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RESEARCH

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Exploring links between local knowledge, values and livelihoods in land-sea interface: insights on emerging tradeoffs and change in Southern Chile

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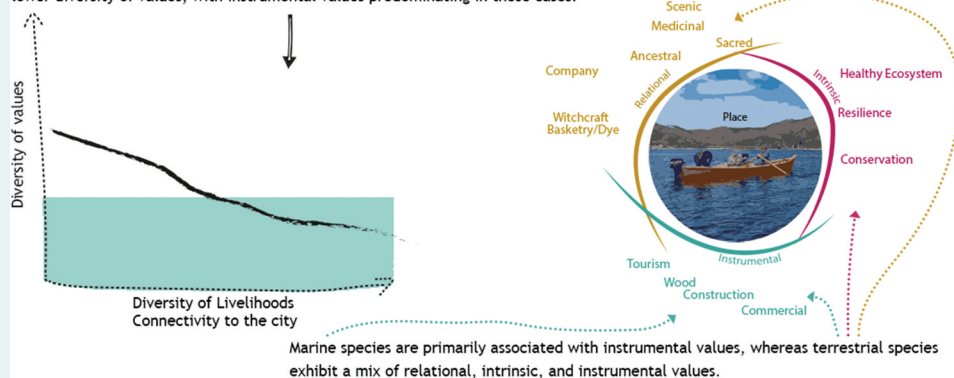
ABSTRACT

Local knowledge and values of coastal communities offer insights into the intricate human-nature relationships in the land-sea interface. Considering a diversity of values unveils how people perceive nature, encompassing both tangible and intangible dimensions, and this understanding is part of how they navigate dynamic environmental challenges by embracing livelihood diversification spanning land-sea activities. Better understanding of these values, relationships and diversification strategies can improve social-ecological systems theory and practice. Here we assess links between local knowledge, values and livelihoods in order to identify emerging tradeoffs. Using semi-structured interviews with qualitative and quantitative methods, we conducted a total of 88 interviews in five communities in Southern Chile. Local knowledge and values were collected as free-listing on terrestrial and marine species. We probed relationships between livelihood diversification and values, classified as relational, intrinsic, and instrumental. Our findings showed that marine species were most associated with instrumental values, while terrestrial species had a balance between relational, intrinsic and instrumental values. We observed that as communities expand their livelihoods and live closer to the city, they showed lower knowledge and values, and in these cases instrumental values predominate. Certain diversification strategies could lead to time constraints, impacting the transmission of knowledge and resulting in less values. Deeper and long-term cooperation between different actors to recover and protect different values is necessary to couple local knowledge and values with livelihood diversification. Our research provides valuable insights for policymakers aiming to develop holistic strategies that include relational values and leverage diverse knowledge systems to address contemporary environmental challenges.

KEY POLICY HIGHLIGHTS

- Coastal communities present a wide diversity of livelihoods, ranging from communities specialized in marine activities, to those with activities in the sea, land and tourism. It is important to understand the current relationship between livelihoods and nature.
- Connectivity to cities, urbanization and new markets could have a negative effect on the diversity of nature's values, therefore it is necessary to adopt measures to prevent this erosion of knowledge and values.
- Relational values offer an opportunity to explore the diversification of livelihoods and move towards sustainable futures in the relationship with nature.
- Decision-makers need to consider different values of nature, especially relational values, to understand the connection between humans and nature and develop policies that promote positive futures.

Inhabitants who expand their livelihoods, and who live closer to the city, tend to have a lower diversity of values, with instrumental values predominating in these cases.



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Introduction

Coastal communities who depend on natural resources are vulnerable to negative social-ecological changes in terrestrial and marine ecosystems (Bunce et al. 2010). A decrease of resources or shifts in species ranges due to climate change is a challenge but also offer a window of opportunity that allows for exploration or diversification of livelihoods (Gelcich et al. 2010). Diversification of livelihoods in the land-sea interface is important for communities to decrease vulnerability (Armah et al. 2010; Haider et al. 2018). Yet, the profound impact of diversification of livelihoods on local knowledge and values often goes unnoticed. Local knowledge is defined as cumulative knowledge, practices and beliefs about nature (Berkes et al. 2000), associated with a diversity of values. This diversity of values can be categorized into three groups of values. First, instrumental values, which are related to economic valuations due its substitutable means to people. Second, intrinsic values refer to the own value of nature independent of people. Third, relational values, refer to the tangible and intangible relationships between people and nature, such as care or sense of place (Chan et al. 2016; O'Connor and Kenter 2019). Engagement with relational values complement instrumental and intrinsic dimensions as it opens up for a deeper understanding of the dimension of local knowledge about species and nature, beyond knowledge about harvesting or resource use, and how it relates to decision-making under changing circumstances. Thus, studying relational values alongside instrumental and intrinsic values does not only enrich our comprehension of the intricate and dynamic ties between people and nature but also can foster a sustainable approach to environmental conservation and resource management.

Most studies on the valuation of nature are from the perspective of instrumental values (IPBES 2022; Pascual et al. 2023). Including all types of values as an approach will help to understand how individuals conceive nature with tangible and intangible meanings (Lotz-Sisitka et al. 2017; West et al. 2018). Despite their complementarity, relational approaches offer a pathway to explore the space between people and nature, which is a network of relationships between and among living beings where attention should be given to the inter-relationships and multiple forms to address valuation (Bourdieu and Wacquant 1992). While mapping of instrumental values can trigger conflicts among different actors through competition for natural resources as a result of their utilitarian vision (Ratner et al. 2017), the relational values fosters engagement, reduces conflicts, balances value systems (Brett and

Mitchell 2019), and cultivates shared perspectives on humanity's relationship with nature (Bataille et al. 2021). Hence, capturing local knowledge and values together with an explicit focus on relational values allows us to understand intangible values that matter for decision-making in local communities, which is often difficult to understand using instrumental approaches alone. A broad view of values and how it relates to local knowledge is critical for understanding and supporting coastal communities, who, in the face of dynamic environmental challenges, must consider diversification of livelihoods as a means to their well-being.

Understanding the link between diversification of livelihoods and the preservation of local knowledge and values is critical, as a high diversification of livelihoods implies less time spent on each activity, it may potentially disrupt the transmission of essential knowledge and values in communities (Pearce et al. 2011). For instance, the commercialization of specific species or the introduction of new livelihood activities, such as local industries, may disrupt traditional practices and opportunities for continued knowledge sharing within the community (Lyver et al. 2019). There are three different strategies of livelihood diversification known as: (i) balance, which is improving an actual activity, and it can be seen as a specialization; (ii) variety, which represents a new activity within an established sector of work (e.g. fishing new species); and (iii) disparity, which is a completely new activity (Scoones 1998; Stirling 2007; Roscher et al. 2022). Despite the importance of livelihoods and the role that local knowledge can play in determining new pathways of livelihood diversification, research focusing on livelihoods and the implications of perceived values of nature has still not received the attention it deserves. The term 'livelihood' often remains loosely defined and applied generically (Kassegn and Endris 2021). For this research, we will refer to the term livelihoods only as economic activities or sources of income from natural resources.

As we proceed, it becomes evident that bridging the gap between livelihood diversification, local knowledge, and values of nature holds the potential to provide a more harmonious future for coastal communities in the face of dynamic environmental challenges. This research aims to explore this relationship in order to identify emerging synergies or trade-offs associated with the livelihoods of various actors and communities. We aim to assess how understanding values and their connection to livelihood diversification can help us better understand how to support livelihood diversification without compromising human-nature relationships. We hypothesize that relational values may play a significant role in promoting

more sustainable livelihood diversification strategies. To investigate this, we interview inhabitants in five coastal communities in Chile, with different degree of dependence of natural resources and different patterns of livelihood diversification. Our comprehensive assessment will encompass three key dimensions: (1) the livelihoods of different communities and what kind of livelihood diversification strategies have been adopted; (2) the diversity of values associated with the knowledge of the different species in the land-sea interface and how these values are categorized into instrumental, intrinsic and relational values; and (3) the relationship between diversity of values and livelihood diversifications.

Methods

Social-ecological context

Research was conducted in the Valdivian coast, southern Chile (Figure 1). This coastal area is composed of several small communities with a low number of

inhabitants, ranging from 11 to 220 (INE 2019), except for Niebla, which has a population of about 2,000 inhabitants. We interviewed inhabitants in 5 communities along the coast: Niebla, Amargos, Huape, Chaihuín and Huiro (Figure 1). The choice of conducting a comparative case study stems from the distinct historical and geographical factors that have shaped these communities. Historically, these communities have been isolated, especially the most distant ones from the main city like Huiro, Chaihuín and Huape. Isolation, low connectivity and the challenges of maintaining quality of life have led to a low population density in these communities. In fact, the lack of school and other basic services has meant that people have had to leave to seek education and work opportunities outside of these places. Therefore, although they share a common history of proximity, their development has been differentiated, which makes them an interesting case study at the community level. Currently, connectivity to other communities and localities of the region has improved. The main connection to the principal city of the region is by boat

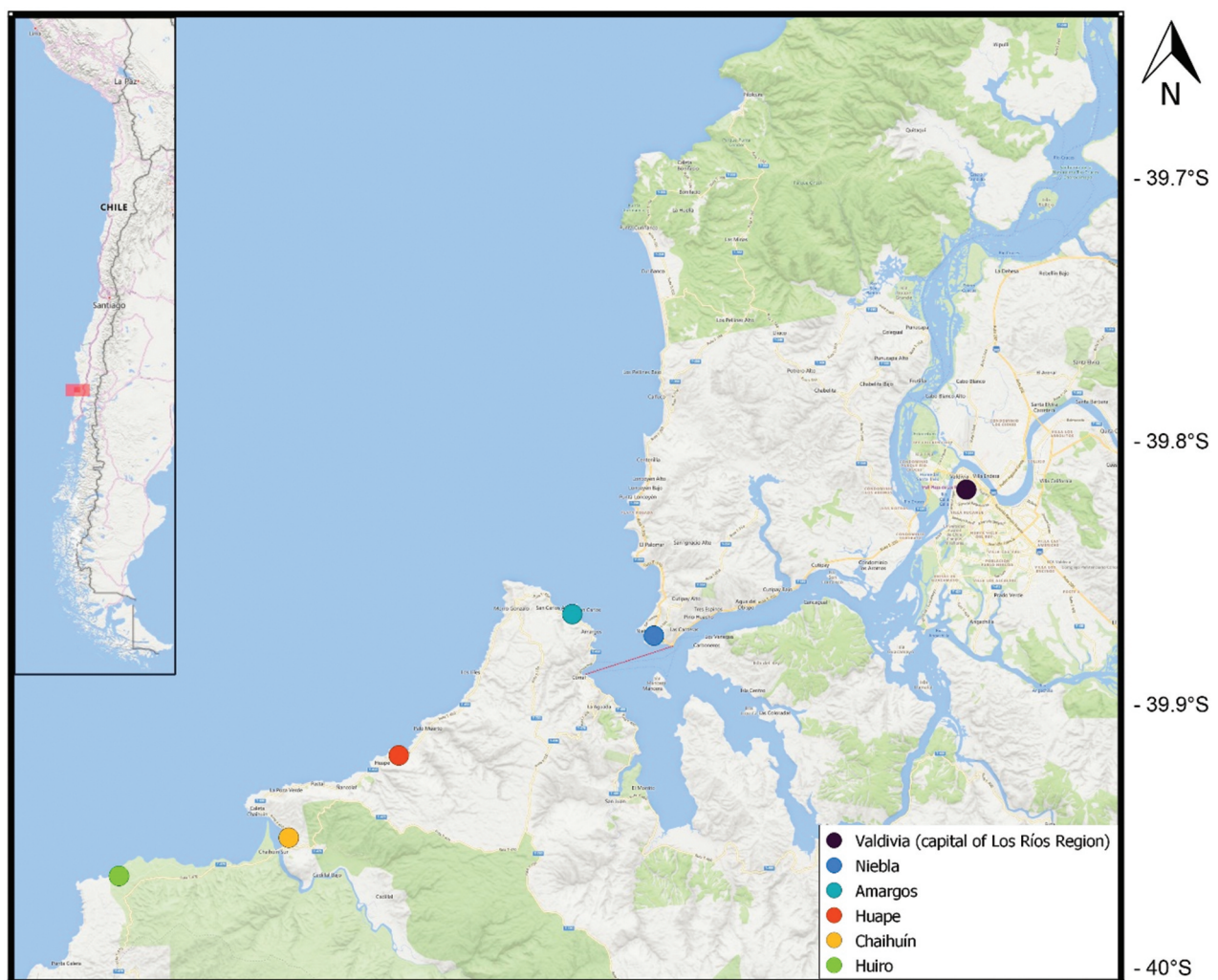


Figure 1. Study area map, showing the location of different communities included in the study of the valdivian coast. Each community is represented by a different color. The red line indicates the crossing of the ship between Niebla and Corral (Corral is a town, commune in Valdivia Province). The black dot represents the main city in the region, Valdivia.

(except for Niebla, which is connected by road). This has led to increased tourism and new job opportunities, but also to the fragmentation of natural areas for the construction of summer homes. These communities have a strong connection and history to both land and sea, depending on forestry, agriculture, livestock and marine resources as part of their livelihoods. As in most of the coastal communities of Chile, people depend mostly on marine resources as fishes, shellfish, and algae (Gelcich et al. 2009). Fishers are associated to associations that have exclusive access rights in the form of Territorial User Rights for Fisheries (TURF). These aim to manage benthic species. On land, this area is surrounded by large extents of native forest. However, a high proportion of this native forest have been converted to exotic tree plantations and agriculture.

Data collection and analysis

Research was conducted following the approval by the ethical and scientific committee of social sciences, arts and humanities of the Pontifical Catholic University of Chile (Reference ID 210,322,009). In the study, participation was voluntary, and participants had the right not to respond to any questions and to withdraw at any time. Informed consent was obtained from the participants following assurance of confidentiality and anonymity of responses.

From the end of 2019, we gathered background information about different communities and lifestyle of people living in the study area. We drew on previous literature (van Holt 2012; Van Holt et al. 2017; Parga León 2020) and interviews with key informants. Using this information, we developed a semi-structured interview protocol that focused on livelihoods and values. From July 2021 to December 2022, we conducted 88 semi-structured interviews with local communities in Niebla ($n=20$), Amargos ($n=13$), Huape ($n=20$), Chaihuín ($n=21$), and Huiro ($n=14$). Given that most people in the study area are involved in the extraction of marine resources, we began by interviewing the leadership of the fisher association and then used snowball sampling (Cohen and Arieli 2011) to identify additional interviewees. All interviews were conducted individually.

The semi-structured interviews were divided into three parts: basic information (such as age, gender, and education), livelihoods, and local knowledge and values. For this study, we used the term livelihoods only as economic activities or sources of income from natural resources. To assess this, we used a pre-defined list of different jobs, which we had identified in previous visits and conversations with key actors. The pre-defined list of job was the following: fishing, shellfish extraction, seaweed harvesting, marine products intermediary, tourism, cultural/religious activities,

aquaculture, farming activities (crops, agriculture), activities with animals (cattle, sheep, etc.), wage work, informal activities (*pololos* in local language), forest activities (wood), collection of non-timber products and others. During the interviews, we asked participants whether they engaged in any of the listed jobs and whether it was a source of income for them. We also asked about the most important source of income for each job. Livelihoods were then categorized as either land or sea-based, depending on the natural resources they used, or as jobs in tourism or other formal (contractual arrangements) or informal (sporadic and independent) employment.

We use the number of species they are familiar with as a proxy for local knowledge, as it offers a unique and simple lens to comprehend the world, rather than a mere compilation of information about plants and animals (Berkes et al. 2000; Reyes-García et al. 2011). It was collected using free-listing technique (Newing et al. 2011) to record terrestrial and marine species. First, we asked the names of species on land and after that, about species in the sea, with a maximum of ten species per ecosystem. Then, using that list species, we asked about different meanings or values for each species named, as an open response. This response could have more than one different value (Table S1). Response of values were coded in one word that summarized the meaning of the response. For example, 'we have to take care of it because it is important for the environment', or 'they must be protected' were categorized as conservation values. 'I like to look at it' or 'it's a delight for my eyes' were categorized as scenic values (Supplementary material table S2). Additionally, to evaluate the overall salience of species and values mentioned in the resulting free lists, we employed the Cognitive Salience Index (Sutrop 2001). This index serves to gauge the perceived relative importance of these species and values, taking into consideration various factors such as item frequency, mean position, and the number of informants. Notably, it mitigates potential biases stemming from the length of individual lists. The formula for calculating this index is expressed as: $S = (F^2) / (N * \sum R)$, where 'F' represents an item's frequency (i.e. the number of lists in which an item appears), 'N' stands for the total number of interviewees, and 'R' means the rank of an item within an individual list (Sutrop 2001). The Cognitive Salience Index ranges from 0 to 1, with a value of 1 indicating the highest salience – an item consistently listed first by all subjects. The use of mixed methods, both qualitative (interviews, narratives) and quantitative (index) allows us to better understand the data, using the strength of each approach to investigate relational values, and to achieve the objectives social-ecological studies (Murray et al. 2016).

We utilized boxplots, which encompass crucial statistical measures such as the median, quartiles, outliers, and the overall data distribution, to effectively highlight the various facets and intricacies within livelihoods. To depict the relationships between local knowledge, values, and species in different communities, we employed a Sankey diagram, which displays the flow between entities using the width of lines. Since the relationship between species and values was based on interviewee responses, a single species could be associated with several values. To better visualize these relationships, we grouped species by their taxonomic classifications. Additionally, each value was assigned a weight of 1 and distributed among the three value groups (relational, intrinsic, and instrumental), allowing a single value to represent both instrumental and relational values. Supplementary Material Table S2 provides additional details. All data were managed and analyzed using R Studio.

Results

A total of 88 interviews were made, where 29 participants were women (4 from Amargos, 4 from Niebla, 8 from Huape, 8 from Chaihuín and 5 from Huiro) and 59 were men (9 from Amargos, 16 from Niebla, 12 from Huape, 13 from Chaihuín and 9 from Huiro). The average age of the informants was 52.5 years (min = 20, max = 84) with a median of 52 years.

Local knowledge and values

Respondents named a total of 302 different species, where 181 corresponded to the terrestrial ecosystem and 121 to the marine ecosystem. Of these species, according to the salience index, the most important species in the terrestrial ecosystem were mainly trees, while for the marine ecosystem they were marine species regarded as resources (Table 1). As for the values, the first values named in the free lists were instrumental values. However, other intrinsic or relational values as conservation or scenic, also appeared with a higher score (Table 1).

Overall results of frequency of local knowledge and values showed that marine species were most associated with instrumental values, while terrestrial species had more relational values and a higher diversity of values (Table S1). Species could also show different sets of values, for example the following quotes show how the Chilean mussel and Canelo tree are recognized by interviewees as having multiple values:

Chorito (Chilean blue mussel) has cultural values in this community, but it also has a commercial value, it is the hallmark of Chaihuín (Interviewee from Chaihuín, 2021)

Canelo (considered sacred by the Mapuches) has medicinal proprieties, also has a sacred value, and it has a lot of meaning for Mapuches people (Interviewee from Huiro, 2021)

Some species also were associated with biological indicator as references in the quotes:

When the Pelú (*Sophora cassioides*) blooms, it is a good time to extract Erizos (Sea urchin) (Interviewee from Chaihuín, 2021)

When the Pelicano (Pelican) flies towards the coast, it means that bad weather is coming (Interviewee from Huape, 2022)

We found significative differences in diversity of values and in frequency between communities (Figure 2). Amargos and Niebla showed a low diversity of values, and a high frequency of instrumental values as consumption and commercial use. On the other hand, Chaihuín and Huiro, showed a high diversity of values with small frequency, by naming other values besides the category of instrumental values. Figure 2 also shows the relation between values and species group mentioned by the interviewees. Marine and fish species (shown as Actinopterygii taxa) were strongly related with instrumental values, while terrestrial species had a higher diversity of values. For example, terrestrial mammals or trees member of the Magnoliopsida taxa, showed a diverse set of instrumental, relational, and intrinsic values (Figure 2). When we categorized all species by ecosystem, as terrestrial and marine species, we could observe that terrestrial species present a balanced relationship between the 3 groups of values, while marine species present

Table 1. Top five of saliency index for species and values on terrestrial and marine ecosystems. Values close to 1 are the most salient item, always named first.

Ecosystem	Species	Saliency Index	Value	Saliency Index
Land	Arrayan (tree)	0.204	Consumption	0.441
Land	Horse	0.141	Commercial	0.392
Land	Canelo (sacred tree)	0.138	Conservation	0.266
Land	Alerce (tree)	0.102	Construction	0.222
Land	Avellano (tree)	0.101	Scenic	0.137
Sea	Chorito (Chilean blue mussel)	0.235	Commercial	1.000
Sea	Whale	0.160	Consumption	0.628
Sea	Chancharro (fish)	0.145	Scenic	0.069
Sea	Congrio (fish)	0.140	Conservation	0.056
Sea	Erizo (Sea urchin)	0.138	Biological indicator	0.026

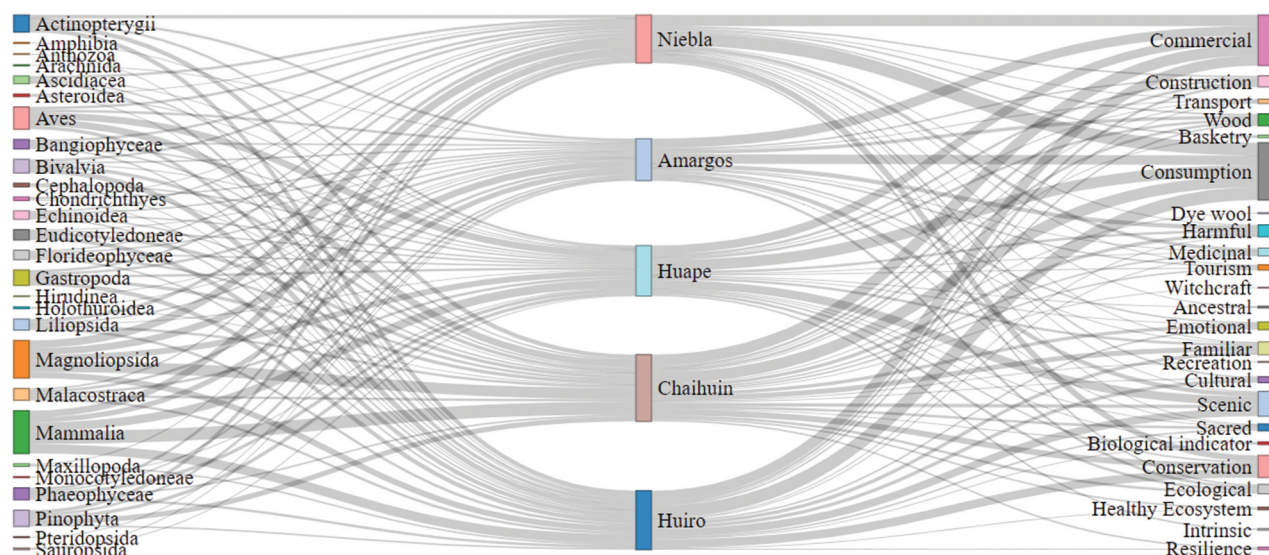


Figure 2. Sankey diagram representing connections between group of species, represented as class of species (left panel), communities (middle panel) and values (right panel). The width of each bar represents the frequency of data.

a greater inclination towards instrumental values (Figure 3). On the other hand, when we classified the different species according to whether they are native or exotic, we did not see such large differences in the different types of values (Figure 3). Furthermore, within the classification of relational values, certain examples illustrate the intricate relationship between people and nature. Relational values were categorized into distinct categories, encompassing cultural identity, social cohesion, social responsibility, moral responsibility, individual identity, eudaimonic, and virtue (Table 2). These values extend to both terrestrial and marine species, underlining the depth and breadth of human-nature relationships.

Livelihoods

Individuals have a mean of 4.48 with a median of 4 jobs (from a range from 1 to 9 different jobs) and people had more jobs on sea (mean = 2.47, median

= 3), followed by jobs on land (mean = 0.85, median = 1). These livelihoods are supported by what is the most important source of income of people. 53% inhabitants responded that the principal source of income was sea livelihoods followed by formal jobs (20.4% of inhabitants). For the communities of Amargos and Niebla, sea livelihoods represented 81.8% and 90% of the most important source of income, respectively, supporting this specialization on marine resources. 60% of the inhabitants of Huape also indicate that their main source of income is income from marine activities. However, this is not concordant with all communities, where sea livelihoods in Huiro are only mentioned 7.1% of times as the most important jobs. Informal livelihoods or land livelihoods are more important in Huiro. On the other hand, 55.5% of inhabitants of Chaihuín reported that tourism and sea livelihoods (in equal parts) are considered as the most important source of

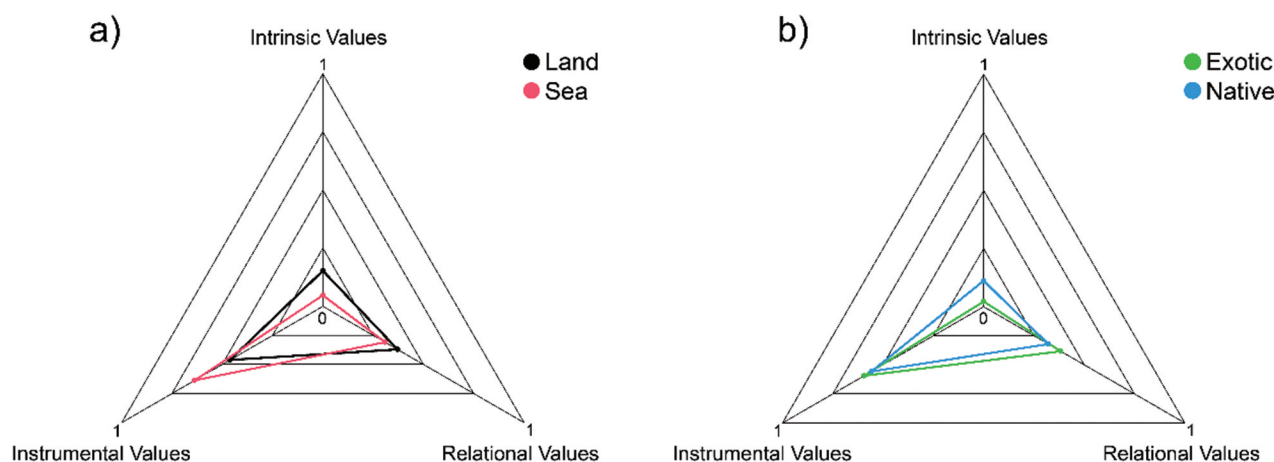


Figure 3. Radar plot showing the relation between the different group of values: relational, intrinsic, and instrumental for a) land and sea species and for b) exotic and native species. Each group has a value between 0 and 1.

Table 2. Concepts of relational values approach defined by Chan et al. (2016) and land and marine based examples from the fieldwork.

Relation	Subset of Relational Values	Definition	Land species	Sea species
Individual	Identity	Species is important to me as a person, who I am	'It (Cat) has a sentimental value for me and my life'.	'I grew up with the 'Chorito' ^a and it has been with me and my family all my life.
	Eudaímonia	It helps me to lead a good life	'The care and breeding of my animals (ducks and sheep) is important to have a good life and to be able to eat and generate some money'.	'Robalo' ^b) It helps me to eat and have something to sell'
	Virtue	Caring is the right thing to do	'(Olivillo ^c) It is the protector of the sea'	'I like to see the Chungungo ^d and we need to take care of it'
Collective	Cultural identity	Species is important to my people, to who we are	'(Canelo ^e) it is a sacred and ancestral tree, with a lot of meaning for my people'	The connection with the Cochayuyo ^f and Luche ^g has a cultural and historical value for us, which has been lost over time"
	Social cohesion	Species provides a link to connect with people	'Nocha ^h brings us together, it has a cultural value, and we use it for basketry'	'The gathering of Lapas' and Caracoles ⁱ is a time to get together with our families and generate bonds'
	Social responsibility	Care of species is important to care to my people	'Birds as Zorzal ^k or Picaflor ^l are important for resilience of native forest'	'We need to keep protecting the Loco ^m as a union for the good of our community'
	Moral responsibility	Caring about species is a moral necessity	'(Alerce ⁿ) It is sacred, resilient and has wisdom'	'Although it causes negative damage to our nets, we must care for the sea lion because it is part of nature'

^aChorito (*Mytilus chilensis*) or Chilean blue mussel is a native species of filter-feeding bivalve.^bRobalo (*Eleginops maclovinus*) or Patagonian blennie or is a marine fish that is caught through artisanal fishing.^cOlivillo (*Aextoxicon punctatum*) is a tree endemic to Chile and Argentina.^dChungungo (*Lontra felina*) or Marine otter is one of the smallest otters and the smallest marine mammal.^eCanelo (*Drimys winteri*) is one of the sacred trees of the Mapuche people and is found in Chile and Argentina.^fCochayuyo (*Durvillaea antarctica*) is an edible brown seaweed that has long been one of the food resources of indigenous and local communities.^gLuche (*Ulva lactuca*) also known as sea lettuce, is an edible green alga which grows in the intertidal zone of most of the world's oceans.^hNocha (*Greigia landbeckii*) is a plant endemic to Chile of the Bromeliaceae family and is traditionally used in basketry.ⁱLapa (*Fissurella spp*) or Limpet is a gastropod mollusk inhabiting the intertidal, which is harvested for consumption or sale.^jCaracol or sea snail, a marine gastropod mollusk inhabiting the intertidal.^kZorzal (*Turdus falcklandii*) or austral thrush is a native bird inhabiting both urban and rural areas.^lPicaflor (*Sephanoides sephanioides*) or Green-backed firecrown is the most common hummingbird in Chile.^mLoco (*Concholepas concholepas*) or Chilean abalone is a marine gastropod mollusk used in Chilean cuisine and sold internationally as a delicacy.ⁿAlerce (*Fitzroya cupressoides*) is an ancient tree, whose longest-living individuals are considered to be one of the oldest living things on earth.

income, keeping a balance between these two kinds of jobs. Our findings showed different strategies of for livelihood diversification where communities as Amargos and Niebla are specializing on sea-related livelihoods (with a median of 0 for the other livelihoods) showing a balance or variety strategy which suggests potential enhancements in current resource activity or the exploration of additional marine species. Conversely, communities like Chaihuín and Huiro, exhibit a generalist behavior of different activities, that show a disparity strategy, engaging in a variety of activities, including tourism, a relatively new activity not observed in other communities (Figure 4).

Diversity of values and livelihoods

Our research revealed a significant variation in the number of livelihoods among the inhabitants. While some individuals had 9 different livelihoods, others relied on just 1 activity. In terms of values, we observed a wide variation at the individual level, with one individual who held 12 different values, while others expressed only 1 value. This broad dispersion of data underscores a high diversity within the communities we examined (Figure 5). Despite a negative slope, the coefficient of determination is too low to find any general relationship between livelihoods and values (Figure 5, $R = 0.04$, slope = -0.25 , $p = 0.05$). This

high dispersion can be explained by the fact that each community presents a particular set of relationships with nature. Within these communities, only Amargos and Huape presented a coefficient of determination not so low (R of 0.23 and 0.25 respectively) which are the only ones that present a negative correlation between the diversity of values and the number of jobs (Figure 5).

Discussion

Our results have helped us gain a better understanding of the significance of local knowledge and values in relation to livelihood diversification and in exploring potential tradeoffs that may arise. Based in our results, we discuss our findings and limitations of our study.

Local knowledge and values

The overall salience of species and values underwent changes across land and sea. In the marine ecosystem, it is noteworthy that aside from whales, all species with higher value indices primarily serve purposes related to consumption and trade. Conversely, in terrestrial ecosystems, the species with higher value indices are predominantly native trees with significant conservation value. This result finds support in the salience of values, as it reveals the emergence of not only instrumental values but also intrinsic and relational values where Chaihuín and Huiro had the

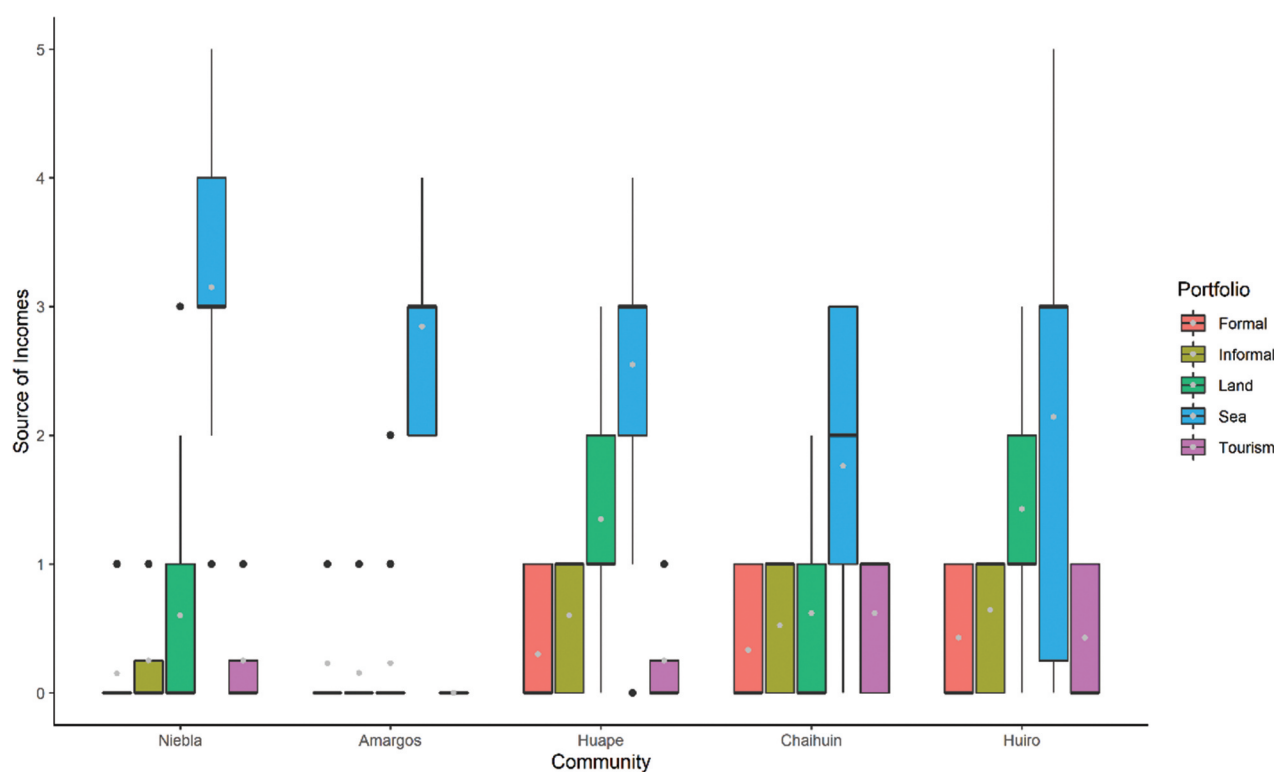


Figure 4. Comparison of livelihoods of different communities. Colors represent a different activity. Boxplots show the mean (grey dot), median, hinges, whiskers, and outliers (black dot). Formal, informal and tourism jobs are a binary response between 0 and 1.

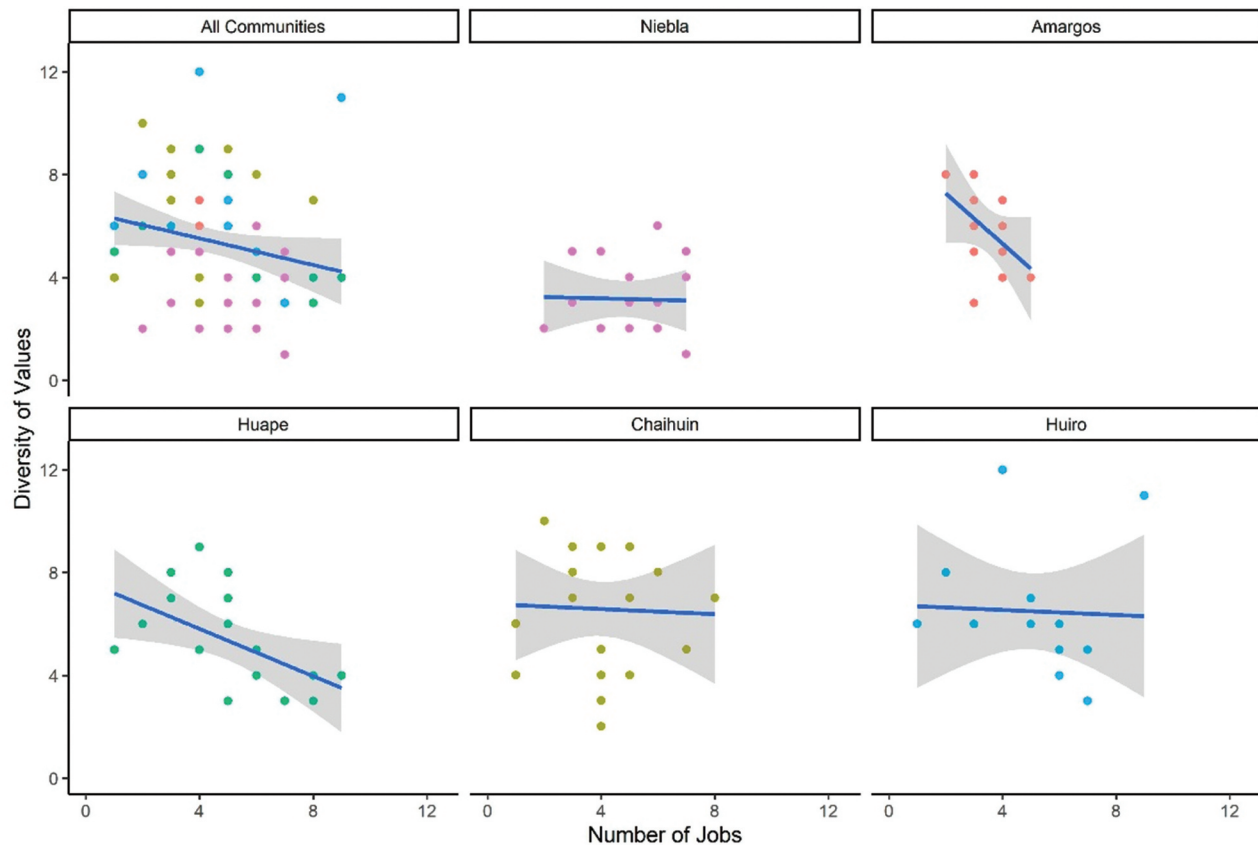


Figure 5. Relation between livelihoods (as number of different jobs) and diversity of values at individual-level. Blue slope shows the correlation. Each point was colored according to the community that each inhabitant belonged to.

highest diversity of values showing significantly larger amount of knowledge, therefore could be considered as culturally keystone communities (Cámara-Leret et al. 2019). Understanding the relationship between local knowledge and values could provide insights into how to move towards a more sustainable relationship with the natural resources, considering not only the instrumental values but also the intrinsic and relational values (Jax et al. 2018; West et al. 2018) where a plurality of values will be essential to build future sustainable scenarios of relationship with nature (Harmáčková et al. 2023).

Our results show how some species have different values between communities and marine and terrestrial ecosystems (Figure 4). O'Connor and Kenter (2019) have proposed a framework that offers an opportunity to bridge and reconcile the different types of values. This framework provides a holistic view of the relationship between humans and nature. This reconciliation of values could easily emerge since interviewees understand that species such as the cougar that prey on their chickens, have positive values for biodiversity. Therefore, mainly instrumental values presented by marine species can be transformed into relational values, as can happen with species that have a negative perception (Skubel et al. 2019). Relational and intrinsic values of marine

species, such as 'conservation', will be vital to offer pathways to strengthen relationships with nature and go beyond instrumental values. We found different aspects of relationships with nature, including cohesion, culture, responsibility, and identity, which are based on the care of species (Table 2). Although most common marine species have more instrumental value compared to terrestrial species, intrinsic and relational values such as 'conservation', 'emotional', 'cultural', and 'scenic' are present in marine species (Table S1). Relational values and its subsets may be crucial in engaging diverse groups of people in caring for places in the future, including communities and stakeholders (Allen et al. 2018). This narrative underscores the significance of caring for marine (and land) species, as demonstrated in Table 2 with relational values, especially when diversifying livelihoods.

Livelihoods

Our study identified different livelihoods strategies among the communities. Some communities showed a diversified set of livelihoods, while others specialized in specific occupations (Figure 2). Interestingly, communities like Niebla and Amargos, which are located closer to the city and have better connectivity (Figure 1), showed less diversification in their

livelihoods, with over 80% of respondents mentioning sea activity as the most important, compared to other communities that are more isolated. Our results of number of livelihoods we found is consistent with what has been reported in other coastal communities, where the number of different occupations ranges from 1 to 6 (Cinner et al. 2009; Cinner and Bodin 2010; Martin et al. 2013). Coastal communities in rural areas often present diverse livelihoods which may depend on the natural resources' availability across land-sea interface (Bunce et al. 2010). A possible explanation for the difference in the livelihoods of the communities in our study may be that those communities close to the big city, and therefore more connected to markets, infrastructure and services, have a higher population density, therefore, less space for natural resource activities (except for marine activities), while more distant communities with less connectivity have a lower population density, and therefore more space to subsist on natural resources, as well as greater challenges in relation to economic well-being. However, there are other determinants of diversification of livelihoods as households' assets, social network and government support that may explain the diversification of livelihoods (Avila-Foucat and Rodríguez-Robayo 2018; Roy and Basu 2020). Livelihood diversification is understood as a poverty and vulnerability reduction strategy for coastal communities (Adger et al. 2005; Kassie et al. 2017). Evidence from the literature has shown that there is no consensus about the positive outcome of diversifying livelihoods, showing that diversification could not improve well-being and may have negative ecological consequences (Roscher et al. 2022). Therefore, addressing relational values along with livelihood diversification can help to identify livelihood options that are aligned with local values as well as broader societal values of conservation and sustainability. Our findings indicate what may be more sustainable practices, similar to what is occurring on land, where intrinsic and relational values like 'sacred', 'conservation', 'resilience', and 'healthy ecosystem' are attributed to the most common species in our study site. This demonstrates an awareness in communities of the need to protect and preserve the local environment. Thus, recognition of relational values could help to identify and develop livelihood strategies that balance the three groups of values and also support ecosystems as well as human well-being.

Diversity of values and livelihoods

Our findings suggest that communities, despite the short distance between them, showed differences in livelihoods, strategies and differences in local knowledge and values and its categories of classification. Results show a slight negative correlation between

diversity of values and livelihoods. As people have more jobs, they have fewer values associated with marine and terrestrial species. However, the high dispersion of the data and the value of the coefficient of determination do not make it possible to establish such an association (Figure 5). The findings point to the possibility that livelihood diversification means less time spent in the ecosystem, which can impact knowledge transmission and relational values (Pearce et al. 2011; Fawcett et al. 2018). In one Unit community of Canada, Pearce et al. (2011) found that the loss of local knowledge was related to the transmission gap between older and younger people, as well as the reduced time spent on subsistence activities. The transition to diversified livelihoods in the land-sea interface often entails allocating less time to subsistence activities, potentially compromising community knowledge transmission and values. This in turn potentially means lower capacity to adapt to environmental changes over the time (Lyver et al. 2019). Indigenous and local knowledge of small-scale farmers in Southern Chile has allowed them to sustain and improve their livelihoods despite external disturbances (Caviedes et al. 2024). Local knowledge and values can have an important role in improving and diversifying livelihoods and, at the same time taking care of natural resources without ecological consequences (Etongo et al. 2017). Recognition of relational values provides a broader understanding of the many ways ecosystems provide benefits to nature, which can strengthen local identities related to nature, and the transmission of knowledge and values despite emergence of new activities and livelihoods.

We argue that initiatives towards diversification of livelihoods should be accompanied by the relational perspective that recognizes a space of values and meanings between the individuals and the environment as species or natural resources could improve the management of natural resources (Lejano 2019; Bataille et al. 2021). Cámara-Leret et al. (2019) reported that the collapse of knowledge networks between species and cultural heritage happens when plant species become extinct or when cultural diffusion is lost. This is particularly relevant following crisis such as local extinctions, if coastal communities can draw on knowledge and experience of the past to improve future conditions. For example, in the Valdivian coast in Chile, local extinctions such as the 'macha fever' (*Mesodesma donacium*) have taught the consequences of overexploitation of natural resources. The 'macha fever' refers to the intense and unsustainable harvesting of macha clams, leading to declines in their population and eventual local extinction. This serves as a cautionary tale in the communities, highlighting the importance of sustainable resource management and the need to avoid overexploitation. A similar 'fever' with the loco

(*Concholepas concholepas*) where at national level, landing of this species increased as a response of new markets. This particular case allowed small-scale fisheries' institutional transformation, creating rules for regulated extraction (Gelcich et al. 2010). These lessons from the past and this space between people and nature could allow a deeper and long-term understanding of local knowledge and values to improve resource management (Molnár and Babai 2021). Hence, in our global crisis, engagement with relational values could foster a holistic perception of people and nature as social-ecological systems and go beyond classical diversification based on economic incentives, to couple livelihoods with sustainability and a wider sense of human well-being.

Emerging tradeoffs and limitations of the study

The communities of Niebla and Amargos, which are the most connected, show a lower diversity of values and a lower and negative tendency of the relationship between values and livelihoods, compared to the other communities in the study area, located within a 30-km distance. This variation may be a consequence of social-ecological changes. As observed in other parts of the territory, historical social-ecological changes have contributed to the loss of the relationship with nature. Particularly, although land-sea interface offers multiples opportunities of livelihoods (Castro and Oliveira 2007), land-sea interactions can negatively affect ecosystem services and human well-being, affecting the connection with nature (Barceló et al. 2023). This decline is evident through restricted access to forests and the transformation of land use from native forest to monocultures (Barreau et al. 2016; Parra et al. 2019). Our results may suggest that as connectivity increased from the city, markets, overexploitation and the decrease of natural resources became greater for communities closer to the city, thus negatively affecting communities' livelihoods and local knowledge. Social-ecological changes, market pressure, connectivity, and environmental changes can all impact values (Riechers et al. 2022). Globalization and new markets also influence whether people decide to leave or start new livelihoods in the land-sea interface (Kramer et al. 2017). Thus, the potential tradeoffs exist between diversifying livelihoods and changing values is likely to be influenced by proximity to urban centers.

Another aspect of market pressure and globalization, is that overexploitation of natural resources can harm social relationships in coastal communities, which makes it more difficult for them to share information and can also negatively affect or change the values and priorities of different groups within the community (Ramirez-Sanchez and Pinkerton

2009; Riechers et al. 2022). For example, strong social networks and supportive relationships can provide access to resources and opportunities that individuals would not have otherwise. Positive social relationships can also provide emotional support and a sense of belonging (Chan et al. 2016, see Table 2), which can help individuals cope with difficult circumstances. On the other hand, if relational values are eroded or human relationships are strained, it can make it harder for individuals and households to access the resources and opportunities they need to sustain themselves. In the case of the communities as Niebla and Amargos, the rapid growth and the decreasing availability of natural resources could explain this pattern. For other communities, which still present lower levels of growth and connectivity to the city, the study of the values of nature can be an opportunity to diversify and support livelihoods through engagement with relational values.

Our study had some limitations in terms of the methods used to measure local knowledge and values. We relied solely on free listing of land and sea species and only considered values associated with named species, without addressing values associated with landscapes or ecosystems. To overcome these limitations, future research could benefit from adopting improved methodological approaches based on the Values Assessment of the Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services (IPBES 2022) recommendations, which provide guidance on how to navigate the complex relationship between people and nature. Additionally, incorporating a sustainable livelihoods approach could be a guide to further understanding of this relationship. By incorporating such approaches, we can obtain a more nuanced and comprehensive understanding of the values and knowledge associated with natural resources in different communities.

Final remarks

This paper examines the relation between local knowledge, different kinds of values and livelihood of communities living in the land-sea interface, to explore insights towards livelihood diversification. This interface presents complex interdependencies and vulnerabilities, where land-based activities can impact coastal communities dependent on marine resources, and vice versa. Based on our fieldwork and results from this study, we show how communities have been adopting different strategies to face the actual context where marine resources are decreasing, land use is changing and people are abandoning activities as agricultural and fisheries. People on the coast recognize their ability and capacity to change. However, our findings indicate that livelihood diversification can also lead to the loss of

knowledge and the relational values that underpin knowledge generation and practices of care for long-term sustainability of resources. We argue that attention to and recognition of relational values in studies of livelihoods, beyond a sole focus on economic rationales, can provide a deeper understanding of potential transformative change and how to achieve more sustainable pathways. The community of Chaihuín is an interesting example where the expression of a diverse kind of values, including relational values, is supporting a livelihood diversification while protecting the natural resources, but a deeper understanding of these relationships is needed. Tourism has been developing as a potential and secure livelihood that is gradually positioning itself as the most important source of income and that does not affect natural resources in the way that resources exclusive use for sale does. Thus, experience in the past, learning in the light of new opportunities and a diverse set of values, focusing on relational values, could shape a sustainable future.

Understanding the reasons and mechanisms underlying the significance of nature to individuals is imperative. Relational values offer a valuable perspective for exploring the dynamics of human-nature relationships and their importance. By conducting research on relational values, we can enhance conceptual clarity and strengthen the relevance of research findings to sustainability and conservation science. Considering recent studies on the current crises of biodiversity, our study contributes new empirical evidence regarding the role of local knowledge and relational values. This underscores the critical importance of embracing relational values and engaging with their respective holders to shape responses to ongoing social-ecological crises. Our research provides valuable insights for policymakers aiming to develop holistic and inclusive strategies that leverage diverse knowledge systems, particularly understanding the importance of considering another vision of nature, to address contemporary environmental challenges.

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