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Sustainability Meets Society: Public Perceptions of Energy-Efficient Timber Construction and Implications for Chile's Decarbonisation Policies

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Abstract

Timber construction is increasingly promoted in Chile as a route to low-carbon, energy-efficient housing, yet public acceptance remains decisive for its diffusion. This study reports the first large-scale perception survey of timber buildings in Greater Concepción (N = 200) and contrasts key results with an earlier identical survey in Valdivia. Concepción residents strongly recognise timber's thermal comfort attributes and associate wood housing with lower winter heating demand, a perception markedly stronger than in Valdivia. Conversely, 73% of Concepción respondents believe timber homes burn easily, but a majority also accept that modern engineering can mitigate this risk, indicating scope for targeted technical communication. Environmental perceptions are more ambivalent: although respondents value wood's renewable origin, 42% doubt that timber construction reduces climate change, and many equate it with deforestation, echoing controversies around Chile's plantation model. Cluster analysis reveals a techno-optimist subgroup coupling enthusiasm for energy savings with confidence in fire-safety innovations, suggesting a strategic constituency for demonstration projects. By situating end-user attitudes within national decarbonisation goals, this paper argues that region-specific outreach—emphasising verified energy-efficiency gains, certified sustainable forestry and visible fire-safety performance—can convert passive approval into active demand and accelerate Chile's transition to a net-zero housing stock.

Keywords: timber construction; perceptions; climate change; consumer

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1. Introduction

1.1. The Perception of Timber Construction Revisited

Chile's Framework Law on Climate Change establishes the country's commitment to achieving carbon neutrality by 2050, creating a clear mandate for emissions mitigation across all sectors [1,2]. This aligns with international decarbonisation goals in the construction industry: reducing the carbon footprint of building materials has become a priority worldwide. Timber is increasingly recognised as a viable low-carbon alternative to more carbon-intensive materials like concrete and steel, especially with modern engineered wood products enabling its use in larger and taller structures (e.g., high-rise wooden buildings) and contributing to greener cities. Reflecting this trend, many countries with significant forestry sectors have adopted policies to promote timber construction as part of their climate strategies [3]. Because of this, the Nationally Determined Contribution (NDC) from Chile under the Paris Agreement includes a specific mitigation measure to "promote construction in wood" as part of the forestry sector contribution to emissions reduction [4]. Chile seeks to capitalise on the carbon sequestration and lower emissions of wood-based construction by encouraging a transition to timber buildings. However, it has been noted that this NDC commitment lacked detail in its initial form because it did not have clear metrics or implementation mechanisms, making progress difficult to track [5]. In addition, Chile's Long-Term Climate Strategy [6] and sectoral climate plans emphasise sustainable practices in construction, through improving energy efficiency and promoting cleaner technologies in buildings. However, some scholars have noted that the timber's potential to reduce embodied carbon in urban development has not yet been fully exploited [3]. Current climate instruments focus more on forest conservation and reforestation (as carbon sinks) than on city wood use. This gap is prompting calls for more explicit integration of timber construction in climate policy, beyond high-level statements.

In this context, this study seeks to provide concrete evidence for developing metrics and implementing mechanisms for Chile's timber-based decarbonisation goals. By quantifying public acceptance and concerns, the findings can help establish benchmarks to monitor progress and shape targeted outreach programmes. Such evidence-based collaboration between decision makers, industry, and academia will be key to credibility, ensuring that Chile's approach aligns with international best practices and has broader applicability. Indeed, sustainable development demands a careful balance between energy needs and environmental and societal goals [7]. Innovative financial tools, such as green bonds, have significantly boosted green technological innovation in the energy sector [8], illustrating mechanisms that could complement Chile's decarbonisation efforts. Beyond carbon and energy outcomes, recent work shows that construction and demolition waste entails measurable health externalities. Using a life-cycle assessment coupled with Disability-Adjusted Life Years and a Willingness-To-Pay (WTP) monetisation, it has been demonstrated that inhalable particulate matter (PM10) carries the highest health cost and that the disposal stage dominates the total WTP burden [9]. These results underscore that waste prevention and cleaner end-of-life processes should be treated as part of the social benefits of timber's industrialisation. The survey insights can thus inform policies that promote timber construction as a low-carbon solution, with measurable community engagement and robust implementation frameworks.

At subnational levels, emerging initiatives link timber construction with climate goals. In 2024, the Region of Biobío, Chile's forestry heartland, brokered a pioneering public–private agreement to advance wood construction as a climate solution. This pact, endorsed by regional authorities, industry (CORMA), academia and labour unions, recognises timber buildings as a strategy to sequester carbon long-term while tackling a housing deficit. It sets out commitments to use wood in 30,000 new homes and public projects, sustainable forestry supply, and workforce training for a "sustainable growth model based on renewable resources" [10]. Likewise, Chile's innovation and economic development agencies have launched programmes to industrialise timber housing, particularly for social housing, to cut building emissions and reduce the current housing deficit, estimated at around 550,000 dwellings [11]. These efforts underscore a growing consensus that decarbonising construction will require material substitution alongside energy efficiency—and that wood offers a viable path to deep emissions cuts in the sector.

Against this backdrop, a recent study in the southern city of Valdivia shed new light on how the public perceives timber housing [12]. Valdivia, often dubbed a "forest city" for its mixed native and plantation forestry landscape, provided an ideal case to explore these perceptions. Using a comprehensive survey of local households, the study revealed persistent reservations contradicting the wood sustainability promise. On one hand, many residents voiced long-standing concerns about timber's performance, citing worries over structural durability, fire safety, pest resistance, and maintenance costs, especially when compared to the perceived solidity of masonry construction. On the other hand, respondents acknowledged several positive attributes of wooden dwellings, including lower construction costs and good thermal comfort in the home. Strikingly, the Valdivia survey also found that a significant segment of the public harbours misgivings about the environmental implications of wood. Participants questioned timber's purported ecological advantages by raising issues like deforestation and unsustainable forestry, even though wood is widely known for its low carbon footprint and renewability. This paradox—that timber is promoted as a climate-friendly material yet some end-users fear it may harm the environment—highlights a critical tension. The Valdivia case concluded that such perceptions are not merely knowledge gaps but are shaped by deeper ideological and sociopolitical factors. In other words, there is a discrepancy between the pro-sustainability narrative around timber and the lived perceptions of citizens, who remain sceptical due to practical experiences and broader concerns. These findings underscore that realising wood's potential in Chilean construction will require more than technical innovation or marketing; it calls for addressing ingrained public doubts through policy, education, and trust-building initiatives.

The present study builds upon those insights by turning to the Greater Concepción area, the regional capital of the already mentioned Region of Biobío. This region is heavily forested: official land-use data indicate roughly 597,600 ha of native forest [13]– about a quarter of the region's 2.4 million ha area—alongside approximately 834,000 ha of planted ("productive") forestry plantations [14]. The forest sector is also a key economic pillar: it contributed about 15.8% of Biobío's regional GDP [15], and historically has provided a large share of local jobs (e.g., some 53,000 workers or 43.8% of Chile's forestry workforce were in Biobío in 2013) [16]. Greater Concepción is the region's main urban area; according to the new metropolitan definition [17], it now comprises 11 communes: Concepción, Talcahuano, San Pedro de la Paz, Coronel, Chiguayante, Hualpén, Lota, Penco, Santa Juana, Hualqui and Tomé, with about 985,000 inhabitants in total (roughly 63% of the region's population). Yet this has not translated into widespread residential adoption of timber construction: building-permit data for 2022 show that only 8% of new dwellings in the metropolitan area were built in timber. However, the proportion rises sharply in the case of extensions, reaching 64.5% of the total [18].

Consequently, by applying the same survey instrument in this metropolitan area, we examine whether the patterns observed in Valdivia hold in a different locale, where the timber sector's presence is prominent and recent environmental events are salient. In particular, the Greater Concepción area has endured highly publicised forestry-related challenges, from devastating wildfires to conflicts over monoculture tree plantations, which may further colour local attitudes toward wood in construction [19,20]. In particular, the major wildfires of 2017 and 2023—the most significant of the past decade in terms of hectares affected (Figure 1)—substantially impacted public opinion. Even the best engineering solutions will face an uphill battle if people vividly remember these tragic events. We therefore ask how place-based perceptions might amplify or alter the previously identified contradictions, and what this means for bridging national climate policy with social acceptance on the ground. This follow-up study allows us to probe whether proximity to the timber industry and its territorial context intensifies the tensions between Chile's climate ambitions and the public's lived sustainability experience. Do communities in a heartland of forestry view wooden housing more favourably due to familiarity, or do they voice even stronger reservations due to first-hand awareness of environmental risks? By comparing findings across Valdivia and Concepción, we aim to deepen the understanding of how regional context mediates the alignment (or misalignment) between sustainability narratives and societal perceptions.

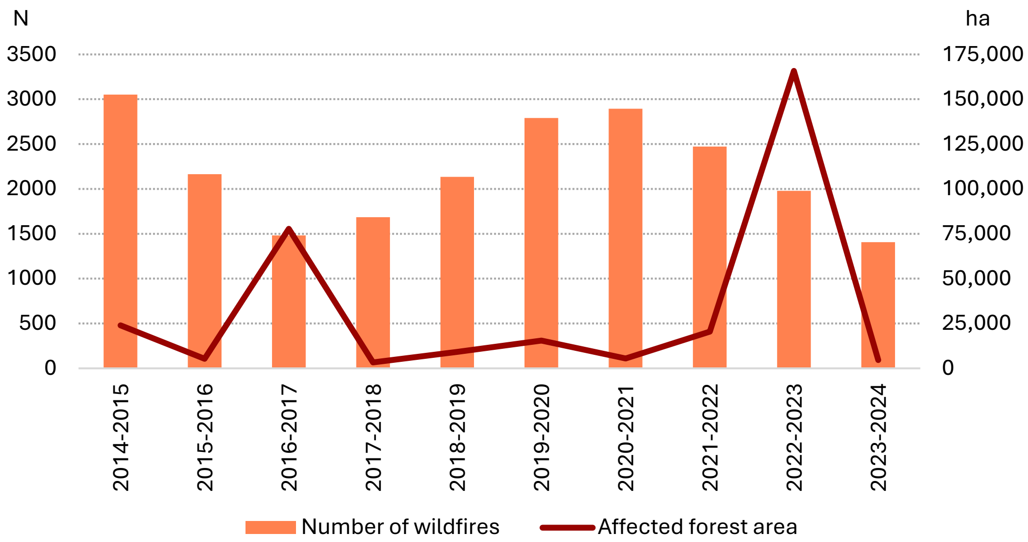

Figure 1. Number of wildfires and affected forest area for the Region of Biobío (provinces of Biobío, Concepción and Arauco) in the last 10 years. Source: National Forest Corporation (CONAF) [21].

It is worth noting that public wariness toward timber construction in Chile is nothing new. Nearly two decades ago, a landmark nationwide survey commissioned by the timber industry captured the classic fears that Chileans associated with wooden houses [22]. That study, which at the time found very low willingness among residents (especially in Santiago) to choose a wood-built home, highlighted recurring themes of distrust. Respondents tended to dismiss wooden houses as less "solid" or permanent than houses of concrete or brick, citing concerns over fire hazards, insect infestation, and poor longevity as key deterrents. Such issues of safety and durability dominated the public narrative around wood construction in the early 2000s. However, the kinds of environmental considerations that have since come to the fore were absent from those discussions. A generation ago, climate change was not a mainstream factor in housing choices, and timber was generally regarded as a traditional material rather than a climate solution or a threat in the public mind. Over the ensuing years, as sustainability has become a societal priority, the discourse around timber has evolved. Contemporary surveys (including our Valdivia study) reveal that Chilean citizens now weigh the familiar structural concerns and broader environmental questions such as carbon footprints, forest stewardship and biodiversity. This marks a significant shift in narratives: whereas the scepticism toward wood was rooted almost entirely in functional anxieties two decades ago, today it also encompasses the material's perceived alignment with (or deviation from) climate and conservation goals. The historical trajectory from the 2005 industry study to the present research thus illustrates how new collective values and information about sustainability have reshaped public representations of timber.

In light of the above, this paper aims to reassess and contextualise the perception of timber construction in Chile by revisiting the issue through a regional lens. We specifically examine the Greater Concepción area to explore how local context and experiences might reinforce or recalibrate the tensions previously identified between timber's sustainable reputation and the public's reservations. Through this comparative, place-sensitive approach, the study seeks to illuminate the interplay between national climate objectives (which promote wood as a low-carbon solution) and the social representations that can either enable or impede those objectives on the ground. In doing so, we provide an updated diagnosis of the opportunities and obstacles for mainstreaming timber in Chile's building sector. The findings, in brief, indicate that while positive awareness of wood's environmental advantages is growing, significant challenges persist in public confidence. Respondents in the Concepción survey echo many of the traditional concerns about quality and safety, and also express nuanced environmental apprehensions reflecting local realities—from distrust in forestry practices to fears of resource depletion. These results confirm an enduring perception gap that policy rhetoric alone has yet to close. Overall, the study highlights the need for more integrative strategies that align decarbonisation policies with community values, ensuring that timber construction's sustainability resonates with society in a truly resonant way.

1.2. Bibliometric Analysis

The article updates the bibliometric analysis reported in [12] by employing the bibliometrix package from R's statistical software version 4.4.3 [23]. The original search string—timber AND construction AND (consumer OR user) AND (perception OR attitudes OR influence)—was re-run in the Web of Science database [24] and retrieved 49 records—six more than in the previous query. The expanded corpus now comprises the article cited in [12] and five additional papers published in late 2024 and during 2025.

These five recent studies—spanning Asia, Europe, and Latin America—demonstrate notable convergences in findings, alongside differences shaped by cultural and stakeholder contexts. Convergent themes include the persistence of public misgivings about wood's performance (especially its durability and fire safety) and a cautiously optimistic view of its environmental merits. For example, Zhang et al. [25] found that Chinese and Japanese consumers harbour the same prejudices regarding timber housing: they perceive timber buildings as less fire-resistant, less long-lasting, and poorer at sound insulation, even while acknowledging the material's healthiness and natural appeal. Such technical scepticism—particularly the belief that "wooden homes burn easily" or degrade faster than concrete—echoes a longstanding global concern. At the same time, there is widespread recognition that timber is a "green" material with sustainability benefits, though this too is nuanced. The same study noted that consumers in both China and Japan doubted the climate benefits of timber construction despite its renewable image, indicating ambivalence.

At the same time, the literature also highlights divergences stemming from cultural frameworks and stakeholder perspectives. User-focused studies such as Baul et al. [26] emphasise end-user attitudes, whereas industry-oriented analyses—e.g., Stordal et al. [27] on developers and Pham, Tang & Lowe [28] on timber companies—reveal contrasting viewpoints within the construction supply chain. This distinction is crucial: the barriers perceived by the public (fire safety, longevity, aesthetics) are not always the same as those identified by practitioners and suppliers (cost premiums, market conditions, regulatory compliance). For instance, Stordal et al. [27] examined Norwegian housing developers' expectations regarding reused wood materials and found that forward-looking firms can anticipate lower cost barriers over time. In other words, developers may be willing to absorb higher upfront costs for sustainable timber use, believing consumer willingness will eventually rise. This contrasts with many user surveys where buyers often baulk at paying a "green premium" for wood.

Cultural and geographical contexts further shape these perspectives. In regions with deep traditions of wood construction, societal attitudes can be markedly different from those in places where modern building with wood is relatively novel. Baul et al. [26] illustrate this in a study from Bangladesh, a country with a long history of timber use in buildings and furnishing. They report high public affinity for wood products: most local consumers and shopkeepers ranked wood as more attractive and environmentally friendly than steel or plastic alternatives, with over 80% affirming wood's green credentials. Meanwhile, in Europe's Nordic countries, timber enjoys broad acceptance in low-rise housing (over 80% of single-family homes in Sweden are wooden). Yet, Nagy et al. [29] reveal a slow transition to multi-storey urban buildings. Their research in Sweden attributes this lag partly to historical biases and regulatory hurdles: for over a century, building codes curtailed wood use in cities due to fire concerns, and only in the late 20th century were these restrictions lifted. Such historical context means that, even today, developers must actively convince stakeholders of wood's safety for taller buildings. Summarising, the cultural narrative around timber—whether seen as a traditional "tried and true" material or a risky new technology—varies widely. This helps explain why perceptual barriers (e.g., fear of fire or termites) persist strongly in some locales while being less pronounced in others.

Beyond individual studies, the bibliometric analysis presents a broader evolution of research connecting sustainability and societal acceptance of timber. First, Figure 2 shows the international collaboration network by country, revealing how academic efforts on this topic are globally distributed. Chilean scholars appear well-connected with researchers in Spain and other Latin American countries, pointing to a strong Ibero-American link that, in turn, connects to other European countries in terms of timber research.

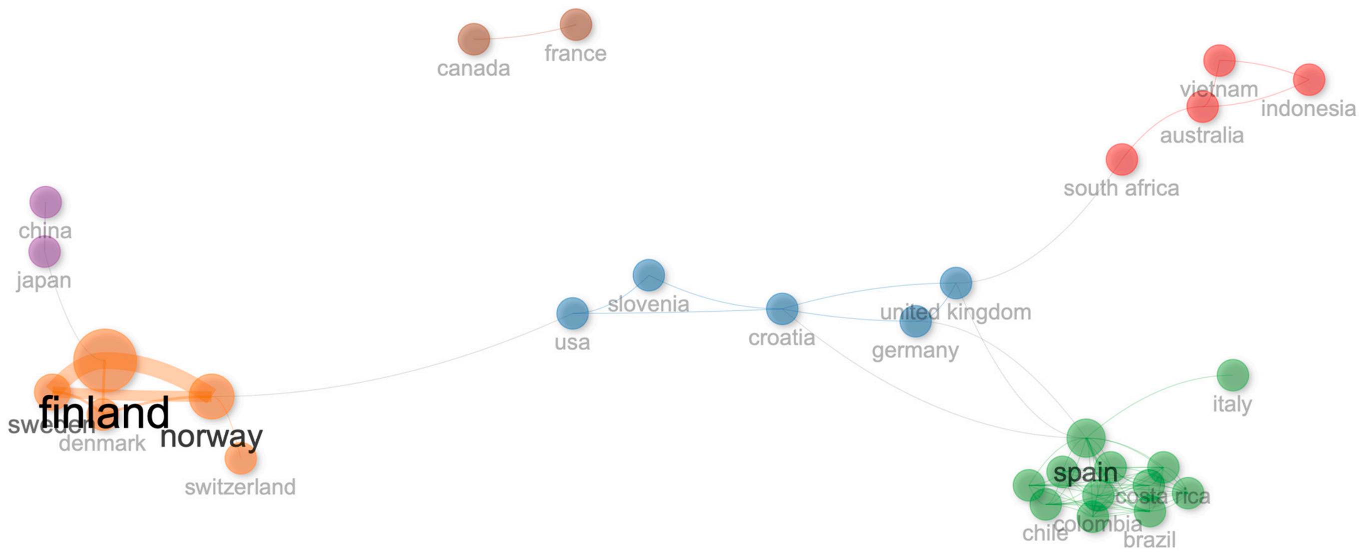

Figure 2. Collaboration network by country.

In contrast, the network shows Chile is somewhat distant from Finland, Norway, Sweden and Denmark, which are predominant in scientific production, due to their long history and volume of research in wood engineering and design [12]. A substantial proportion of this scholarly output is linked to local or regional circumstances, as evidenced by the pronounced clustering of Latin-American countries compared with their European or Asian counterparts. Although constructing a common narrative and identifying shared regional themes can encourage the uptake of timber as a safe and sustainable construction material, broader academic collaboration is crucial for situating Latin-American perspectives within the global debate. In brief, this collaboration network highlights Chile's role in timber construction research and the need to strengthen connections with leading research hubs to foster a more integrated global knowledge base.

Figure 3 illustrates a keyword co-occurrence network (generated using Web of Science's Keywords Plus) that maps the principal thematic clusters in the selected timber construction literature. The most prominent cluster (depicted in orange) centres on technical and societal aspects of wood construction. It includes representative terms such as "construction", "frame houses", "attitudes", and "behaviour". A second cluster (in green) broadens the social and perceptual themes, comprising keywords like "perceptions", "products", "perceptions", and "barriers". Both groups indicate a growing scholarly focus on how the public views and accepts timber buildings, and how such perceptions might influence the adoption of wood-based construction. A third cluster (in brown) addresses construction, performance and market dynamics, grouping terms such as "timber", "energy efficiency", "thermal comfort", "price", and "frame multistory construction". This network reveals three interrelated knowledge domains that align with the primary analytical axes: advanced timber construction techniques and their sustainability implications, social perception of wood buildings, and the decarbonisation challenges associated with policy and market frameworks. The clustering underscores that progress in timber-based construction requires an integrated approach that combines architectural and engineering innovation with public acceptance and supportive governance.

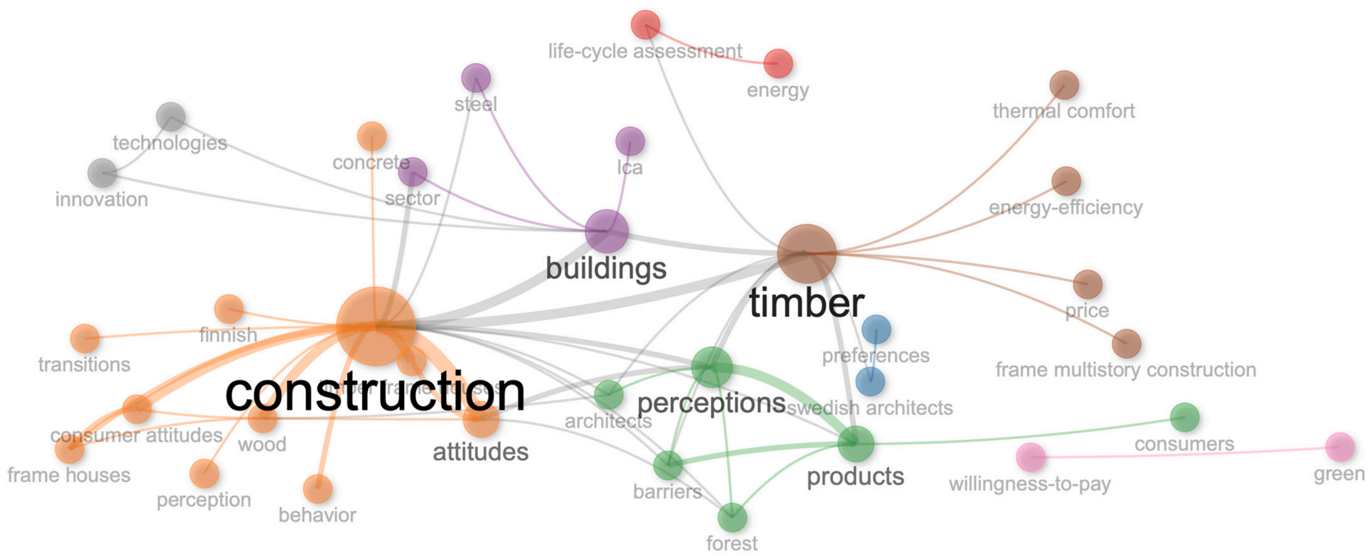

Figure 3. Co-occurrence network from the keywords of the bibliometric analysis.

Finally, the evolution of the clusters over time (as hinted by the time slices of Figure 4) reveals an interesting trajectory. The first period, which concludes in 2009, lays the groundwork for the thematic landscape identified in the literature search, coalescing around four overarching concepts: attitudes, perceptions, construction, and timber. From that juncture up to the most recent period—namely, the last two years—these topics appear at first sight to remain essentially unchanged (the sole novelty being the emergence of willingness to pay). The interest, however, lies in how the themes evolve: they split, merge, and give rise to new configurations. For example, the strand initially labelled "timber" is redesignated as "products" around 2022–2023, before expanding into the broader vantage of construction. Thus, the discussion of timber in the 2024–2025 corpus is not the same as five years ago, for contemporary scholarship foregrounds users' willingness to pay, reinforcing the notion that purely technical arguments are insufficient unless accompanied by public acceptance. Though consistently present, the literature on "perception" and "attitudes" has been continually rearticulated through association with varying concepts. Its strongest linkage is with the keyword "construction", mirroring the analytical perspective advanced in this article and offering substantial implications for public policy.

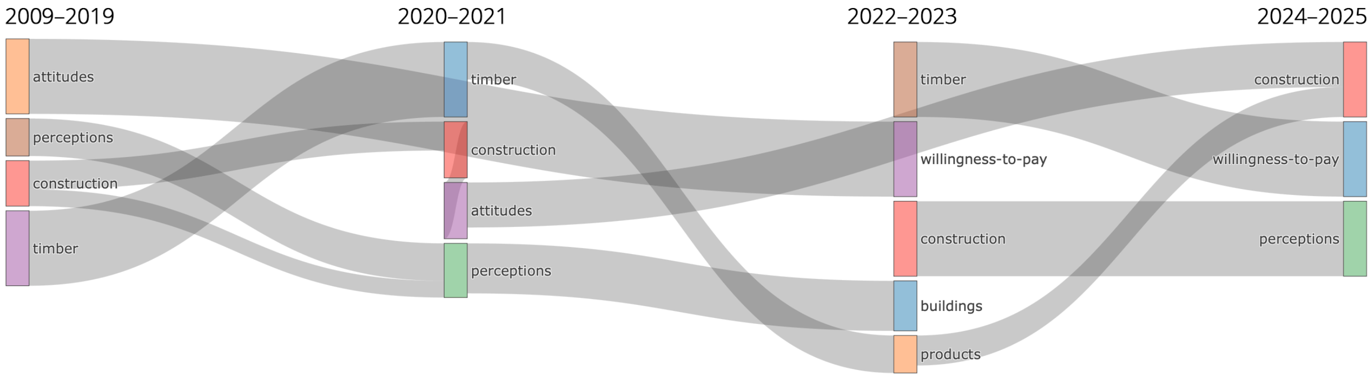

Figure 4. Thematic evolution in four time slices utilising the bibliometric analysis.

2. Methodology

2.1. The Survey

A structured questionnaire survey captured urban residents' perceptions of timber construction. This approach was chosen for its effectiveness in systematically quantifying subjective opinions across a broad sample, providing standardised data for analysis. To balance comprehensiveness with respondent engagement, the questionnaire was designed to be concise, comprising 33 mostly closed-ended questions, to gather rich information yet keep the interview duration reasonable and prevent respondent fatigue. Face-to-face delivery in respondents' homes further helped minimise non-response and allowed clarifications on the spot, an important consideration given the technical nature of some topics. All participants were interviewed in Spanish (the questionnaire was translated from an original Spanish version, with an English copy provided in Appendix A).

The content and structure of the questionnaire were developed based on local and international best practices to ensure its validity. In particular, the definition of survey indicators and items drew upon prior Chilean studies of public views on housing and sustainability, insights from preliminary interviews with relevant stakeholders (e.g., forestry-sector professionals and policymakers), and themes highlighted in recent international research on attitudes towards timber building [30–32]. For example, the chosen thematic dimensions (such as concerns about fire safety and durability, or beliefs about environmental benefits) mirror those identified in contemporary studies of public opinions on wood construction in other countries [33–36]. This coherence with earlier research attests to the content validity of the questionnaire, as it addresses comparable topics and uses terminology that has effectively elicited citizen views elsewhere.

As summarised in Table 1, the final questionnaire for the Greater Concepción consisted of 33 items grouped into three broad sections (or indicators). The first section collected basic sociodemographic information (8 questions) such as age, gender, education level, household size and tenure, providing a profile of each respondent. The second section—arguably the most critical in terms of content—focused on perceptions of wooden housing, comprising 17 statements on a 5-point Likert scale (from "strongly agree" to "strongly disagree") addressing six key dimensions of timber construction: durability, fire safety, environmental sustainability and climate impact, costs (construction and maintenance), flexibility in construction, and industrialisation potential. Respondents were asked to indicate their level of agreement with statements such as "A wooden house burns easily," among others, capturing their views on each aspect. This attitudinal section was adopted directly from the prior Valdivia survey instrument [12]. It remained entirely unaltered in the present study, a deliberate decision to ensure that the results would be comparable between the two cities. The third section covered decision factors for acquiring or building a timber home. This version expanded this section to six questions, adding one new item asking about the respondents' prior experience with timber construction. This extra question was intended to gauge whether familiarity (such as having lived in or built a wooden house before) might influence one's attitudes. Finally, to facilitate a subsequent qualitative research phase, the survey concluded with a short yes/no question inquiring about the respondent's interest in participating in an in-depth follow-up interview and collecting contact information. These concluding items did not pertain to perception measurement but were used to recruit volunteers for later interviews.

Table 1. Definition of the data collection instrument.

Indicator	Dimension	Items
Sociodemographic characterisation	Age	1 ordinal variable
	Gender	1 categorical variable
	Education level	1 ordinal variable
	Occupation	1 ordinal variable
	Household	3 categorical variables
	Tenure or occupancy regime	1 ordinal variable
	Subtotal	8 variables
Perception of wooden houses	Durability	3 categorical variables (Likert scale)
	Fire resistance	2 categorical variables (Likert scale)
	Environmental sustainability and climate impact	4 categorical variables (Likert scale)
	Costs (construction and maintenance)	2 categorical variables (Likert scale)
	Flexibility in construction	3 categorical variables (Likert scale)
	Industrialisation potential	3 categorical variables (Likert scale)
	Subtotal	17 variables
Decision variables for acquiring or constructing a wooden house	Housing types associated with timber construction	1 categorical variable
	Environmental actions in daily life	1 categorical variable
	Factors that would encourage buying a wooden house	1 categorical variable
	Perception of the reputation of the wood industry	1 categorical variable
	Previous experience with timber construction	1 categorical variable
	Willingness to buy a wooden house	1 categorical variable (1 to 10 scale)
	Subtotal	6 variables
Other	Interest in participating in the 2nd phase of the study	1 dichotomic variable (yes or no)
	Contact details of interested individuals	1 open-ended variable
	Subtotal	2 variables
Total		33 variables

2.2. The Spatial Sampling

Following the documented shortcomings in the 2012 and 2017 national census processes and official socio-economic surveys, there is growing interest in alternative sampling strategies to improve data quality [37]. A recurring issue in traditional surveys is the underestimation of spatial autocorrelation, which leads to information redundancy during the sampling design process [38]. Our study favours a spatially stratified sampling approach, based on representative clusters, over simple random sampling to address this issue. This approach leverages the fact that geographically proximate or socio-economically similar units can be grouped into homogeneous clusters, thereby reducing sample heterogeneity and, consequently, allowing for a smaller sample size to achieve a given level of precision [37].

In contrast to classical regionalisation (which often uses fixed geographic subdivisions and requires contiguous primary units), clustering methods allow grouping units by similarity without contiguity constraints [39]. This flexibility is advantageous for smaller-scale surveys, as it yields more internally consistent strata (i.e., high within-cluster homogeneity) based on a chosen stratification variable. According to prior regionalisation research, using a finer spatial scale produces more homogenous groups [37]. We therefore conducted the clustering at the census block level, selecting a variable that correlates strongly with socio-economic status to define the clusters. In particular, the head-of-household education index was used as a socio-material indicator of socio-economic level, ensuring that each cluster represents a distinct socio-economic stratum of the city [40,41].

Using a K-means algorithm, we employed the open-source GeoDa software (v.1.22) for the clustering implementation. K-means was chosen for its strong performance in spatial clustering applications and because it does not impose contiguity requirements, allowing clusters to form based purely on attribute similarity [42,43]. The algorithm was run with a high number of iterations and random starts to ensure a stable solution given the size of the study area. To determine the appropriate number of clusters K, we applied an "elbow" method, examining how the proportion of variance explained improved as K increased. The analysis identified a point of diminishing returns where adding more clusters yielded negligible gains in within-cluster variance reduction. In addition, we constrained the solution to align with meaningful socio-economic groupings to preserve interpretability. In practice, the optimal clustering was the smallest K that satisfied the following conditions:

- When the increase in the ratio is marginal with the growth of K clusters.
- The ratio is greater than 0.85, and the within-cluster variance is less than one year of individual education for all clusters.
- That no overlap occurs in cluster recognition and that it is assimilable to a concept, in this case, socio-economic.

Based on these criteria, a six-cluster solution was selected as optimal. This partition (K = 6) meets all the above requirements, with the following results:

- The total within-cluster sum of squares: 8.71472.
- The between-cluster sum of squares: 154.542.
- The ratio of the between-cluster sum of squares to the total sum of squares: 0.946619.

Considering minimal variance and taking the 49,825 households in Valdivia, the sample size calculation was defined as a 3.25% margin of error for a 95% confidence level.

Finally, six clusters corresponding to standard socio-economic levels were defined according to the classification criteria of Chile's Market Research Association [44] (Figure 5). Using the spatial clustering framework (with an initial target of 200 households), we allocated the sample across clusters in proportion to each cluster's share of the population and its internal heterogeneity (Table 2). This ensured that every socio-economic segment was represented in the survey in line with its size and variability (heterogeneity), regardless of whether some municipalities within the metropolitan area might end up with no selected cases. In this case, the sampling methodology aims to achieve representativeness of the Great Concepción for each of its socio-economic segments.

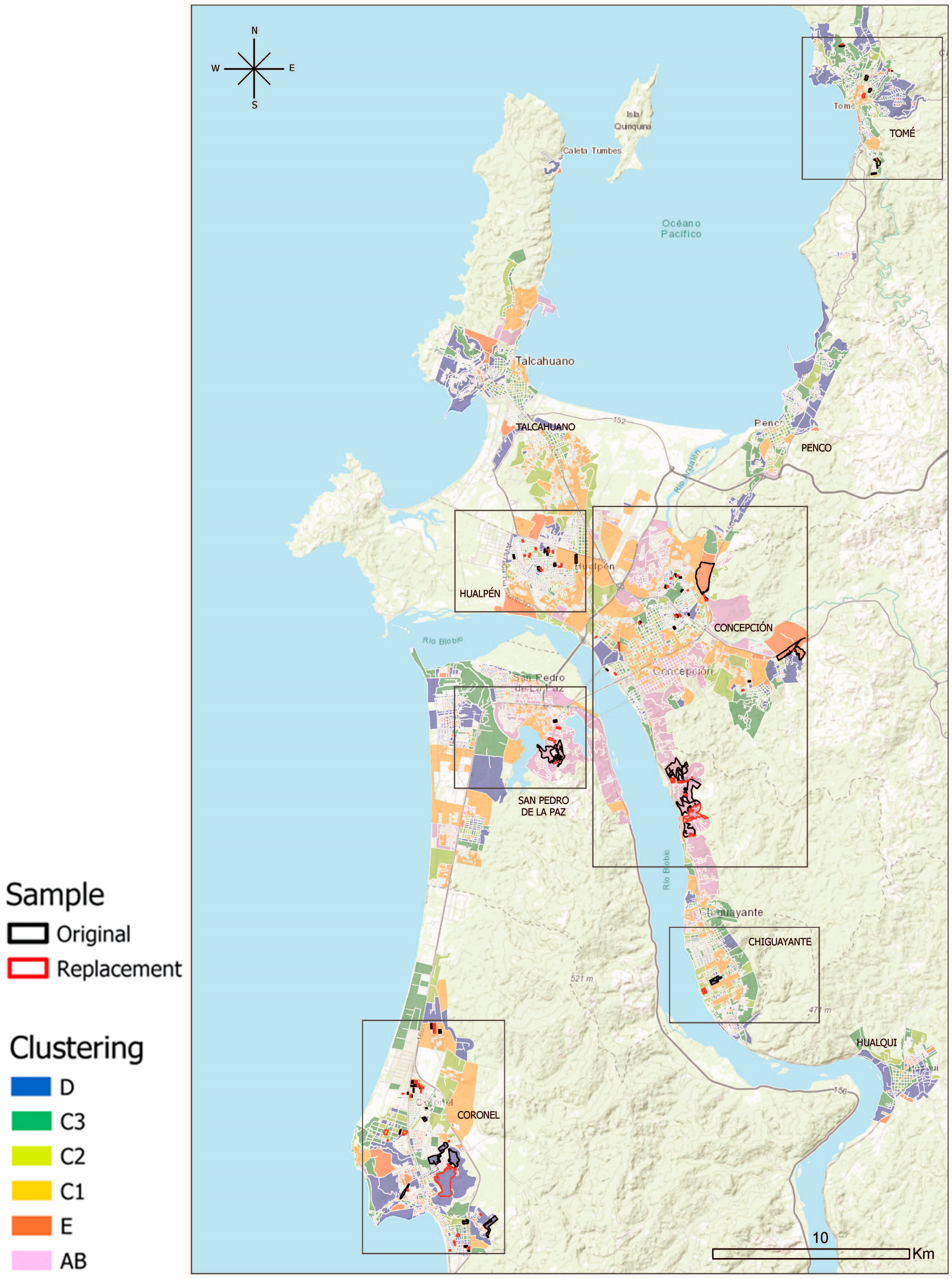

Figure 5. Cluster analysis based on the head of household education index with six representative clusters of the socio-economic levels in the Greater Concepción.

Table 2. Definition of the data collection instrument.

Cluster	Socio-Economic Level	Households	*p*-Value	Within Clusters	Heterogeneity	N
AB	high	48,096	0.95	1.43	0.87%	33
C1	medium-high	58,736	0.95	1.09	0.66%	24
C2	medium	58,406	0.95	1.1	0.67%	25
C3	medium-low	77,562	0.95	1.18	0.67%	25
D	low	73,306	0.95	1.53	0.94%	35
E	very low	18,800	0.95	2.36	1.40%	52

An interactive online map tool was developed to carry out the cluster-based sampling in the field. This map visualised all city blocks coloured by cluster. It was used to randomly select the specific census blocks to be surveyed in each cluster, with additional replacement blocks pre-selected in case an original block proved unsuitable (Figure 6). Each selected block entry included relevant details (such as the number of households and their cluster classification) to assist the surveyors in locating households and verifying they were in the correct cluster.

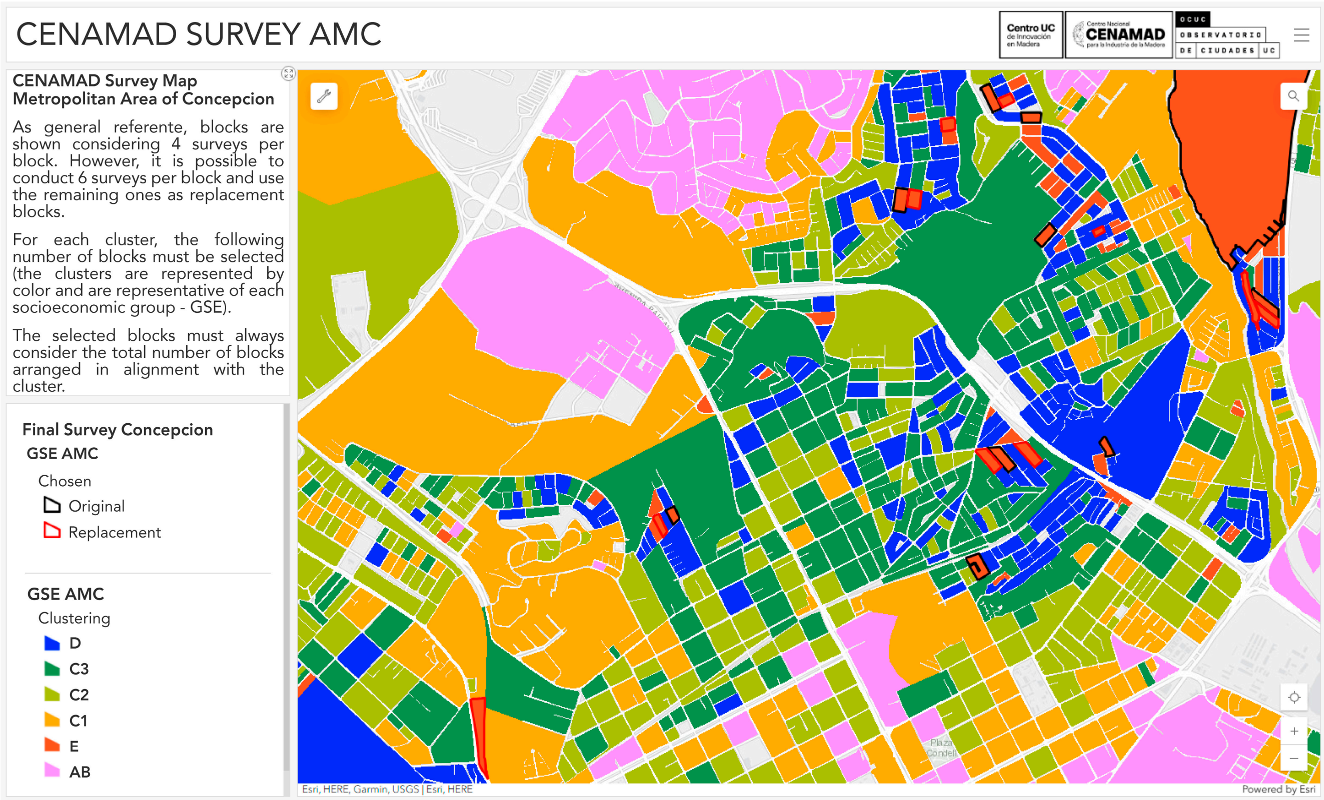

Figure 6. Online map resource for field work in a section of the Concepcion borough, including the original random selection of blocks (in black), the replacement blocks (in red) and the socio-economic clustering levels.

Finally, the survey was carried out between 5 December 2024 and 24 January 2025 and involved 200 households and 59 blocks, considering four selected blocks on average (Table 3).

Table 3. Definition of the data collection instrument.

Cluster	Socio-Economic Level	Number of Surveys	Percent of Surveys	Households per Block	Number of Blocks
AB	high	34	17.0%	4	10
C1	medium-high	25	12.5%	3	10
C2	medium	26	13.0%	4	7
C3	medium-low	26	13.0%	4	7
D	low	36	18.0%	4	10
E	very low	53	26.5%	4	15
Total	Total	200	100.0%		59

2.3. Principal Component Analysis and Cluster Analysis

Following the analytical framework of the earlier Valdivia case study, we applied an identical multivariate approach to ensure comparability of results. A Principal Component Analysis (PCA) was performed on the set of perception survey items (measured on 5-point Likert scales) to uncover latent dimensions in the data. Although Likert-scale responses are ordinal, it is standard practice in such contexts to treat them as quasi-interval data for PCA, given a sufficiently robust sample size and well-distributed responses. This approach is supported by established multivariate analysis guidelines [45], which note that dimension-reduction techniques can be meaningfully applied to these variables. The PCA thus condenses the large number of observed variables into smaller components while minimising information loss, providing a basis for subsequent clustering.

Using the Kaiser eigenvalue criterion ($\lambda \geq 1$), six principal components were extracted from the data, and together these accounted for 57.4% of the total variance (Table 4). We applied an orthogonal Varimax rotation to the initial solution to facilitate the interpretation of the underlying factors. This rotation yields a more transparent factor structure by maximising high loadings and reducing cross-loadings, making characterising each component in substantive terms easier. The retained components correspond to the main dimensions of variation in respondents' perceptions and form the input for the subsequent analysis stage.

Table 4. Eigenvalues and variance percentages per component of the PCA.

	Components					
	C1	**C2**	**C3**	**C4**	**C5**	**C6**
Eigenvalues	4.17	1.97	1.42	1.24	1.07	1.04
Percent of variance	21.9%	10.3%	7.5%	6.5%	5.6%	5.5%
Cumulative percent	21.9%	32.3%	39.8%	46.3%	51.9%	57.4%

Next, the factor scores obtained for each respondent on the six components were used as variables in a hierarchical cluster analysis. We opted for an agglomerative clustering procedure based on Euclidean distance as the dissimilarity measure and using Ward's linkage method to merge clusters. This approach—identical to that employed in the Valdivia study– iteratively joins respondents into clusters to minimise within-cluster variance. The appropriate number of clusters was determined by examining the dendrogram and comparing solutions for different cluster counts in terms of their coherence and distinctness. A solution with five clusters emerged as the respondents' most parsimonious and interpretable grouping, balancing internal homogeneity with clear differentiation between clusters. Notably, using the PCA-derived factor scores for clustering offers methodological advantages: since the components are orthogonal, this mitigates issues of multicollinearity among the input variables, and it also standardises the scale, given that factor scores are typically z-standardised. In combination, the PCA and clustering procedures enabled the identification of distinct respondent profiles regarding timber construction, highlighting heterogeneous perception patterns within the sample.

3. Results

3.1. Descriptive Analysis

The initial frequency distributions reveal clear patterns in Concepción's perceptions. Under the durability dimension, most residents expressed concern about timber's longevity (Figure 7). For example, 73.5% agreed that a wooden house "lasts less" than masonry (37.5% strongly agree + 36.0% agree), and 88% agreed it is more susceptible to insect infestation. By contrast, only about 27% decided that wood is "as resistant as concrete" (the majority disagreed), indicating scepticism of wood's structural parity with brick. In the cost dimension (Figure 8), however, responses were more positive: nearly 70% saw timber construction as cheaper to build (31.5% strongly agree + 38.5% agree), whereas roughly 55% expected higher maintenance costs for wood over time (18.0% strongly agree + 37.0% agree). In other words, most respondents anticipate initial savings from wood but also foresee increased upkeep expenses.

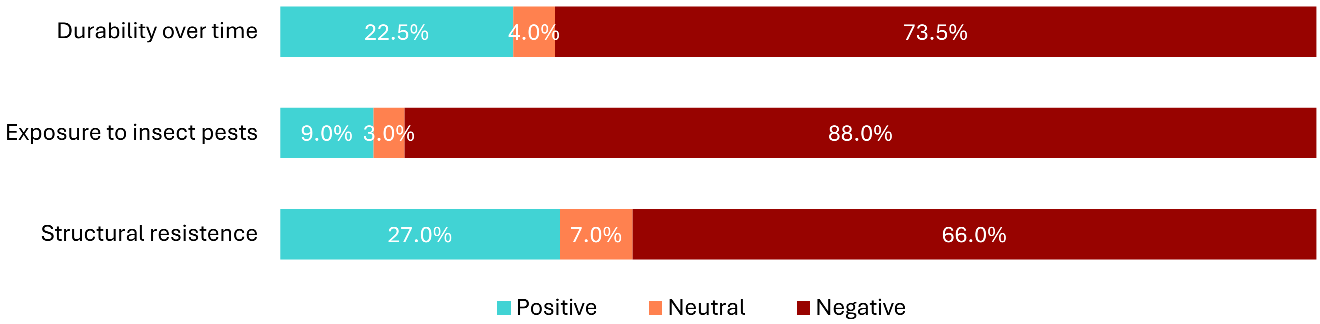

Figure 7. Descriptive results of the perception of wood construction regarding durability.

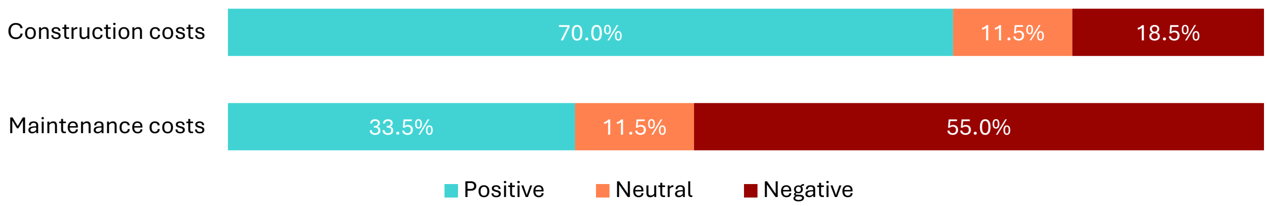

Figure 8. Descriptive results of the perception of wood construction regarding costs.

Concerns about fire safety were nearly unanimous (Figure 9). About 97.5% of interviewees agreed that a wooden house "burns easily" (57.5% strongly agree + 40.0% agree), highlighting a deep-seated anxiety about flammability. Yet a majority (approximately 64.5%) also believed this risk can be overcome: 17.5% strongly agree and 47.0% agree that modern engineering can technically resolve the fire hazard. These figures suggest that while almost all respondents recognise fire as a weakness of wood, many still trust in mitigation measures.

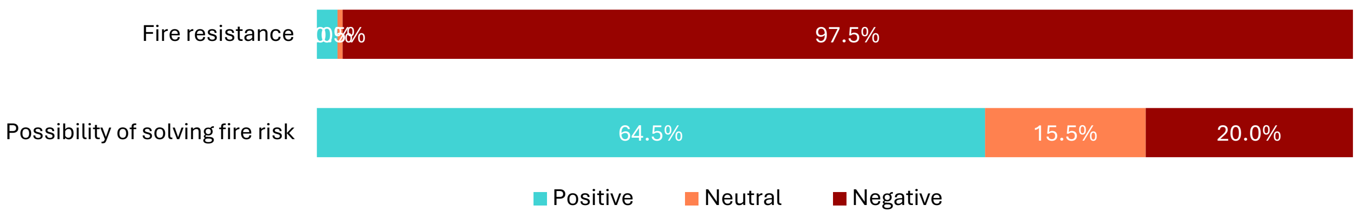

Figure 9. Descriptive results of the perception of wood construction regarding fire resistance.

The thermal comfort and environmental dimensions showed more ambivalence (Figure 10). About 68.5% agreed that a wooden home offers better thermal comfort than traditional materials (21.5% strongly agree + 47.0% agree). However, sustainability perceptions were mixed: 36% agreed that wood construction "helps combat climate change" (7.5% strongly agree + 28.5% agree), whereas 42.5% disagreed. Also, a substantial majority (72%) associated timber building with deforestation (37.5% strongly agree + 34.5% agree), reflecting pronounced environmental scepticism. Respondents did not universally view wood as ecologically beneficial—many doubted its climate impact and linked it to forest loss.

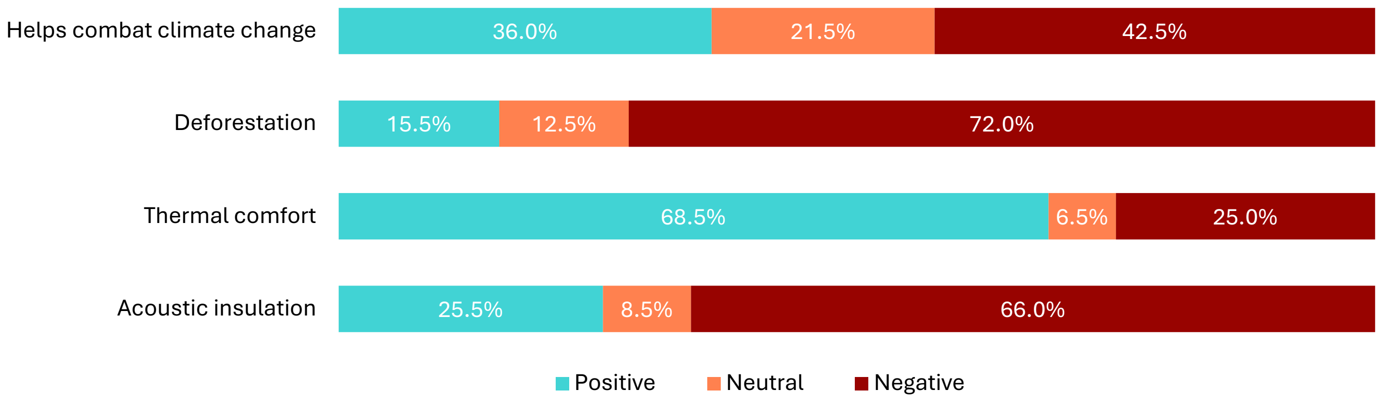

Figure 10. Descriptive results of the perception of wood construction regarding climate change, sustainability and comfort.

Finally, on construction flexibility and industrialisation, the responses were mainly favourable. Nearly all respondents found timber homes easier to work with (Figure 11): about 88.0% agreed they are faster to build than conventional houses (40.0% strongly agree + 48.0% agree), and roughly 93.5% agreed they are easier to extend or adapt to changing needs (40.5% strongly agree + 53.0% agree). Similarly, large majorities saw benefits in prefabrication (Figure 12): approximately 74.5% agreed that prefabricated wooden houses cost less to build (24.5% strongly agree + 50.0% agree), and about 69.5% agreed that prefabricated methods generate less waste (26.0% strongly agree + 43.5% agree). Some limits were still noted: 43.0% felt that prefabrication narrows architectural possibilities (13.5% strongly agree + 29.5% agree). Overall, however, the flexibility indicators were considered key advantages of timber construction.

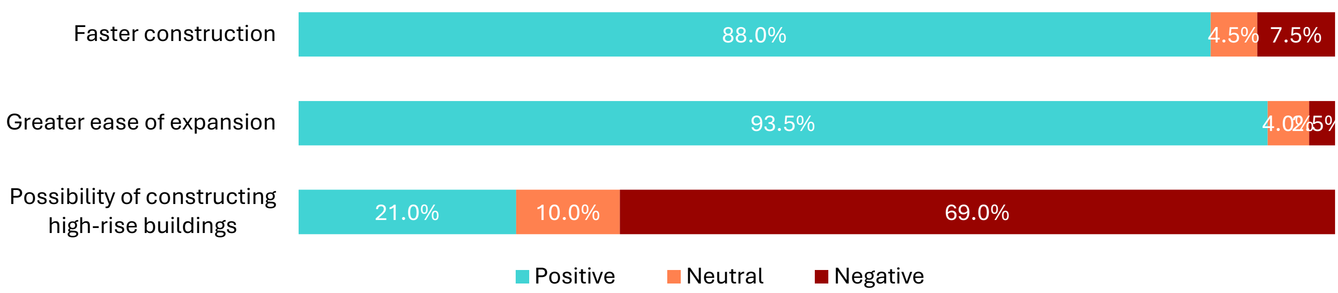

Figure 11. Descriptive results of the perception of wood construction regarding flexibility in construction.

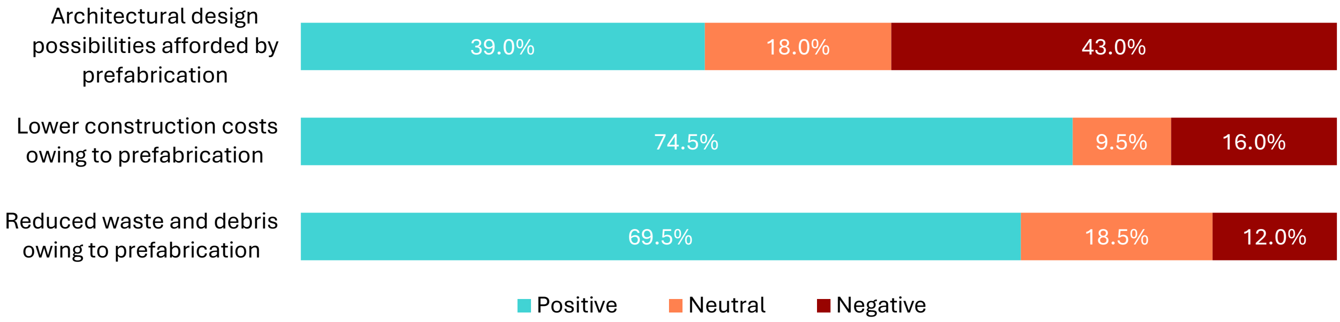

Figure 12. Descriptive results of the perception of wood construction regarding industrialisation potential.

3.2. Exploratory Analysis

Before extracting factors, we verified the suitability of the perception data for dimension reduction. Bartlett's test of sphericity was significant ($p < 0.001$) and the Kaiser–Meyer–Olkin measure indicated good sampling adequacy (KMO = 0.761), confirming that the inter-item correlations supported factor analysis [45]. We then performed a Principal Component Analysis (PCA) on the 19 perception items (5-point Likert scale) to uncover latent dimensions. Treating these ordinal responses as approximately continuous is justified by established multivariate guidelines, which were also applied to the Valdivia case [12]. The PCA thus reduced the original item set to a smaller number of components, minimising information loss and providing a parsimonious representation of the data.

Using Kaiser's criterion (eigenvalue ≥ 1), we retained six components, which together explained roughly 57.4% of the variance, as shown in Table 4. To aid interpretation, the initial solution was rotated using an orthogonal Varimax criterion, which maximises large factor loadings while minimising cross-loadings, yielding a cleaner and more interpretable factor structure (Table 5). By construction, the Varimax factors are uncorrelated, which improves their interpretability and avoids redundancy. In other words, the orthogonal rotation ensures the components remain statistically independent and helps prevent multicollinearity among variables.

Table 5. Rotated component matrix [1] using Varimax.

Variables	**Components**						**Communalities**
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	
Reduced durability over time	0.78						0.69
Increased exposure to insect pests	0.67						0.50
Enhanced structural strength	−0.64						0.68
Reduced fire resistance	0.58						0.51
Technical feasibility of mitigating fire risk			0.60				0.50
Contributes to mitigating climate change		0.52					0.60
Causes deforestation	0.60						0.50
Greater thermal comfort		0.73					0.57
Reduced acoustic comfort			−0.47				0.41
Lower construction costs					0.60		0.57
Higher maintenance costs					−0.59		0.54
Faster construction					0.58		0.60
Greater ease of extension to meet changing needs						0.65	0.57
More limited architectural design possibilities						0.70	0.55
Lower construction costs owing to prefabrication				0.76			0.65
Reduced waste and debris during construction				0.64			0.50
Contribution of the timber industry to national development		0.74					0.62
Higher educational attainment			0.78				0.69
Higher occupational status			0.80				0.72

[1] Component loadings > |0.5| were significant according to the sample size criterion [45].

Then, each component was defined with a concept to facilitate understanding and suggest interpretations that will later be complemented with the sociodemographic segmentation variables. Accordingly, the six components are interpreted as follows:

- Classical and emerging fears (C1): This component captures negative perceptions of timber construction, encompassing its presumed shorter service life, heightened vulnerability to insects, lower structural capacity, reduced fire resistance, and the belief that its use accelerates deforestation.
- Environmental capital (C2): Respondents associate timber with positive environmental qualities, highlighting its potential contribution to climate-change mitigation, superior thermal comfort, and a favourable appraisal of the timber industry's role in national development.
- Techno-social confidence (C3): This dimension reflects confidence in technological solutions and social capital: respondents recognise the technical feasibility of mitigating fire risk, report improved acoustic performance, and link timber acceptance to higher educational attainment and occupational status.

- Industrial efficiency (C4): The component denotes positive views of prefabricated timber construction, stressing lower construction costs alongside reduced generation of waste and debris during the building process.
- Fast and inexpensive (C5): Here, timber is valued for economic expediency: lower initial and maintenance costs, coupled with substantially quicker construction times, position it as a cost-effective option.
- Conditional flexibility (C6): Perceptions are ambivalent: while acknowledging timber's adaptability and ease of extension to meet changing household needs, respondents also recognise architectural design constraints inherent in prefabricated systems.

Each respondent's scores on the six rotated components were then used as input for hierarchical cluster analysis (Table 6). In essence, cluster analysis finds "natural groupings" in the data by partitioning respondents into internally homogeneous sets. Following the already applied approach, we applied an agglomerative clustering procedure (Ward's method with Euclidean distance) [12]. Using the orthogonal component scores in the clustering step has the methodological advantage of eliminating multicollinearity and standardising the data. The number of clusters was determined by inspecting the dendrogram and assessing solution coherence; a five-cluster solution was selected as the most parsimonious and meaningful grouping (Figure 13). In conclusion, these five clusters correspond to an internally consistent group of survey participants who share similar responses across the six components.

Table 6. Settings and variables for cluster analysis.

Clustering Method	Agglomerative Hierarchical Clustering (AHC)
Proximity type	Euclidean distance
Agglomeration method	Ward's method
Number of observations	96
Input variables	C1, C2, C3, C4, C5, C6 [2]
Truncation	Number of clusters = 5

[2] obtained through the Principal Component Analysis

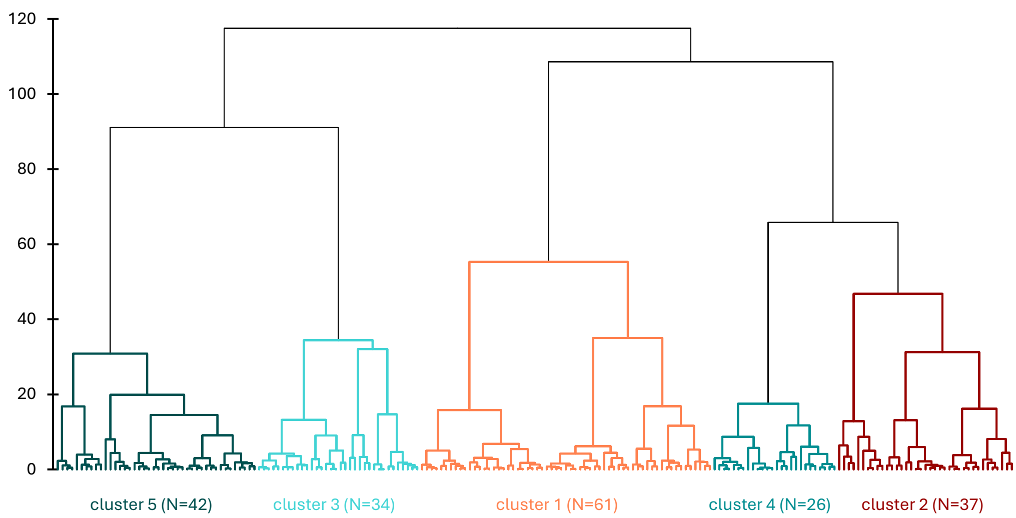

Figure 13. Dendrogram of the hierarchical cluster analysis. Dissimilarity values in the Y axis.

The dendrogram allowed the observations to be grouped into clusters with similar features and distinct sociodemographic profiles (Figure 13). The respondents in each group were analysed using the metrics of their variables, highlighting the real differences between each one. Consequently, five clusters were identified, which can be described by the following characteristics:

- Distrustful Followers (cluster 1, N = 61, 30.5%): Profile Individuals predominantly of low socio-economic status with school-level education; they associate timber with first homes, adopt energy-efficiency measures at home, are attuned to certification schemes, hold a favourable image of the timber industry, and exhibit a high willingness to live in a timber dwelling.
- Sceptical Pragmatists (cluster 2, N = 37, 18.5%): Mainly upper-middle and high socio-economic groups aged 45–65, possessing undergraduate or postgraduate degrees and mid-level executive occupations; they view timber primarily as social housing and maintain an unfavourable perception of the timber industry.
- Cautious Conservatives (cluster 3, N = 34, 17.0%): Respondents primarily of low socio-economic status with school education and manual occupations; this cluster has a high proportion of older adults, links timber to first-home ownership, relies on public transport, shows little enthusiasm for architectural contemporary design, yet retains a very positive image of the timber industry.
- Complacent Deniers (cluster 4, N = 26, 13.0%): Predominantly middle socio-economic levels (C2–C3), mostly men with technical education; they associate timber with emergency housing, judge the timber industry negatively, and display low willingness to occupy timber housing. Their notably negative view of the timber industry (the most relevant compared to the other clusters) hints at distrust in industry practices, which reinforces their low willingness to live in a timber home. In short, the 'Complacent Deniers' appear to be rooted in a socio-demographic segment that is comfortable with the status quo (conventional materials) and sceptical of timber's touted benefits, perhaps due to a perception that wood construction is a step backwards in quality or safety. This insight, albeit based on the smallest cluster, points to the need for targeted education or demonstrations to reach this resistant segment.
- Informed Enthusiasts (cluster 5, N = 42, 21.0%): Principally high socio-economic status, aged 45–65 with university education and mid-level executive roles; they link timber to both first and holiday homes, are receptive to housing incentives, view the timber industry positively, and demonstrate high readiness to live in timber housing.

4. Discussion

The perceptual segmentation of respondents presented in Table 7 and visualised in Figure 13 offers a detailed map of how different profiles relate to the underlying components extracted via PCA. The five clusters are distributed in distinct regions of the perceptual space, evidencing marked differences in their positioning across the six factors and in the intensity and coherence of their attitudinal orientations. The dispersion pattern is analytically significant: clusters are not randomly distributed but align along two principal tensions: traditional distrust and emergent confidence in timber construction and environmental scepticism and ecological enthusiasm. These two axes crosscut the factorial plane, suggesting that underlying perceptions are organised around techno-cultural legacies and climate-related ideologies.

Table 7 reveals that the 'Classical and emerging fears' component (C1) continues to operate as a powerful factor, linked to negative perceptions, that unites all clusters except the 'informed enthusiasts', the only group exhibiting an almost entirely positive view of timber construction. This is further reinforced by the second component ('Environmental Capital'), which distinguishes 'Distrustful Followers', 'Cautious Conservatives' and 'Informed Enthusiasts' (positive values) from 'Sceptical Pragmatists' and 'Complacent Deniers' (negative values). Thus, we observe a dual differentiation: some segments align wood with climate action and comfort, while others dismiss it as risky or environmentally suspect. Importantly, 'Informed Enthusiasts' —positioned at the positive pole of components 1 and 2— represents a high-trust, high-engagement group, combining confidence in technical solutions with strong environmental motivations. In contrast, 'Sceptical Pragmatists' —located negatively on both axes— expresses a perceptual disconnection: they neither trust in wood's traditional attributes, nor believe in its ecological contribution.

Table 7. Centroid values and their interpretation [3] by PCA components according to the different profiles (clusters).

Clusters	Components					
	Classical and Emerging Fears	Environmental Capital	Techno-Social Confidence	Industrial Efficiency	Fast and Inexpensive	Conditional Flexibility
Distrustful Followers	0.37	0.55	−0.22	0.58	−0.63	
Sceptical Pragmatists	0.47	−0.82	0.87	0.29	0.54	
Cautious Conservatives	0.42	0.56	−0.59	−0.96	0.73	
Complacent Deniers		−1.35	−0.68		−0.53	−0.30
Informed Enthusiasts	−1.28	0.30	0.46	−0.27	0.17	

[3] Positive perception. Negative perception.

Figure 14 provides additional insight by plotting the clusters in the factorial plane defined by the first two components. The spatial distribution shows that clusters 2 and 5 lie at opposing ends of the main diagonal, reinforcing the view that they are perceptual opposites. As expected, 'Informed Enthusiasts' is positioned at the intersection of high environmental value and low fears. Meanwhile, 'Sceptical Pragmatist' occupies the inverse corner, combining scepticism about ecological benefits with a firm belief in the material's traditional weaknesses. Meanwhile, 'Distrustful Followers' and 'Cautious Conservatives' are in the same position of an intermediate regions: their proximity in the plane suggests some shared concerns, yet their strong divergence along the 'Fast and inexpensive' fifth component (at right of the figure) suggests more nuanced attitudinal distinctions, possibly associated with socio-demographic factors or personal experience. 'Complacent Deniers' appears as an outlier, markedly distant from the central axis of the case of 'Environmental capital' component and situated in a non-significant position concerning the classical and emerging fears. This interesting positioning suggests ambivalence rather than conviction.

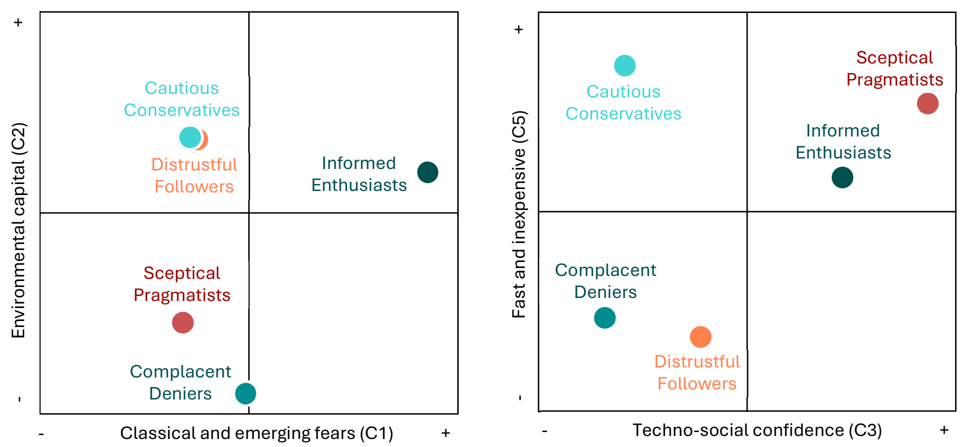

Figure 14. Perceptual maps of profile (clusters) centroids according to PCA components.

Notably, the principal components underlying these attitudes also show parallels and divergences in comparison with the case study of Valdivia [12]. Indeed, seven components were extracted in Valdivia (C1–C7), whereas Concepción yielded six, implying that some dimensions combine differently. For instance, Valdivia separated climate scepticism ('Denialist Drift', C3) from urgent ecological worries (C4), finding even high-education groups who did not believe wooden houses helped combat climate change. Concepción's analysis likewise identifies an environmental scepticism axis, but it appears intertwined with practical considerations (such as questions of local resource use and regulation). Conversely, Valdivia's 'The Great Advantage of Industrialisation' fifth component highlights how one segment viewed industrial-scale wood construction as beneficial. In Concepción, with its booming cross-laminated timber (CLT) factories and modular construction industry, a similar theme emerges, albeit as part of a broader factor linked to economic modernisation. Industry reports underscore this technological optimism: Chile's timber sector today "has recently advanced in incorporating greater capacities and state-of-the-art technologies" and is poised to become "an international benchmark" if regulations adapt [46]. It seems Concepción respondents absorb this narrative more holistically, whereas Valdivia's sample separated it into a distinct component. Both cities share core attitudinal dimensions —weighing perceived benefits (sustainability, economy) against perceived risks (durability, fire)— but their component structure diverges. Environmental scepticism looms large in both, yet Concepción's factors merge it with techno-economic confidence, while Valdivia splits it into pure climate-denial and urgent-concern axes. Similarly, "industrialisation" is a salient idea for both, but operates differently: in Valdivia, it formed a standalone theme, whereas in Concepción, it integrates with clusters' pragmatic outlooks.

These contrasts underscore the firm territorial heterogeneity of Chilean citizens' views on timber construction—direct familiarity with wood housing, local building traditions, and the regional timber industry shape cluster attitudes. Valdivia —often called a "forest city—features many old wooden homes and new mass-timber projects, so its residents bring cultural affinity and ecological unease to the question. For example, Valdivians voiced concerns about deforestation and ecosystem impacts even as they recognised wood's eco-credentials. By contrast, Concepción is a larger industrial hub where timber is a modern engineering material. Its citizens have less everyday experience of living in wood, and a significant part of its housing stock is dominated by concrete apartments (68,7% of new buildings in 2022, according to the National Statistics Institute [47]). Accordingly, Concepción clusters tend to emphasise practical and industrial aspects: the sector's push to use high-tech timber (reinforced by statements from industry that Chile is ready to "become a benchmark in timber construction" [46]) resonates with more urban, growth-oriented respondents. Concepción segments that value new construction techniques and local jobs are larger.

In contrast, segments defined by social-housing or traditional-wood lifestyle concerns are smaller than in Valdivia. This pattern matches international findings: in countries with deep wood-building traditions (e.g., Finland, Norway, Sweden), citizens generally report more positive, varied views of wood than those in less-wooded nations [33]. Such findings suggest that Concepción's perhaps lower familiarity could help explain why its respondents more often foreground abstract risks, whereas Valdivians rely on concrete experiences. At the same time, flammability concerns are not absent globally but are usually mitigated by familiarity and strong building regulations. Indeed, a recent study applied in Denmark and Sweden refutes the general idea of timber's perceived combustibility as a market barrier [48]. Likewise, Finnish homeowners report that fire or moisture concerns all construction materials, not only wood, suggesting that with proper engineering and experience, wood is not viewed as inherently more dangerous than other materials [49]. In Canada, a representative survey of Quebec residents reports that safety—particularly fire-related—and lifespan dominate the perceived barriers to multi-storey timber housing, with high-rise wood solutions largely outside most citizens' mental models; this mirrors Chile's fire-risk salience despite differing regulatory contexts [34]. In this sense, Chile's public scepticism about fire is comparable to other contexts without long-established timber cultures and underscores the need for demonstrable safety standards to build confidence. In summary, regional context—including direct experience, dominant housing types and the local timber economy—plays a critical role in shaping the composition of each cluster.

Finally, these empirical results must be viewed against Chile's national decarbonisation and housing strategy. Chile has set a carbon neutrality target by 2050, and its latest NDC [4] explicitly promotes wood as part of the solution [4], even though a roadmap and the specific implementation measures required to realise it have yet to be defined. This policy push is motivated by the fact that buildings are a primary emissions source (roughly 40% globally) and that substituting wood for concrete/steel can cut 'embodied' carbon. Our findings shed light on how the public might receive these initiatives. Many Chileans recognise wood's advantages (lower embodied emissions, thermal comfort), echoing internationally broadly positive citizen attitudes [33]. Yet, doubts about durability, fire safety and maintenance, among others, persist, even globally. For instance, the Australian survey of mass-timber acceptance similarly found that consumers admired wood's natural and green image but worried about fire and rot [50]. In Concepción and Valdivia alike, these technical fears temper enthusiasm for wood. To achieve the decarbonisation goals, policy must therefore address such beliefs. Experts insist on the need for visible "emblematic" wooden projects to change perceptions, and for clearer standards and labelling to build trust [3,46,51]. A key question is how to evaluate the success of these outreach and education efforts in the future. We suggest that policymakers establish metrics to track changes in public perceptions and behaviour over time. For instance, follow-up surveys or polls could be conducted a few years after implementing campaigns or building demonstration projects, to gauge shifts in attitudes and identify remaining misconceptions. Similarly, tangible indicators such as the uptake of timber construction (e.g., market share of timber homes or number of timber building permits issued) and participation rates in educational programmes can be monitored. By comparing these metrics against the baseline established in our study, Chile can measure whether outreach strategies are closing the acceptance gap. This feedback loop would allow policy adjustments and ensure that decarbonisation efforts in construction remain on track and responsive to public concerns. In practice, this means tailoring messages to each regional profile: Concepción's tech-optimistic clusters might respond to information on advanced timber engineering and economic incentives, whereas Valdivia's environmentally concerned clusters may need communication about sustainable forestry practices and lifecycle carbon benefits. In this way, the cluster analysis illuminates how the national timber-in-construction agenda can be implemented in a geographically sensitive manner, leveraging each cluster's dominant motivations to meet Chile's carbon-neutrality strategy.

5. Conclusions

Our Concepción survey confirms that many Chileans continue to hold the classical fears about timber housing that were documented two decades ago. Residents still associate wooden homes with fire risk, insect infestation and poor durability concerns that dominated the 2005 survey [22]. At the same time, Concepción inhabitants recognise wood's benefits (notably good thermal comfort and cost advantages) as highlighted in the explanatory analysis results. However, these positive attributes coexist with deep-seated doubts: for example, 73% of respondents believe timber homes "burn easily," even though a majority also accept that modern engineering can mitigate this risk. In the Principal Component

Analysis, the ‘Classical and Emerging Fears’ remained dominant (linking all perceptual clusters except the only mostly positive), underscoring how traditional safety and durability anxieties still anchor people’s attitudes. In Greater Concepción—a timber-industry heartland—proximity to forestry has not dispelled distrust; recent wildfire disasters (in 2017 and 2023) and plantation controversies seem to feed nuanced anxieties about resource use and regulation. These tragedies, widely covered in the media, likely reinforce the public’s association of wood with fire risk, posing a challenge for any policy promoting timber (even if new engineering solutions exist).

Beyond these well-known issues, our analysis reveals new environmental concerns that challenge the straightforward sustainability narrative of wood. In Concepción, nearly half of the respondents are sceptical that timber construction reduces climate change, and many instinctively equate wood building with deforestation. The analysis also identified an ‘Environmental Capital’ axis that splits the population: one segment embraces timber as a climate-friendly, low-carbon material, while another—notably the ‘Sceptical Pragmatists’ and ‘Complacent Deniers’ clusters—doubts wood’s ecological value. If these deforestation fears are not directly addressed, the sustainability narrative around timber could backfire, undermining public trust. This pattern was not seen in Chile twenty years ago, when climate change was seldom mentioned; it reflects contemporary, place-based ideologies about forests and industry. In short, we observe a dual perception tension: some citizens align timber with comfort and climate action, whereas others dismiss it as risky or suspect. The ‘Informed Enthusiasts’ cluster, which combines confidence in fire-safety innovations with strong environmental motivations, highlights that positive engagement is possible, but only within a fraction of the public.

These findings pose a clear challenge to Chile’s decarbonisation assumptions. National policies and the Paris NDC envisage broad public acceptance of wood as a sustainable construction material, yet our results illustrate a perception gap. In Greater Concepción—a timber-industry heartland—proximity to forestry has not dispelled distrust; local experiences (wildfires, plantation controversies) seem to feed nuanced anxieties about resource use and regulation. Unlike Valdivia, where environmental worries appeared as a distinct factor, economic confidence and ecological scepticism are intertwined here. The policy narrative (“timber = low carbon”) does not automatically translate to societal buy-in. If mitigation plans rely on voluntary demand for wooden housing, they must contend with the fact that many citizens remain unconvinced of the climate benefits.

To bridge this divide, policy responses must be geographically and socially differentiated. The cluster profiles suggest concrete strategies. For the techno-optimistic segment—those who already trust engineered timber and care about efficiency—visible pilot projects (for example, landmark wood housing or school buildings in Biobío) can demonstrate energy savings and fire performance. These “emblematic” constructions, accompanied by clear standards and labelling, would provide tangible evidence to convert passive approval into active demand. In other words, building trust through transparent regulation and factual information—rather than oversimplified “green” messaging—is essential to avoid any perception of greenwashing.

Meanwhile, the more sceptical and environmentally concerned groups will require outreach to address their fears. Communication campaigns should emphasise certified sustainable forestry practices, carbon accounting of timber versus other materials, and regulatory commitments to protect native forests. Building a positive narrative requires acknowledging and mitigating deforestation concerns, not dismissing them. In other words, building trust through regulation and information, not just marketing, is essential. The Valdivia study similarly concluded that only a collaborative effort (public policy, industry, independent science) can shift entrenched biases. Here in Concepción, it means aligning the timber narrative with local values and history and acknowledging that scepticism about sustainability may have deep ideological roots.

In summary, our PCA and cluster analysis synthesise a complex picture: while awareness of wood's comfort and efficiency is high, traditional fears persist, and new environmental doubts have emerged. These insights close the loop set out in the introduction: the social feasibility of Chile's wood-based decarbonisation depends on how sound policies mesh with the people and places they affect. Policymakers should not assume uniform enthusiasm for timber; they must design differentiated outreach and demonstrate real benefits on the ground. By connecting public perception to territory, we see that achieving carbon-neutral housing requires more than technical substitutes—it requires building consensus. Only then can Chile's climate ambitions and community values truly converge.

Limitations and Future Research

While this study offers valuable insights, several limitations must be acknowledged. First, our survey was limited to a single region (Greater Concepción) at one point; thus, the results may not capture the full diversity of Chilean public opinions. Future research should expand to other regions (ideally, national surveys) to compare perception trends and conduct longitudinal studies to see how attitudes evolve, especially as pro-timber initiatives roll out. Second, with a sample of 200, the statistical power to detect fine-grained subgroup differences is limited; larger follow-up studies could further disentangle demographic effects or include more nuanced questions to deepen the analysis. Third, we focused on stated perceptions and intentions rather than actual behaviour. It remains to be studied whether positive attitudes (e.g., among 'Informed Enthusiasts') translate into action (such as purchasing or building a timber home) in practice.

Additionally, external factors not captured in our survey, such as media coverage, economic shifts, or events like wildfires, could influence perceptions and merit investigation. We also recognise that our scope was confined to perceptions of timber's benefits and risks regarding energy efficiency and climate; other sustainability aspects (for example, the broader environmental impacts of construction life cycles) were beyond our analysis. Incorporating a more holistic sustainability perspective—e.g., considering construction waste's health and pollution impacts or the full carbon footprint of building materials—would complement this work. Addressing these gaps presents clear perspectives for future research. In particular, we encourage studies that evaluate the outcomes of the strategies we discuss: for instance, do educational campaigns measurably increase knowledge or reduce misconceptions? Does the construction of flagship timber buildings in Chile lead to greater public willingness to live in such buildings? Such evaluations would provide crucial feedback for policymakers and help refine strategies for decarbonising the building sector.

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Appendix A

The following questionnaire corresponds to the second section of the survey: perception of wooden houses. The 5-point answers based on a Likert scale are: ( ) Strongly agree; ( ) Agree; ( ) Neither agree nor disagree; ( ) Disagree; ( ) Strongly disagree.

Q4. A wooden house lasts less than a brick or concrete construction.
Q5. A wooden house is more exposed to insect pests.
Q6. A wooden house is as resistant as a brick or concrete construction.
Q7. A wooden house burns easily.
Q8. The fire risk in a wooden house can be technically resolved.
Q9. Wood construction helps combat climate change.
Q10. The use of wood in construction leads to deforestation.
Q11. A wooden house offers better thermal comfort than a brick or concrete construction.
Q12. A wooden house has acoustic insulation problems.
Q13. Building a wooden house is cheaper than a brick or concrete construction.
Q14. A wooden house is more expensive to maintain.
Q15. A wooden house is faster to build than a brick or concrete construction.
Q16. A wooden house is easier to expand according to the family's needs.
Q17. With wood, houses and high-rise apartment buildings can be constructed.
Q18. Architectural design possibilities are more limited in a prefabricated wooden house (where components and modules are built in a factory and assembled on-site).
Q19. A prefabricated wooden house is cheaper to build than one built traditionally (where it is completely done on-site).
Q20. The construction of a prefabricated wooden house generates less waste and debris than one built in a traditional way (where it is completely done on-site).

Table A1 presents the frequency results, quantity and percentage for each response on the Likert scale for the 17-wood housing perception indicator questions. The identification code for each question corresponds to the one presented in Appendix A.

Table A1. Frequency results for the indicator of perception of wooden houses from the questionnaire.

Questions	Strongly Agree		Agree		Neither Agree Nor Disagree		Disagree		Strongly Disagree		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Q4	75	37.5%	72	36.0%	8	4.0%	39	19.5%	6	3.0%	200	100%
Q5	88	44.0%	88	44.0%	6	3.0%	16	8.0%	2	1.0%	200	100%
Q6	9	4.5%	45	22.5%	14	7.0%	71	35.5%	61	30.5%	200	100%
Q7	115	57.5%	80	40.0%	1	0.5%	4	2.0%	0	0.0%	200	100%
Q8	35	17.5%	94	47.0%	31	15.5%	26	13.0%	14	7.0%	200	100%
Q9	15	7.5%	57	28.5%	43	21.5%	62	31.0%	23	11.5%	200	100%
Q10	75	37.5%	69	34.5%	25	12.5%	27	13.5%	4	2.0%	200	100%
Q11	43	21.5%	38	19.0%	13	6.5%	94	47.0%	12	6.0%	200	100%
Q12	48	24.0%	84	42.0%	17	8.5%	46	23.0%	5	2.5%	200	100%
Q13	63	31.5%	77	38.5%	23	11.5%	33	16.5%	4	2.0%	200	100%

Table A1. *Cont.*

Questions	Strongly Agree		Agree		Neither Agree Nor Disagree		Disagree		Strongly Disagree		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Q14	36	18.0%	74	37.0%	23	11.5%	56	28.0%	11	5.5%	200	100%
Q15	80	40.0%	96	48.0%	9	4.5%	14	7.0%	1	0.5%	200	100%
Q16	81	40.5%	106	53.0%	8	4.0%	4	2.0%	1	0.5%	200	100%
Q17	8	4.0%	34	17.0%	20	10.0%	67	33.5%	71	35.5%	200	100%
Q18	27	13.5%	59	29.5%	36	18.0%	71	35.5%	7	3.5%	200	100%
Q19	49	24.5%	100	50.0%	19	9.5%	26	13.0%	6	3.0%	200	100%
Q20	52	26.0%	87	43.5%	37	18.5%	19	9.5%	5	2.5%	200	100%

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