landscape multifunctionality and the provision of ecosystem services, particularly in agricultural and wetland regions (Virah-Sawmy and Sturmberg, 2025).

At the same time, procedural justice emerges as a pivotal factor for both local and market acceptance, with early and meaningful community participation fostering trust, legitimacy, and social support for projects (Hübner, 2020; Kojo et al., 2022; Hübner et al., 2023). Distributive justice complements this by shaping perceptions of whether costs and benefits are equitably shared, reinforcing the importance of outcomes that communities experience as fair (Hübner et al., 2023). However, empirical studies continue to reveal persistent gaps in participation, information access, and communication, which exacerbate pre-existing territorial inequalities and erode trust (Delamaza et al., 2017; Cordoves-Sánchez and Vallejos-Romero, 2019; Vallejos-Romero et al., 2020).

Despite robust conceptual frameworks, less is known about how these affective, procedural, distributive, and spatial dynamics converge in territories undergoing rapid landscape transformation. In Latin America, a significant gap remains regarding how perceived ecosystem services (ES) and perceived risks jointly shape evaluations of renewable-energy projects in rural territories. While Chilean evidence suggests ES are central to risk construction (Cordoves-Sánchez and Vallejos-Romero, 2019), research elsewhere has focused more narrowly on distributive or procedural justice (Barragan-Contreras, 2022;

Velasco-Herrejón and Bauwens, 2024). Despite increasing attention to justice-oriented spatial planning approaches, risk perception is seldom integrated explicitly as an analytical component within ES-landscape assessments (Caretta and McHenry, 2020; Urkidi Azkarraga and Gurrutxaga, 2024).

Wind-energy infrastructures may constrain landscape multifunctionality by competing with ES supply and intensifying spatial inequalities (Hastik et al., 2015; Espécie et al., 2019). These trade-offs often undermine local values attached to the territory, reinforcing local opposition (Enevoldsen and Sovacool, 2016; Scorza et al., 2020). In Chile, wind-energy development has progressed under a predominantly top-down, market-oriented policy framework characterized by limited participation and information asymmetries (Acuña Reyes, 2015; Schaeffer and Smits, 2015). Such dynamics amplify existing social inequalities (OECD, 2020) and contribute to recurring conflicts around renewable energy (Delamaza et al., 2017), particularly where projects overlap with agricultural areas, cultural landscapes, or territories historically exposed to extractive pressures, sometimes described as “sacrifice zones” (Arrese and Wells, 2016; Blanco-Wells, 2019; Castán Broto and Sanzana Calvet, 2020; Hernando-Arrese and Rasch, 2022).

The Biobío region has emerged as a key hotspot of energy-related socio-environmental conflict in Chile and shows strong tendencies toward contestation of new projects (Tironi and Pirkovic, 2017). Despite its role as an important energy hub, public concern about cumulative impacts remains high (Castán Broto and Sanzana Calvet, 2020). National policy instruments, including Law 20.257 and the Green Hydrogen Action Plan 2023–2030, are accelerating project expansion, adding new socio-territorial pressures. Together, these dynamics underscore a critical empirical and conceptual gap: the need to understand how communities, in rapidly transforming landscapes, integrate perceptions of ES, risk, justice, and landscape change when evaluating wind-energy expansion, particularly in territories where multifunctionality and local identities are already under strain.

This study adopts a constructivist sociological approach, conceptualizing risk as both material and socially constructed (Kasperson et al., 1988; Renn et al., 1992; Beck, 1998). We integrate three complementary analytical frameworks to examine wind energy development as a socio-territorial process. First, landscape multifunctionality and ecosystem services to capture the material, ecological, and relational changes experienced in rural territories, are understood as landscapes’ capacity to deliver multiple ecological and social benefits, provide a complementary lens (Termorshuizen and Opdam, 2009; Mastrangelo et al., 2014; Li et al., 2020). Landscapes are thus conceptualized not as merely physical backdrops but as socially constructed territories where biophysical and human processes interact in complex ways (Gailing and Leibenath, 2015). When energy infrastructures alter these dynamics, they affect ecological processes as well as the social recognition and valuation of services (Dwivedi et al., 2022). Second, Energy Justice provides a normative lens to assess how these changes are distributed, governed, and recognized across social actors. Third, we apply the Social Amplification of Risk Framework (SARF) which explains how these material and normative dimensions are translated into perceptions of risk through symbolic meanings,

social interactions, and institutional practices. SARF examine how symbolic, cultural, and institutional processes shape public responses to energy infrastructures (Slovic, 2000; Fast et al., 2016). Together, these frameworks allows to analyze how perceived injustices contribute to the amplification of risk in renewable energy transitions, and how risk perception becomes a vehicle for articulating justice claims. In this study, risk perception and energy justice are not treated as parallel or competing frameworks. Rather, risk perception is conceptualized as a socio-cognitive mechanism through which procedural, distributive, and recognitional injustices are experienced, interpreted, and articulated at the territorial level.

Empirical evidence from Chile shows that risk amplification emerges from perceived landscape transformations, weakened place-based relations, and declining institutional trust (Vallejos-Romero et al., 2020; Vargas-Payera et al., 2020; Alarcón-Barrueto, 2025). Moreover, research on renewable energy projects shows that perceived reductions in ES contribute directly to social construction of risks and local opposition (Cordoves-Sánchez and Vallejos-Romero, 2019). Building on these insights, this study advances the working hypothesis that the social amplification of risk around wind energy projects is associated with three interrelated factors: (1) perceived loss of landscape functions and ES; (2) the strength of place attachment; and (3) deficits in trust and procedural quality, particularly in participation, information, and communication. Accordingly, the study explores how wind energy development reconfigures the perceived landscape as well as to understand how these transformations translate into different forms of perceived risk (ecological, functional, sociocultural, and visual), and how procedural and distributive factors influence risk amplification and opposition. Here the recognition dimension is treated as a transversal analytical axis that emerges inductively from the empirical material and directly links justice claims to risk perception.

Drawing on a qualitative fieldwork conducted in 2024 across five municipalities in Biobío, this study contributes to: 1) providing empirical evidence on the social construction of risk for Latin America towards the context of the wind energy transition; 2) proposing a conceptual bridge linking perceived ES, landscape multifunctionality, and energy justice, particularly its procedural and distributive dimensions; 3) offering a qualitative methodological contribution through the integration of coded interviews and co-occurrence analysis, and (4) outlining implications for early participation and landscape-sensitive territorial governance.

2 Contextualization

2.1 Historical trajectories of energy development and extractivism in Chile

Wind energy development in Chile unfolds within longer socio-environmental trajectories of extractivism and centralized governance that shape contemporary perceptions of risk, justice, and legitimacy. Large-scale hydropower marked the initial phase of this transition, particularly in southern Chile, where projects expanded into rural and Indigenous territories under regulatory frameworks that inadequately recognized territorial rights, reflecting

colonial legacies that treated land and water as economic resources detached from cultural and relational meanings (Bórquez et al., 2021).

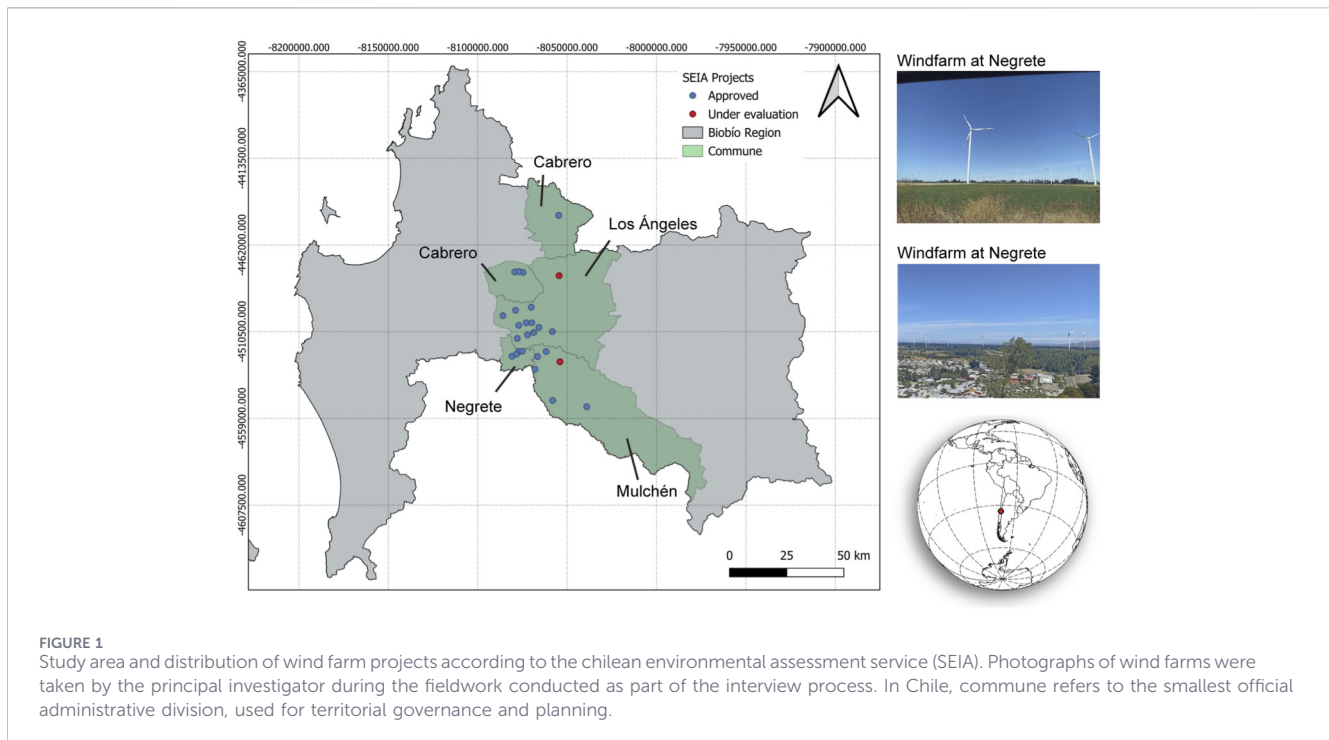
Hydropower development in southern Chile has been widely interpreted through water extractivism, understood as a political-historical mode of resource appropriation through which state and private actors secured control over water while marginalizing territorial relations and local governance (Torres Salinas et al., 2022). Emblematic conflicts such as HidroAysén crystallized these tensions, triggering mobilization, enduring mistrust toward institutions and energy companies, and the consolidation of civil society organizations shaping territorial narratives and governance (Vallejos-Romero et al., 2016; Silva and Nasirov, 2017; Serra, 2022). These extractivist legacies provide an interpretive frame through which contemporary renewable energy projects, including wind energy, are evaluated by local communities.

2.2 From hydropower to renewables: continuity of technocratic governance

From an institutional perspective, low-carbon energy projects in Chile are governed through technocratic arrangements that confine participation to formal procedures shaped by strong power asymmetries. Although justice-oriented discourses have been incorporated into policy, they have not redistributed decision-making authority, resulting in late consultation and largely procedural participation (Serra, 2022). Empirical evidence shows that socio-environmental conflicts may delay but rarely block project approval, revealing governance arrangements that absorb contestation while privileging technical expertise over place-based knowledge without addressing its structural causes and reinforcing epistemic asymmetries and limiting the effective recognition of local perspectives in decision-making processes (Bórquez et al., 2021; Huneeus et al., 2021; Serra, 2022).

2.3 The Biobío region as a socio-territorial hotspot

The Biobío region is a hotspot of socio-environmental conflict where wind-energy expansion overlaps with agricultural and forestry landscapes already shaped by extractivism and cumulative environmental pressures. Concerns over cumulative impacts, landscape transformation, and the erosion of local livelihoods are particularly pronounced, and are likely to intensify as national policy instruments, including Law 20.257 and the Green Hydrogen Action Plan 2023–2030, accelerate renewable energy deployment (Castán Broto and Sanzana Calvet, 2020). Long-standing processes of land appropriation and institutional neglect have produced persistent mistrust, amplifying the relevance of local perceptions in shaping project acceptance or opposition. Wind energy development in Biobío is thus layered onto already contested and transformed territories shaped by hydroelectric projects, industrial forestry, and associated infrastructure, rather than occurring on a neutral or empty landscape. Although Indigenous communities were not direct actors in this study, indigenous struggles form part of the broader historical context shaping local narratives of risk and injustice.



3 Materials and methods

This study applied a qualitative design based on in-depth territorial case study. This design is particularly suited to examining how risk, justice, and landscape change are socially constructed and negotiated across multiple actor groups. The methodological approach integrated theoretical, spatial, and perceptual dimensions to examine how wind-energy expansion relates to landscape multifunctionality and risk perception. The study followed three sequential stages: (1) study area selection and contextual characterization; (2) data collection and coding; and (3) analytical integration and triangulation. This structure ensured transparency and reproducibility.

3.1 Study area and participant selection

The study was conducted in the Biobío region, Chile, which concentrates the highest number of wind-energy projects in southern Chile and plays a key role in the Green Hydrogen Action Plan 2023–2030. Five predominantly rural or semi-rural municipalities were selected (Negrete, Laja, Mulchén, Los Ángeles, and Cabrero; [Figure 1](#)). According to existing research on regional productive restructuring and rural territorial dynamics in the Biobío region ([Maturana Miranda et al., 2016](#)), these territories are embedded in a strongly hierarchical regional system and are characterized by mixed local livelihoods combining small-scale agriculture, forestry-related activities, livestock production, and seasonal wage labor. These processes have shaped socio-territorial configurations in which land and water hold not only productive but also cultural and affective value, reflecting strong place-based relationships with the landscape. The region has also undergone significant historical-economic transformations, including a major productive restructuring from agricultural to forestry activity, with

implications for regional labor markets and daily mobility linkages between municipalities and provincial/regional hubs ([Maturana Miranda et al., 2016](#)). The municipalities were selected through theoretical sampling to capture variability in project trajectories, distinguishing between territories hosting operational wind farms and those where projects were under planning, approval, or environmental evaluation. This distinction enabled comparison between consolidated landscape transformation and anticipated or projected change.

Participant selection followed a purposive and stratified sampling strategy aimed to gain an in-depth understanding of social processes rather than measure population-level tendencies ([Martínez-Salgado, 2012](#)). Inclusion criteria emphasized (a) direct involvement with wind-energy projects, (b) institutional relevance, and (c) knowledge of territorial dynamics. Participants were grouped into four main categories: 1) Political-institutional actors, including representatives from local and regional governments, as well as ministries such as Energy and Environment; 2) Organized civil society, comprising community leaders, environmental organizations, and neighborhood associations; 3) Economic and energy sector actors, including company representatives, consultants, and professionals involved in project development; 4) Academic actors, representing universities and research institutions engaged in regional environmental or social studies. This typology provided a multi-scalar understanding of governance and risk perception, linking local experiences of landscape change to broader institutional narratives about the energy transition. Participants were identified through public records, media coverage, and documented involvement in territorial debates and contacted directly by telephone or email when possible. As no formal prior relationships existed with most participants, particular care was taken to minimize power asymmetries by clearly communicating

TABLE 1 Group of actors description.

| Type of actor | Spatial influence | N | Total |
|-------------------------|-------------------|----|-------|
| Political–institutional | Local | 7 | 14 |
| | Regional | 7 | |
| Organized civil society | Local | 23 | 23 |
| | Regional | 0 | |
| Private sector | Local | 1 | 2 |
| | Regional | 1 | |
| Academia | Local | 1 | 2 |
| | Regional | 1 | |

research objectives, ensuring voluntary participation, and adopting an open-ended interview format that allowed participants to frame issues in their own terms. Such reflexive attention to researcher–participant relationships respond to well-documented methodological challenges associated with fieldwork in socio-environmental conflicts and energy transition contexts, where uneven power relations and procedural injustices are common (Charmaz, 2014; Caretta and McHenry, 2020; Barragan-Contreras, 2022; Hernando-Arrese and Rasch, 2022).

3.2 Data collection and coding

Fieldwork was conducted between July 2023 and February 2024. During data collection, 41 semi-structured interviews were conducted in person, with an average interview duration of 60–90 min. Respondent details are presented in Table 1. Interview guides were designed based on the study's main theoretical frameworks: Ecosystem Services, landscape multifunctionality, risk perception, and the Social Amplification of Risk Framework (SARF), to explore how these dimensions are expressed in local narratives. Interview questions are available in Supplementary Material. All interviews were audio-recorded with prior informed consent. Transcripts were coded in Atlas.ti 25, combining deductive and inductive strategies. Deductive codes operate theoretical categories such as risk, justice, and multifunctionality, while inductive codes captured locally emergent meanings. Each coded segment was labeled with actor type, thematic category, and subcode for further analyses. While the interview guide was informed by predefined theoretical dimensions, the coding process remained open to emergent meanings that were not anticipated in the initial analytical framework.

3.3 Data analysis

Qualitative analysis followed a constructivist grounded approach (Charmaz, 2014), focusing on how actors construct meanings around environmental change rather than treating their accounts as factual statements about impacts. Qualitative and topic modeling analyses were conducted independently. Codes were generated through a combination of deductive and inductive strategies, a common practice in qualitative research that allows theoretical concepts to be operationalized while remaining

open to locally emergent meanings (Martínez-Salgado, 2012; Charmaz, 2014). Deductive codes operationalized theoretical dimensions derived from major research dimensions: characterization and landscape relation; trust and information; governance and management; and risk, response, and solutions. While inductive codes capture locally emergent meanings and narratives not anticipated *a priori*. These blocks served as an analytical and reporting structure rather than a restrictive coding framework and were refined iteratively as new themes emerged during analysis, consistent with constructivist grounded theory principles (Charmaz, 2014).

This structure facilitated the exploration of connections between perceived changes in ES (provisioning, regulating, cultural, and supporting) and risk narratives. Triangulation was achieved through two complementary strategies: (1) by contrasting coded data with the conceptual dimensions that informed the interview design (Ecosystem Services, risk perception, multifunctionality, and justice); and (2) by comparing perspectives across actor categories and spatial contexts, an approach widely used in socio-environmental and energy transition research to address multiple scales and positionalities (Blanco-Wells, 2019; Cordoves-Sánchez and Vallejos-Romero, 2019). This process allowed identification of cross-cutting themes that did not fully align with the initial deductive categories, particularly those related to recognition and symbolic dimensions of risk.

In parallel, an independent topic modeling analysis using Latent Dirichlet Allocation (LDA) was applied to identify recurrent semantic patterns across actor groups. The analysis was conducted without imposing predefined categories or reference to the qualitative coding scheme, allowing exploration of convergence and divergence between computational patterns and qualitative interpretations. Such mixed-methods text analysis approaches are increasingly used to complement qualitative interpretation in energy and environmental governance studies (Ram and Webler, 2022; Tsani et al., 2024). Transcripts were segmented by actor type, and a preprocessing pipeline was applied (tokenization, lowercasing, stopword removal, bigram construction, and lemmatization). The LDA models were estimated separately for each actor group using the “topicmodels” package in the R software, allowing capture the discursive structure specific to each governance scale. The optimal number of topics per actor ($k = 3$) was determined through coherence diagnostics and interpretability criteria, following established guidelines in mixed-methods text analysis. High-probability terms and bigrams supported integration with qualitative findings, strengthening analytical triangulation.

The integration between qualitative analysis and topic modeling results occurred only at the interpretation stage. Topic outputs were examined qualitatively and contrasted with coded narratives to assess whether they reinforced or extended the qualitative analysis. Topics highlighting issues weakly represented in the coding structure were retained and examined qualitatively, contributing to a more comprehensive interpretation.

3.4 Ethical procedures

This research complied with Chilean national regulations and institutional standards for social science research. The study was approved by the Ethics Committee of Universidad de La Frontera

Topics (Civil Society)

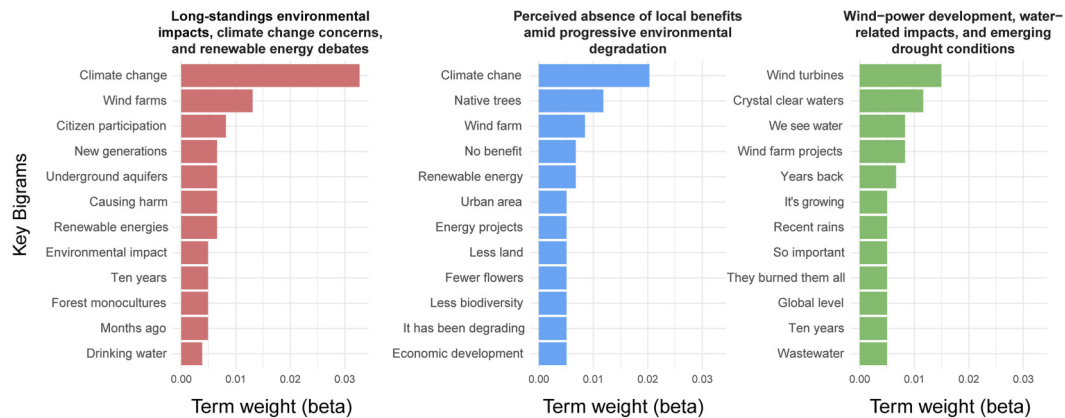


FIGURE 2 Topic model for civil society participants. Latent dirichlet allocation (LDA) results showing three dominant topics in civil society discourse: (1) long-standing environmental impacts, climate change concerns, and renewable energy debates; (2) perceived absence of local benefits amid progressive environmental degradation; and (3) wind-power development, water-related impacts, and emerging drought conditions.

Topics (Political Authorities)

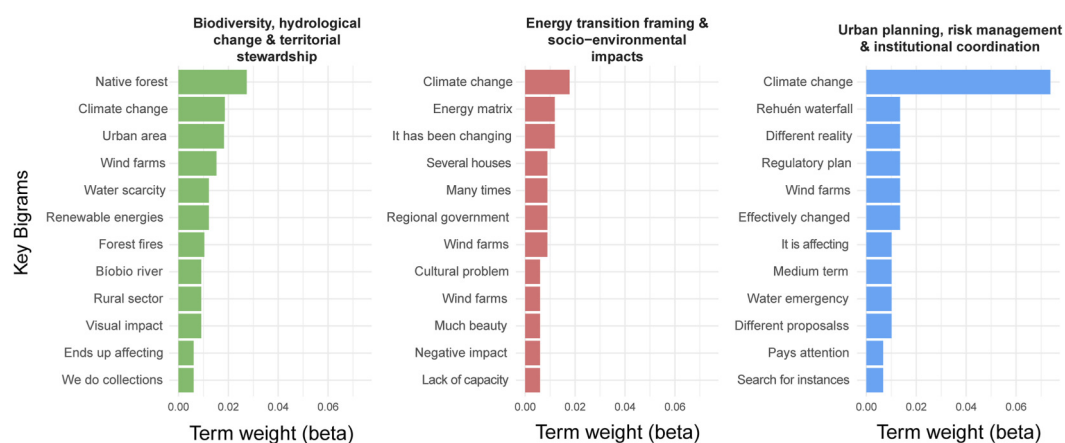


FIGURE 3 Topic model for political authorities. Three discursive clusters emerge: (1) biodiversity, hydrological change, and territorial stewardship; (2) energy transition framing and socio-environmental impacts; and (3) urban planning, risk management, and institutional coordination.

(Approval N°015/23). Written informed consent was obtained from all participants. Participants were guaranteed anonymity and confidentiality; no identifying personal data were collected. Each transcript was coded with a unique alphanumeric identifier to preserve traceability while ensuring privacy. Data was stored securely and used exclusively for research purposes.

4 Results

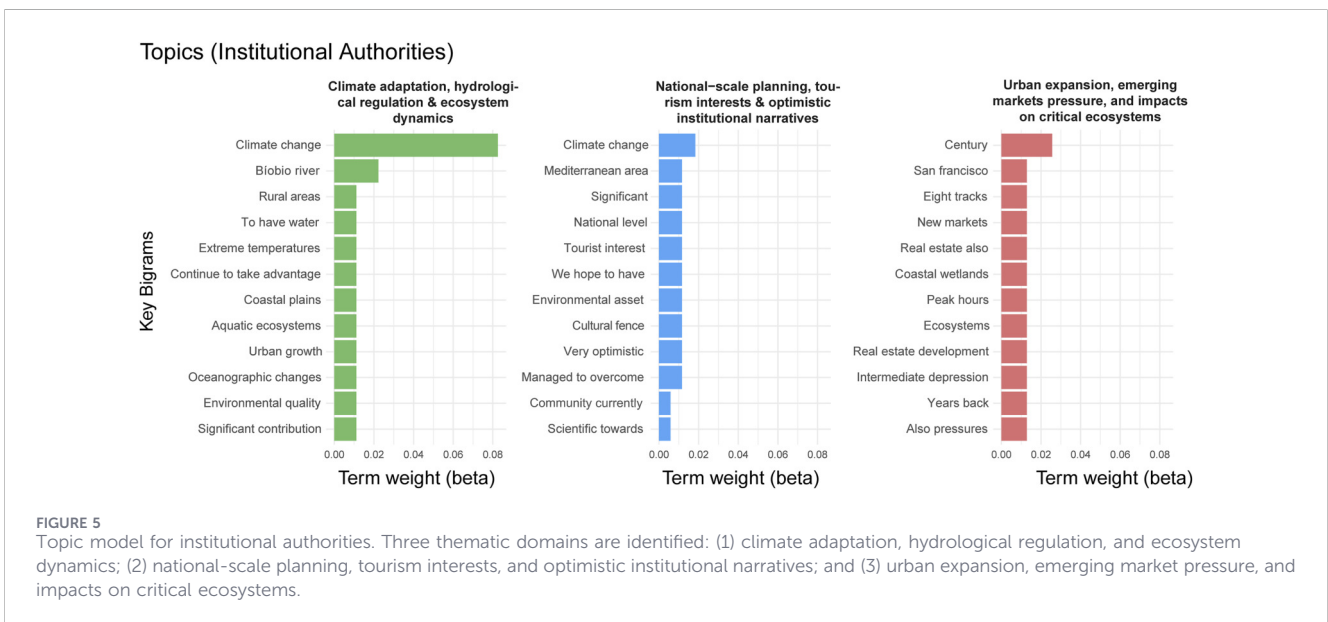
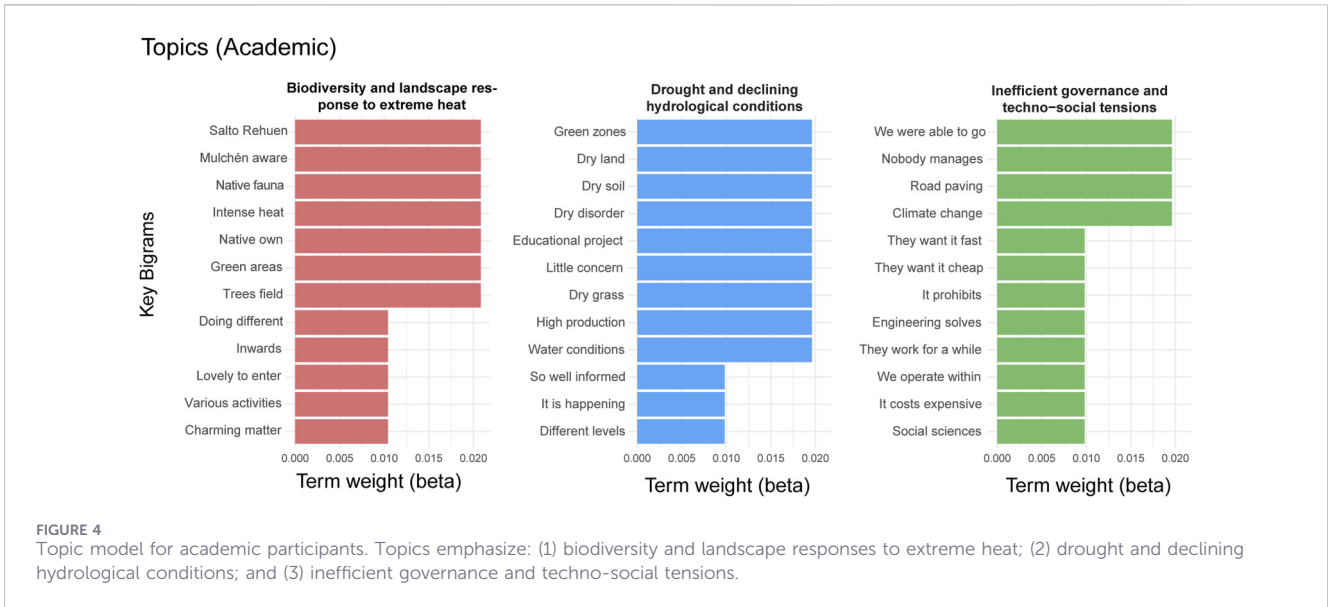
4.1 Topic model analysis

Topic modeling was used as an exploratory and complementary tool to identify recurrent semantic patterns across actor groups,

supporting the qualitative analysis of risk, governance, and landscape change.

For civil society (Figure 2), bigrams cluster around three themes: (1) long-standing environmental impacts, climate change concerns, and renewable energy debates; (2) perceived absence of local benefits amid progressive environmental degradation; and (3) wind-power development, water-related impacts, and emerging drought conditions. Terms such as “wind farms,” “citizen participation processes,” “no benefit,” “native trees,” “drinking water,” and “months ago” show how procedural exclusion is articulated together with cumulative territorial degradation and concerns over unequal socio-environmental impacts.

For political authorities (Figure 3), topic analysis shows three axes: (1) biodiversity, hydrological change, and territorial



stewardship; (2) energy transition framing and socio-environmental impacts; and (3) urban planning, risk management, and institutional coordination. This configuration suggests that conflicts are interpreted mainly as managerial and planning shortcomings, rather than as expressions of structural power or recognition of asymmetries.

For academic participants (Figure 4), topics concentrate on: (1) biodiversity and landscape responses to extreme heat; (2) drought and declining hydrological conditions; and (3) inefficient governance and techno-social tensions, reflecting their diagnostic and mediating role in territorial debates.

For institutional authorities (Figure 5), topics are organized around: (1) climate adaptation, hydrological regulation, and ecosystem dynamics; (2) national-scale planning, tourism interests, and optimistic institutional narratives; and (3) urban

expansion, emerging market pressure, and impacts on critical ecosystems. These patterns point to a technocratic, development-oriented framing in which conflict is treated primarily as a planning and management challenge.

4.2 Energy justice and governance

Results are presented comparatively across actor groups, highlighting how procedural, recognition, and distributive dimensions of energy justice are articulated differently across narratives.

Civil society participants articulated feelings of exclusion and mistrust toward both governmental and private institutions, frequently linking these to the opacity of decision-making and the lack of effective participation. One interviewee (E23) reflected:

“They already had all the permits when we found out. So, what’s the point of participating?”

Others (E18) emphasized that even when participation mechanisms existed, they were symbolic rather than substantive:

“They call it consultation, but decisions are already made”.

These statements exemplify what participants perceived as procedural injustice, the sense that decisions occur elsewhere, beyond their influence. Together, qualitative narratives and topic modeling (Figure 2) point to a coherent discourse: procedural mistrust is embedded in environmental and territorial concerns, not separate from them. For civil society, exclusion from decision-making intersects with visible transformations of water, land, and local ecosystems, amplifying the perception that energy transitions are externally imposed and socially uneven.

Political authorities often acknowledged these perceptions but framed them primarily as coordination or communication issues rather than as structural governance deficits. One municipal representative (E13) noted:

“Communities expect answers we cannot give because companies manage the projects directly”.

This highlights a fragmented governance system in which responsibility is diffused between public and private actors, leaving local governments with limited agency and communities without clear interlocutors.

Institutional and academic actors tended to conceptualize justice in technical or legal terms, referring to the Environmental Impact Assessment (EIA) and the formal compliance of consultation mechanisms. However, their testimonies revealed an implicit awareness of recognition gaps. One academic participant (E16) remarked:

“The problem is that we do have participation, but it’s formal - not cultural. The knowledge that communities bring is rarely part of the evaluation”.

This statement underscores the disjunction between regulatory legitimacy and social legitimacy, a tension widely documented in energy governance literature (Karlsson-Vinkhuyzen, 2015; Donadelli and van der Heijden, 2024).

At the community level, distributive injustice was framed through everyday experiences of environmental degradation and unfulfilled promises. Interviewees described that while companies gained access to land and profit, communities were left with landscape alteration and limited compensation. As one local leader (E19) put it:

“We are asking for the responsibility that companies should have with the community”.

Such claims highlight the expectation of reciprocity and shared benefit, which remains largely unmet.

Although recognition was not initially operationalized as a separate analytical category, it emerged inductively through repeated references to the exclusion of local knowledge, identities, and territorial meanings. In this sense, a transversal pattern emerges across actor groups: wind energy projects are seen as reproducing, rather than redressing, territorial inequalities. The sense of injustice is cumulative, drawing on long histories of extractivism, marginalization, and spatial neglect. Wind energy, though framed as sustainable, is described by several participants as “*the same model with a new face*”.

From a governance perspective, these findings reveal the fragility of participatory mechanisms in mediating power asymmetries. Institutional emphasis on procedural compliance contrasts with community demands for recognition of their knowledge, identities, and territorial attachments; when such recognition is absent, renewable energy transitions risk producing “*green injustices*” in which environmental goals are pursued at the expense of social legitimacy. In summary, the discourse of justice around wind energy in Biobío Region goes beyond material distribution or formal participation to encompass symbolic and epistemic dimensions of governance. For communities, justice entails the right to be informed, heard, and to co-decide, not merely to be consulted, aligning with a territorial ethics of sustainability that links environmental responsibility with cultural continuity and democratic agency.

4.3 Risk perception and landscape transformation

Risk perception in the Biobío Region is articulated through material, symbolic, and emotional registers, showing that perceptions of risk around wind projects are deeply intertwined with social memory, lived territorial change, and collective wellbeing. Beyond technical concerns (noise, shadow flicker, biodiversity), dominant narratives emphasize territorial degradation and loss of identity, showing that perceptions of risk around wind projects are deeply intertwined with social memory, lived territorial change, and collective wellbeing.

For members of civil society, risk is often expressed in relational rather than technical terms, as the cumulative outcome of historical neglect, extractive pressures, and the unequal distribution of benefits. One participant (E09) explained:

“It’s difficult because most of the territory here in Mulchén, around seventy percent, is forestry monoculture. The rest is in private hands, so the management of the landscape depends on private decisions rather than collective ones”.

This statement situates the perception of risk within a landscape already dominated by privatized land use and environmental degradation, suggesting that new projects are interpreted through a lens of pre-existing vulnerability rather than as isolated interventions. Other interviewees described the progressive loss of environmental balance as a form of erosion that transcends visible impacts. One (E10) noted:

“We no longer talk about rivers; we talk about lakes because the water does not flow anymore”.

This imagery conveys perceptions of ecological and institutional stagnation, where landscape change is associated with decline, dispossession, and threats to the continuity of local ways of life.

Among political and institutional actors, risk tended to be framed through management and adaptation discourses. A municipal representative (E13) highlighted the difficulty of mobilizing communities, observing that:

“People do not externalize the importance of their surroundings . . . maybe new generations will be more sensitive.”

These framing positions environmental concern as a generational or educational issue rather than as a symptom of procedural exclusion and thereby shifting responsibility away from governance structures.

Academic participants (E16), in contrast, described risk perception as a product of information asymmetry and weak environmental literacy:

“People are not well informed, so they do not understand the real risks or the benefits. There’s a lot of misinformation.”

While this diagnosis underscores the need for improved communication, it also reflects a technocratic bias that tends to downplay the emotional and cultural dimensions of territorial risk.

Across interviews, the notion of “*slow degradation*” appeared, a perception that change accumulates subtly but inexorably, altering the landscape’s ecological and symbolic integrity. Civil society actors (e.g., E11) often related this to feelings of abandonment and lack of control:

“We are like the backyard . . . between the forestry and now the wind farms.”

This perception of slow degradation operates as an amplification mechanism, through which incremental landscape change is experienced as cumulative loss and procedural abandonment. This evokes marginalization and spatial injustice in which risk becomes synonym of invisibility and exclusion from decision-making.

Overall, risk perception operates as a diagnostic of both environmental and procedural justice, extending beyond turbines to a broader continuum of territorial inequity. Participants articulate a form of “*symbolic risk*”: the perceived loss of identity, belonging, and agency amid accelerated landscape transformation. Landscape change is thus interpreted not as neutral modernization but as a socially contested reconfiguration of space. Risk functions as a cultural and political resource through which communities express grievances, defend place-based values, and demand recognition, encompassing both epistemic deficits (lack of credible information) and existential threats to landscape continuity, underpinning a symbolic defense of territory and a refusal to become “*zones of sacrifice*” in the name of sustainability. These patterns are echoed in topic-modeling results, where themes of slow degradation, hydrological change, biodiversity loss, and declining territorial control recur across actor groups (Figures 2–5).

4.4 Perceptions of ecosystem services as a lens on landscape multifunctionality

Across actor types, a shared concern emerged regarding the erosion of landscape multifunctionality (the capacity of territories to sustain ecological, cultural, and economic functions simultaneously). Loss of Ecosystem Services (ES) was perceived not only as environmental degradation but as a rupture in identity, autonomy, and emotional connection to place. From this perspective, multifunctionality represents more than ecological productivity: it is the social and emotional foundation of territorial wellbeing. Recognizing both instrumental and symbolic dimensions of ES thus emerges as a key dimension for understanding claims around fairness and participation in energy planning.

In Biobío, ES are experienced not as abstract ecological categories, but as lived relationships that sustain identity, meaning, and daily life. Interviewees linked material, cultural, and ecological values to their sense of belonging

and justice, framing ES as indicators of both wellbeing and fairness in the energy transition. Topic clusters related to ES, such as clean water, native trees, green areas, water scarcity, and biodiversity, further corroborate the centrality of landscape as an axis of identity and wellbeing and correspond to the first link in the causal chain (“*what changes and how it is perceived*”; Figure 5).

For civil society, ES were described through direct, embodied experience, the land as a source of sustenance, memory, and calm. Provisioning and cultural services dominated their narratives, with water, soil fertility, and tranquility cited as the most tangible expressions of wellbeing, as expressed by one member (E07):

“We used to have clear water in the streams, but now it’s less and less; you cannot even use it for irrigation anymore.”

Ecological degradation was associated with loss of autonomy and distributive injustice in a landscape largely controlled by forestry companies, as exemplified by a participant (E09):

“Most of the land here belongs to forestry companies, so the management of the landscape is in private hands. We have no say in what happens.”

Wind farms were perceived as amplifying these asymmetries, operating as an interruption function that disrupts both ecological cycles and symbolic continuity through which landscape multifunctionality is sustained. Everyday landscapes, once experienced as peaceful or spiritually resonant, are now marked by industrial intrusion:

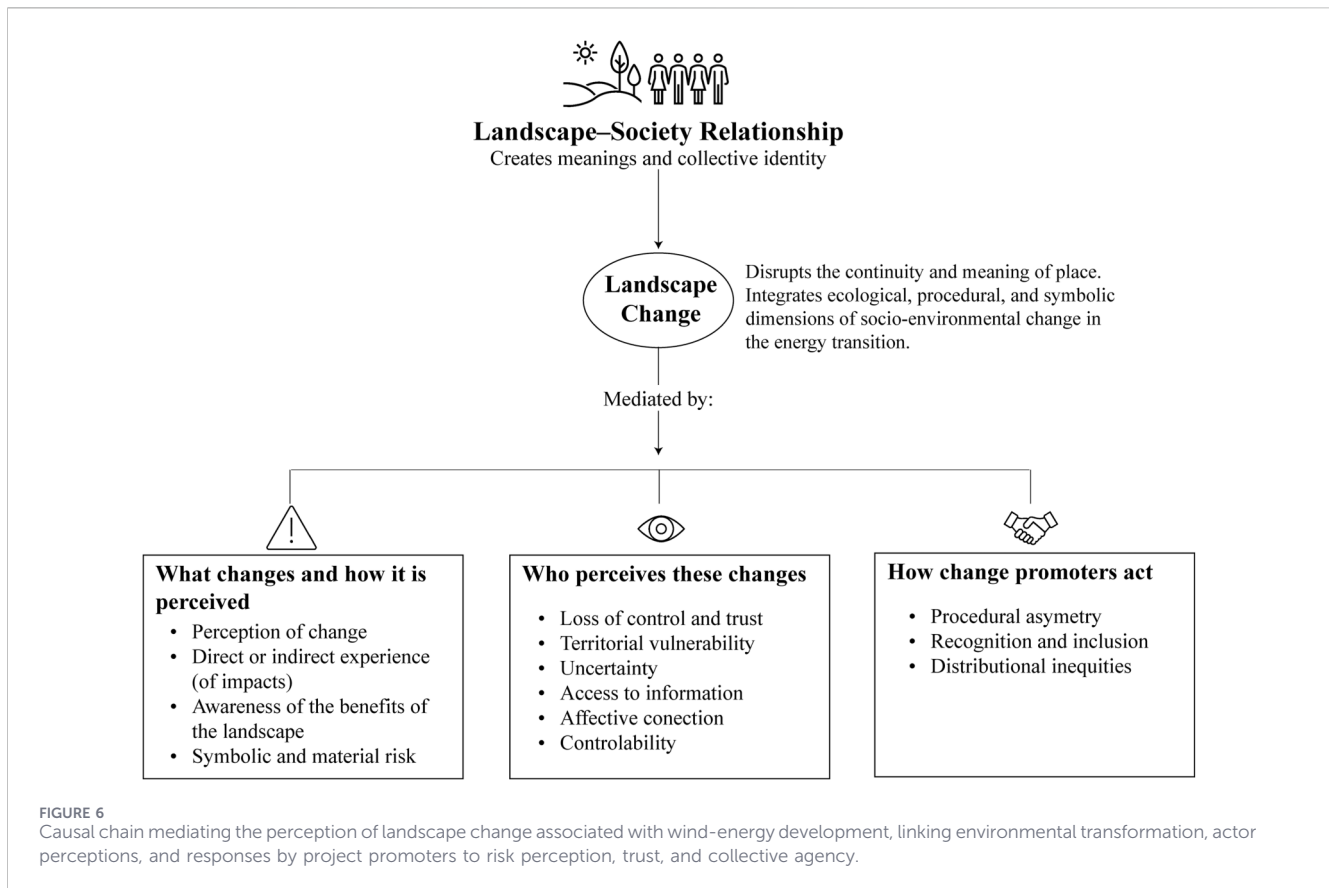
“It changes the feeling of the horizon . . . you’re not in your place anymore” (E10; E25).

Municipal and regional authorities primarily interpreted ES through regulating and supporting functions (water retention, soil stability, microclimate moderation), linking them to governance and adaptation challenges rather than to affective meanings. Their discourse reflected an instrumental view of multifunctionality as a technical condition that can be restored through improved management or coordination, with limited recognition of the link between ecological performance and social legitimacy.

Academic and private-sector participants emphasized supporting and regulating services, describing them in diagnostic terms such as biodiversity, ecosystem connectivity, or soil regeneration. In contrast, although several academic actors acknowledged the importance of reconnecting scientific and experiential knowledge, communities were frequently positioned as data providers rather than as co-producers of knowledge within governance processes (Klain et al., 2018; Blanco-Wells, 2019). Calls to bridge scientific and experiential forms of knowledge were framed to strengthen the legitimacy of environmental governance, echoing broader discussions on risk, learning, and ecosystem services (Blennow et al., 2014; Klain et al., 2018).

4.5 Causal chain mediating the perception of landscape change

The causal chain mediating landscape change (Figure 6) synthesizes how communities link environmental transformation, institutional trust, and collective action. It



distinguishes three components: (a) what changes and how they are perceived, (b) who perceives these changes, and (c) how change promoters act, connecting ecological, procedural, and symbolic dimensions of justice. Rather than assuming a linear progression, the causal chain illustrates how material landscape change becomes socially meaningful through institutional mediation, shaping risk perception and enabling (or constraining) collective responses.

4.5.1 Procedural information, recognition, and the governance gap

Access to information emerged as a recurrent theme across interviews, particularly among civil society actors, who described their experience as one of restricted or fragmented access to information about wind energy projects, their environmental implications, and associated decision-making processes. This deficit was perceived as a structural feature of governance practices that privilege technical formality over direct, transparent communication. Informational exclusion was depicted as both spatial and procedural. Information rarely reached rural areas and, when it did, it was mediated through community leaders rather than official channels:

“We are not informed; everything comes from the government downwards, and it stays in the urban part. In rural areas, it depends on what the community leader can bring to us.” (E07).

These accounts show how informal or *ad hoc* participation structures reproduce informational asymmetries and territorial

inequities. Local actors perceived information dissemination as neither transparent nor consistent. One interviewee (E25) described the circulation of project information as an informal and cautious process:

“When we go there, we do all the paperwork and start transferring information, but you cannot be too open because people might twist it or take it elsewhere.”

As a result, access to information depends on personal networks rather than institutional guarantees, giving rise to informal systems of knowledge circulation that compensate for weak official communication.

Academia participants acknowledged the existence of a generalized disconnection between information availability and accessibility. As one researcher (E16) observed:

“It’s happening a lot, but I feel that since we do not have a space to share and learn together, there’s misinformation; people are not well informed.”

This illustrates that the issue is not necessarily a lack of data, but rather a failure to translate technical or regulatory information into formats understandable to communities, a communicative rather than a cognitive gap.

Political authorities, meanwhile, tended to interpret the lack of information as a social rather than institutional problem. One municipal representative (E13) stated:

“People still look inward; they do not externalize the importance of their environment. We still see people dumping garbage, stealing plants from public squares ... it’s difficult, but maybe new generations will be more sensitive.”

This statement repositions responsibility toward individual behavior and civic culture, diluting institutional accountability and normalizing procedural asymmetries.

Across actor types, responsibility for communication appeared diffuse: civil society blamed institutions and companies, while institutional representatives attributed disinterest or limited capacities to citizens. This misalignment reproduces procedural injustice, as access to timely, comprehensible information depends on personal initiative instead of institutional design, and the opacity of communication channels both undermines participation and trust. As project impacts became visible, several communities in Biobío initiated self-organized strategies to respond, forming informal networks, engaging universities, and disseminated information through local media, often combining environmental concern with territorial defense. Public demonstrations and collective mobilizations emerged almost inevitably, signaling a shift from passive observation to active participation. These actions reflect an awakening of participatory engagement rooted in lived experience rather than institutional invitation. While such initiatives demonstrate resilience and adaptive capacity, they also expose persistent structural inequalities in informational and cognitive access, hallmarks of procedural injustice.

Within the causal chain, informational deficits operate as a critical mediating mechanism. Limited, fragmented, or mistrusted information does not merely constrain participation but actively amplifies perceptions of risk by preventing communities from contextualizing landscape change, evaluating trade-offs, and influencing decisions. As a result, procedural opacity transforms material landscape impacts into broader narratives of threat, exclusion, and loss of control.

4.5.2 From awareness to agency: Conditions for collective action

Environmental awareness and civic engagement emerged as dynamic yet uneven dimensions across interviews, reflecting varying degrees of concern, agency, and fatigue among social actors. Attitudes toward environmental action are shaped not only by individual commitment but also by structural conditions such as information access, institutional responsiveness, and long-standing territorial exclusion.

At the first stage of the causal chain, environmental awareness emerges as a situated and experiential process civil society participants frequently framed their environmental awareness as a lived, situated experience rather than an abstract environmental ideology. Their understanding of the landscape emerged through daily interactions, local observation, and shared histories of transformation. In rural areas such as Mulchén and Laja, interviewees emphasized that environmental learning and concern are constrained not only by privatized land use but also by uneven access to information and participation. As one community member explained:

“People here are not well informed. From the government downward, the concern is mostly urban, maybe ninety-five percent. In rural areas, information depends entirely on what the local leader can bring back to the community. If I do not attend every meeting, I cannot share that information with them.” (E07).

This reflection situates environmental awareness within a context of limited institutional communication and fragmented social organization, where the ability to act collectively depends on informal leadership and uneven flows of information. Such conditions transform environmental awareness into a relational process, one mediated by territorial inequalities, dependence on intermediaries, and the cumulative experience of exclusion. However, while these dynamics are more visible at the regional and private-sector levels, some local governments have attempted to reduce such gaps by organizing information meetings and direct visits to communities. Yet, these efforts seldom translate into broader participation or decision-making power. Interviewees described experiences of “*social punishment*” and institutional stigmatization toward community leaders who voice opposition:

“The social punishment imposed by the authorities and the way they make us socially invisible, both as an organization and as individuals, is extremely strong. (.) when a project is coming, (local authorities) goes to the communities beforehand and says: ‘Neighbors, a project is coming. Now we will have the citizen participation process, but there’s nothing to be done (...) these projects will go ahead anyway. You just have to submit your comments.’ He even offers money so that communities can hire professionals to help them prepare their comments, but on the condition that a particular community does not take part.” (E06).

When repeated experiences of exclusion accumulate, awareness does not translate into empowerment but into fatigue, resignation, or strategic withdrawal. These practices reveal a selective approach to participation in which some communities are marginalized from consultation processes, reproducing structural asymmetries in recognition and access. For many participants, environmental concern coexisted with frustration and resignation. Repeated exposure to extractive activities, unfulfilled promises, and weak participation mechanisms fosters what several interviewees described as “*learned helplessness*”. Some community members identified active environmental monitoring or recycling as ways to reclaim agency, while others admitted to a growing detachment:

“We try to do things, but people are tired; nothing really changes.” (E06).

These expressions highlight the emotional dimension of environmental awareness, a mix of care, fatigue, and disillusionment that affects the sustainability of collective action.

Academic and institutional actors tended to interpret environmental engagement through the lens of education and cultural change. As one university participant (E16) observed:

“People are starting to understand more about their surroundings, but it’s slow. Education takes time, and many are still disconnected from how the environment affects their lives.”

This perspective positions awareness as a developmental process rather than a political claim, emphasizing cognitive rather than structural barriers.

Political authorities, on the other hand, often attributed the lack of environmental participation to citizens’ indifference or insufficient civic culture. One municipal official (E13) argued:

“There are still people who do not externalize the importance of their surroundings. Some still throw garbage in public spaces or refuse to recycle. Maybe new generations will have more sensitivity.”

This narrative of individual responsibility contrasts with the structural constraints identified by local communities and reflects a

tendency to moralize environmental behavior while minimizing institutional accountability. Despite these differences, a transversal pattern emerges, that is environmental awareness is present but unevenly supported. Communities demonstrate willingness to act but lack consistent institutional backing and recognition. Their engagement often takes the form of localized, reactive efforts such as organizing community clean-ups, sharing knowledge through social networks, or defending specific sites threatened by industrial expansion. However, these forms of action remain precarious when not articulated with broader governance mechanisms.

Overall, environmental awareness in Biobío is simultaneously an expression of attachment and exhaustion. It arises from lived experiences of environmental change but is constrained by limited channels through which concern can influence decisions, so civic engagement depends less on motivation than on opportunity. When participatory structures are inclusive, environmental consciousness can evolve into collective agency; when absent, it tends to retreat into resignation. This pattern confirms the causal chain (Figure 6), where risk perception and procedural trust are co-produced through multi-scalar interactions among ecological transformation, affective attachment, and governance practices.

The causal chain is grounded in the assumption that perceptions of landscape change are mediated by place-based knowledge, historical experiences, and culturally situated worldviews (Devine-Wright, 2011; Escalera-Reyes, 2020). Rather than constituting an *a priori* framework, it emerged inductively from interview analysis and was subsequently refined through engagement with literature on risk perception, energy justice, and landscape multifunctionality (Renn et al., 1992; Mastrangelo et al., 2014; Gailing and Leibenath, 2015). Symbolic risk is understood as historically embedded, rooted in longer trajectories of uneven land use, extractivism, and procedural exclusion that predate current wind-energy developments (Blanco-Wells, 2019; Castán Broto and Sanzana Calvet, 2020). Wind farms act as catalysts that reactivate, intensify, and render visible these latent vulnerabilities through material landscape transformations.

The causal chain operates as a feedback loop rather than a linear sequence, consistent with social amplification perspectives (Kasperson et al., 1988; Renn et al., 1992): historical injustices shape how landscape change is interpreted; these interpretations amplify perceived risk; and heightened risk perceptions, in turn, reshape trust, participation, and future governance dynamics. The causal chain thus reveals a bifurcation point: where institutional channels remain closed or punitive, environmental awareness tends to retreat into resignation; where minimal recognition, alliances, or knowledge exchange are possible, awareness can evolve into collective agency, echoing debates on recognition and procedural justice in energy transitions (McCauley et al., 2013; van Uffelen, 2022). Risk perception plays a central mediating role, functioning simultaneously as a warning signal and a mobilizing narrative. Across the causal chain, conflicts over information and participation expose persistent deficits of recognition, expressed in the systematic devaluation of local knowledge, lived experience, and territorial attachment.

5 Discussion

Empirical findings show that risk perception in the Biobío region extends beyond measurable environmental impacts to symbolic and emotional registers through which communities experience landscape transformation. Narratives of slow degradation, loss of belonging, and diminished autonomy indicate that risk is interpreted as both material and existential, consistent with research demonstrating that public evaluations of renewable-energy projects are affective and identity-laden rather than purely technical (Maehr et al., 2015; Peri et al., 2020). In place-based frameworks, changes in landscape meaning can disrupt or reinforce attachment depending on the symbolic fit between projects and local identities, mediating whether transformation is perceived as renewal or dispossession (Thayer and Freeman, 1987; Bishop, 2019).

Risk amplification is closely linked to how information circulates through networks of trust and mistrust. Fragmented and asymmetric communication channels resemble dynamics described by the Social Amplification of Risk Framework, where institutional opacity and selective framing shape public meaning (Fois et al., 2022). Across Latin America, weak procedural transparency and inconsistent communication have been shown to amplify perceived risk and transform informational deficits into governance failures (Baines et al., 2012). In this context, informal knowledge networks emerge as adaptive responses to institutional distrust, illustrating how social learning mediates perceptions of both danger and injustice (Spielhofer et al., 2021). This Chilean case aligns with broader Latin American evidence, showing that informational asymmetries act as both cause and symptom of governance deficits, amplifying risk perception and undermining institutional legitimacy (Siavelis, 2016; Sikora-Fernandez and Stawasz, 2024). The opacity surrounding wind energy projects is therefore not a neutral absence of information but a mechanism of exclusion that shapes how trust, legitimacy, and risk are negotiated across landscapes.

Participants' narratives also reveal how ecosystem services (ES) are understood as lived relationships rather than purely biophysical entities, linking material conditions with cultural identity, autonomy, and local knowledge. This multidimensional valuation aligns with research emphasizing that ES and landscapes are socially co-constructed through shared meanings, practices, and emotional attachments (Termorshuizen and Opdam, 2009; Gailing and Leibenath, 2015; Klain et al., 2018; Whitman et al., 2025). The perception of ES as collective goods reinforces the idea that ecological wellbeing is inseparable from social and territorial wellbeing, a relationship also identified in socio-ecological studies of multifunctionality and sense of place (Bishop, 2019; Lorenzo et al., 2025).

Perceived trade-offs associated with wind-energy expansion were frequently interpreted as a re-territorialization of ES, transforming multifunctional landscapes into spaces of extraction and control. Such interpretations echo critiques where the appropriation of land and resources in the name of environmental goals (often conceptualized as green grabbing in political ecology) reproduces socio-ecological inequalities together with the commodification of nature in renewable energy transitions (Blanco-Wells, 2019; Castán Broto and Sanzana Calvet, 2020;

Furnaro, 2020; Velasco-Herrejón and Bauwens, 2024). Within this framing, the language of clean energy often obscures unequal access to benefits and decision-making, highlighting that ES trade-offs are deeply political, and shape whose interests and values are prioritized in renewable energy transitions.

These interpretations are further reinforced by narratives of loss reported in the Biobío region (decline of soil fertility, water scarcity, and noise intrusion) which can be read as expressions of ontological rupture (Blokzijl and Rasch, 2025). Residents do not simply lament environmental degradation but describe a disarticulation of human-nonhuman relations that once sustained community integrity and reciprocity. Similar dynamics have been documented in Indigenous struggles elsewhere, suggesting that perceptions of “ecosystem harm” can be simultaneously material, affective, and spiritual, revealing how extractive energy transitions erode not only ecosystems but also relational worlds of meaning (Hernando-Arrese and Rasch, 2022; Torres Salinas et al., 2022). This relational framing parallels international evidence demonstrating that nature’s contributions to people operate through emotional, spiritual, and social pathways (de Vries et al., 2012; Maehr et al., 2015; Klain et al., 2018). Thus, interdisciplinary research suggests that integrating these affective dimensions into land-use planning enhances both ecological resilience and social legitimacy (Maehr et al., 2015). From a praxis-oriented perspective, understanding ES through the lens of lived experience underscores the need for participatory and culturally grounded approaches to environmental governance. Studies demonstrate that policies attentive to symbolic meanings foster stewardship and collective responsibility, while purely technocratic designs risk eroding trust and perpetuating inequities (Spielhofer et al., 2021). Consequently, the Biobío case advocates for frameworks that integrate ecological indicators with qualitative assessments of belonging, heritage, and perceived justice, dimensions essential to the sustainability of both landscapes and communities (Peri et al., 2020).

The intertwining of ecological and social degradation reported by residents aligns with socio-ecological research showing that attachment, belonging, and shared identity function as sources of collective agency and resilience (Escalera-Reyes, 2020). In this sense, communities mobilize emotional and symbolic ties to articulate resistance and care. Such affective bonds, often dismissed as subjective, constitute essential drivers of socio-environmental resilience and the reproduction of local knowledge systems. In Biobío, wind-energy projects were perceived to alter not only material environments but also symbolic foundations of belonging, producing tensions between continuity of place and modernization. Consistent with international evidence, attachment mediated acceptance or resistance depending on alignment with local meanings and perceptions of fairness (de Vries et al., 2012; Maehr et al., 2015; Peri et al., 2020). The interplay between symbolic fit and emotional resonance has been repeatedly observed in studies of community responses to renewable-energy development, where feelings of identity continuity mediate perceptions of fairness and legitimacy (Gross, 2007; Tabi and Wüstenhagen, 2017; De Luca et al., 2020). Interview data from Biobío Region revealed that emotional connection to the landscape often coexisted with ambivalence, simultaneous attachment and alienation. Similar tensions have been observed in place-based studies, where attachment functions both as resilience

and as a potential source of conflict when external interventions disrupt local meanings (Maehr et al., 2015; Peri et al., 2020). These dynamics reinforce that attachment is negotiated through power, recognition, and access rather than functioning as a static emotional response, a pattern also observed in European contexts shaped by centralized and market-driven energy governance (Prados et al., 2022). These processes reinforce a broader pattern also visible in Biobío, where communities perceive participation as procedural rather than substantive, and identity becomes a political tool to reclaim agency in the face of hierarchical decision-making, highlighting that attachment is negotiated within power relations rather than a purely emotional response.

These affective and relational interpretations of risk and landscape are inseparable from broader governance dynamics. Discourses of justice and governance in the Biobío region reveal that resistance to wind-energy projects emerged less from opposition to renewable energy itself than from procedural and recognitional asymmetries embedded in project development. Participation was widely perceived as symbolic rather than substantive, reflecting broader critiques of energy governance where procedural injustice undermines social legitimacy and deepens territorial inequalities. Similar patterns have been documented in Latin America, where renewable-energy transitions reproduce historical patterns of exclusion, reinforcing what scholars describe as energy colonialism or green extractivism, processes in which sustainability discourses obscure uneven power relations and benefit distribution (Bishop, 2019; Baxter et al., 2020; Peri et al., 2020). The Chilean case examined in this study aligns with this evidence: rather than democratizing energy governance, current frameworks tend to privilege technical expertise and corporate interests, leaving local actors with limited agency. These patterns demonstrate that justice within the energy transition is not merely a distributive question (about who gains or losses) but also a procedural and epistemic one, concerning whose knowledge and values count in defining sustainability. Additional empirical evidence from Latin America deepens this interpretation. In the Isthmus of Tehuantepec, Mexico, proximity to wind turbines (often less than 500 m from dwellings) has generated persistent noise, shadow flicker, and visual intrusion, undermining health and the experiential continuity of place. While companies emphasize the environmental benefits of clean energy, local residents perceive these projects as intrusive and unjust because decision-making processes systematically ignore cultural meanings, traditional governance, and land-based identities (Martínez-Mendoza et al., 2021).

While energy justice is useful for assessing procedural and distributive dimensions of renewable energy governance, water extractivism and decolonial perspectives reveal deeper structural constraints shaping perceptions of risk and legitimacy beyond formal participation (Torres Salinas et al., 2022). Justice thus operates as an ongoing procedural practice, embedded in transparency, knowledge pluralism, and adaptive participation (Tsani et al., 2024). In Biobío, fragmented coordination and opaque communication translate governance deficits into mistrust and recognitional injustice, excluding situated knowledge through formalized consultation (de Vries et al., 2012; Maehr et al., 2015).

Beyond symbolic, affective, and relational interpretations of landscape change, interview data reveal forms of pragmatic and

strategic agency that operate within technocratic governance frameworks. Communities in the Biobío Region actively mobilized technical tools, such as community mapping, engagement with academic institutions, and the strategic use of environmental indicators, to render territorial concerns legible within formal decision-making processes. These practices indicate that community agency extends beyond cultural or spiritual expressions of place attachment, involving tactical navigation of expert-driven energy governance. Discourses on ecosystem degradation thus function simultaneously as expressions of lived experience and as strategic resources deployed in negotiations, public consultations, and claims-making processes. Recognizing this duality challenges simplistic readings of community resistance, in which communities selectively appropriate technocratic languages to contest asymmetries of power while preserving alternative territorial meanings. Local actors are neither passive victims nor purely symbolic guardians of territory but operate at the intersection of affective attachment and strategic engagement, enacting energy justice claims through both cultural recognition and tactical interaction with institutional frameworks.

These practices resonate with evidence that co-production of knowledge and participatory governance strengthen both environmental performance and social trust (Escalera-Reyes, 2020). Such initiatives exemplify “distributed governance,” where communities exercise agency through continuous negotiation rather than one-time participation. These dynamics suggest that the democratization of energy transitions depends on cultivating institutional permeability and reflexivity rather than expanding procedural checklists. When communities are treated as partners rather than stakeholders, energy transitions can evolve toward socially adaptive systems grounded in reciprocity and shared responsibility. Ultimately, the Biobío case illustrates that achieving energy justice requires rethinking governance architectures beyond compliance and consultation. It demands procedural transparency, epistemic plurality, and recognition of place-based meanings as legitimate sources of authority. This integrative understanding of justice (linking procedural, distributive, and recognitional dimensions within a governance continuum) echoes global calls for transforming institutional cultures, not merely regulatory frameworks, toward genuinely participatory and plural energy futures (Martínez-Mendoza et al., 2021; Tsani et al., 2024). Such an approach aligns with integrative justice frameworks that bridge environmental psychology, political ecology, and sustainability transitions, connecting back to our causal chain by specifying how procedural conditions modulate acceptance/opposition (Peri et al., 2020; Spielhofer et al., 2021). Taken together, these findings highlight that energy justice in Biobío is not reducible to regulatory compliance but emerges through everyday negotiations of meaning, trust, and authority.

6 Shortcomings and future research

Methodologically, the participant assessed might not fully represent the Biobío’s actors, especially from Academia and Private sector where many individuals were contacted with no success, resulting in only two participants for both type of actors. Thus, further assessments could consider complementary

methodologies that increase the probability of participation of some actors. On the other hand, future research should employ longitudinal and mixed-method designs to trace how perceptions evolve through project cycles and governance reforms. Combining spatial analyses of landscape change with participatory methods, such as participatory mapping, deliberative workshops, and narrative inquiry, this would capture the emotional and cognitive transformations that accompany energy transitions (Maehr et al., 2015; Spielhofer et al., 2021; Fois et al., 2022). Integrating social-media and digital ethnography could also illuminate how public discourse and collective emotions around wind energy shift over time (Karakislak et al., 2023; Gulbrandsen, 2025).

7 Conclusion

The interdisciplinary synthesis of this study reveals that perceptions of wind energy in the Biobío region emerge from the intersection of symbolic, informational, and procedural dimensions of justice. Rather than isolated reactions to environmental change, these narratives express situated reasoning grounded in belonging, recognition, and fairness. They challenge technocratic models of governance by evidencing that sustainability is not only ecological or economic but also affective and relational (Peri et al., 2020; Blokzijl and Rasch, 2025).

Risk perception emerged as a lens through which communities interpret and contest territorial inequality. Perceived risks were not expressions of irrational opposition but reflections of procedural opacity, informational asymmetries, and erosion of local control. Risk thus functions as both an affective and cognitive indicator of procedural justice, revealing how governance deficits translate into mistrust and social vulnerability. On the other hand, perceptions of ES highlighted that wellbeing and environmental value are experienced relationally. For local actors, water, soil fertility, and landscape tranquility are not abstract functions but dimensions of belonging and identity. The perceived loss of landscape multifunctionality signifies the weakening of both ecological integrity and social cohesion, underscoring that sustaining ES is inseparable from sustaining cultural continuity and emotional attachment to place.

Persistent deficits in procedural and recognitional justice expose how participation remains largely formal and fragmented. While institutional narratives attribute disinterest or misinformation to citizens, communities actively construct informal systems of knowledge sharing and environmental monitoring. These practices embody cognitive justice, the right to interpret, decide, and act within one’s own territory.

By engaging risk perception as an analytical bridge, this study shows how justice deficits become legible, mobilizable, and contested through lived territorial experiences. In contexts such as the Biobío region, shaped by colonial histories, extractivist legacies, and centralized technocratic governance, the energy justice is most effective when understood as an open, situated and evolving framework, reworked through place-based experience and locally constructed meanings of risk, landscape, and governance rather than applied as a normative checklist.

Taken together, these findings call for a framework of landscape justice, integrating ecological, emotional, and institutional

dimensions in energy governance. Such a perspective bridges analytical gaps by linking risk perception with procedural fairness, ES with lived wellbeing, and energy transitions with historical patterns of extractive development. Our results further show that risk perception operates as a key mechanism through which recognition (in) justice is articulated in transition contexts. The Chilean case illustrates that without structural transformation; renewable energy can reproduce rather than redress long-standing inequities.

Sustainability transitions are processes of meaning-making as much as technological change. Achieving just enduring transformations requires acknowledging the emotional and symbolic dimensions through which belonging, autonomy, and justice are negotiated, allowing renewable-energy policies to move beyond decarbonization toward socially resilient territories. Interpreting wind-energy conflicts within longer trajectories of territorial dispute is therefore critical for understanding social legitimacy in energy transitions.

Although not policy-oriented, the findings suggest that energy governance could be strengthened by integrating place-based qualitative tools into environmental assessment, including participatory mapping and culturally situated visual communication, to capture emotional attachment, local meanings, and perceived loss. Recognizing landscape values and informal community practices as legitimate governance inputs may reduce power asymmetries, enhance trust, and improve long-term project viability (Łuczniak et al., 2022; de Oliveira et al., 2023).

Shifting away from technocratic governance models also requires institutional reforms that address how knowledge, authority, and participation are structured within Environmental Impact Assessment (EIA) processes. This implies the integration of landscape values—such as use, experience, and identity—as formal assessment criteria, rather than treating them as secondary or subjective concerns. Therefore, it is required to revise EIA guidelines so that consultants do not unilaterally define impact categories and ensuring that public authorities retain responsibility for framing assessments (Antonson, 2011; Łuczniak et al., 2022).

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of Universidad de La Frontera, Chile (Approval N°015/23). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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Author contributions

MC-S: Methodology, Data curation, Formal Analysis, Funding acquisition, Conceptualization, Writing – review and editing, Writing – original draft. HA: Writing – review and editing, Visualization. AV-R: Writing – review and editing, Funding acquisition. FA: Writing – review and editing. CC: Writing – review and editing.

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Supplementary material

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