Sustainable Cities and Urban Transformation: The Economics and Drivers of Residential Sustainability Certifications

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Abstract

This paper evaluates the economic impacts of sustainability certifications for urban residential buildings, analyzes real estate professionals' perceptions of their financial return, and identifies the key drivers of sustainable certification adoption. Using a case study approach, natural language processing of semi-structured interviews with real estate professionals, and valuations by professional appraisers, we show that sustainability certifications enhance both building value and profitability while requiring only a modest relative capital expenditure. The magnitude of these returns differs significantly by building type: larger assets, new constructions, and properties in prime urban locations tend to yield greater financial benefits than their smaller, older, or non-prime counterparts. Perceptions of economic benefit also differ by stakeholder group. Sell-side actors (sustainability consultants and certifiers whose revenues depend on originating or delivering certifications) are generally optimistic about the net benefits. Buy-side actors (institutional landlords, property investors, and their financial advisers who bear the cost of upgrades) are markedly more skeptical. This study provides insights for policymakers and urban planners on whether further intervention is needed to promote sustainable urban development and concludes with policy recommendations.

Keywords: Sustainable residential buildings, sustainability residential certifications, CapEx, sustainable cities, BREEAM certification, CO2.

1. Introduction

The built environment accounts for roughly 37% of global energy-related CO_2 emissions and 34% of energy demand, positioning it as a critical sector for climate mitigation (UNEP, 2024). Emissions from buildings and construction continue to rise, leaving the sector far from the Paris Agreement's decarbonization pathway. Between 2015 and 2021, global construction added floor area equivalent to that of Germany, France, Italy, and the Netherlands combined. As urban expansion accelerates, decarbonizing both new development and existing housing emerges as one of the most scalable and cost-effective levers for advancing sustainable cities.

Sustainability certifications such as the Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED), and the

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German Sustainable Building Council (DGNB) have become the most widely adopted global schemes for assessing the environmental and social performance of buildings. Unlike narrower energy-efficiency labels (e.g., ENERGY STAR, Passivhaus, or the Energy Performance Certificate), which focus primarily on energy consumption and emissions, these broader systems incorporate water use, material sourcing, indoor environmental quality, and occupant wellbeing. Their wide adoption reflects the perceived value of certifications as credible policy and market tools for advancing sustainability goals.

Despite this momentum, the economics of residential sustainability certifications remain poorly understood, particularly in Europe and especially with respect to its economics and adoption drivers. Existing empirical research has concentrated overwhelmingly on commercial real estate, where institutionalization and data availability allow estimation of "green premiums" in prices and rents. In contrast, residential real estate, which constitutes the bulk of the urban built environment, has received limited attention. This is a notable omission as roughly 74% of Europe's housing stock predates 1970, more than three-quarters is rated "D" or lower in energy performance, and renovation rates remain below 1% across the European Union (BPIE, 2023). The small body of work on residential assets has focused largely on energy labels, leaving broader certifications that capture environmental and social dimensions relatively underexplored.

Barriers to certification in the residential sector are compounded by fragmented ownership structures, uneven incentives, and uncertainty around the scale of necessary investment (Olubunmi et al., 2016). Yet growing evidence suggests that sustainable ecolabels can generate both Environmental, Social, and Governance (ESG) benefits and positive financial returns, including healthier and more comfortable living conditions (Jayantha & Man, 2013), lower operating costs (Jiang et al., 2021), enhanced market liquidity (An & Pivo, 2020), and higher asset values (Heinzle et al., 2012). Still, robust evidence quantifying these outcomes in dense European urban contexts, where older residential stock dominates, remains scarce.

This paper addresses that gap by examining the economics and drivers of residential sustainability certification along three dimensions: (i) the capital expenditure (CapEx) required to achieve certification, (ii) the associated economic returns, and (iii) the determinants of adoption. We develop six case studies of certified residential buildings in Madrid and Barcelona, Spain's two largest and most active housing markets, using a mixed-methods approach. On the quantitative side, we calculate certification-related CapEx and returns using audited financial records, architectural documentation, and site inspections. On the qualitative side, we analyze stakeholder perspectives through 18 semi-structured interviews with real estate professionals, interpreted with natural language processing (NLP) with OpenAI's ChatGPT-4o large language model (LLM), and supplement these with nine additional interviews with accredited appraisers to assess value premiums.

BREEAM is the focal certification, reflecting both its prominence as one of the three leading global rating systems and its two-decade presence in Spain. While still relatively new in the Spanish residential sector, its standardized framework enables consistent cross-case comparison of capital investments and sustainability performance. To situate the results within a broader landscape, we also incorporate LEED in our spatial and trend analyses and explicitly consider perceptions of real estate professionals and appraisers about multiple international certification systems, enhancing external validity and supporting cautious inference to other sustainability schemes with similar institutional and technical characteristics.

Our analysis indicates that sustainability certification is economically attractive in high-value, multifamily residential buildings, especially new developments in prime urban markets where incremental costs are modest, averaging about 1% of property value, and returns often exceed 150%. Yet this viability is not universal. Financial outcomes vary systematically by asset type, building scale, and location. Large, newly built properties in Madrid and Barcelona achieve the highest returns, while smaller or older buildings in lower-value markets face certification costs that can exceed 11% of asset value, rendering uptake unlikely in the absence of external support. These dynamics generate a spatial and structural segmentation: certifications cluster in affluent, liquid markets where investor awareness is high, while much of the existing stock remains uncertified. Left unaddressed, this pattern risks reinforcing a two-tiered housing system in which environmental and health benefits are concentrated in prime neighborhoods, while peripheral and lower-income areas remain locked into inefficient, aging buildings.

This paper provides the first comprehensive evaluation of sustainability certifications in the European residential sector. To do so, we introduce a tractable method for estimating certification-related capital expenditures and returns, which reveals that profitability is highly segmented. We find that this segmentation is driven by economies of scale and lower relative costs, allowing new, large properties in prime locations to capture disproportionate gains. Our spatially explicit analysis for Spain further reinforces this finding, documenting sharp regional variations in the cost-to-value ratios that underpin this divide. Finally, we deliver the first European appraisal-based estimates of the residential "green premium" for BREEAM-certified buildings, revealing significant heterogeneity across appraiser profiles. Taken together, these contributions clarify the economic dynamics and adoption drivers of residential certification, providing a critical empirical basis for designing more inclusive and effective strategies for sustainable urban development.

2. Literature Review

As environmental concerns intensify, real estate developers increasingly adopt green building practices to reduce emissions, improve efficiency, and enhance occupant welfare. Sustainable residential buildings are now routinely designed and operated to meet higher standards of energy and resource use. Third-party certification systems such as LEED, Energy Star, BREEAM, HK-BEAM (Hong Kong), and CGBL (China) serve as the primary mechanisms for verifying these attributes (Jayantha & Man, 2013; Jiang et al., 2021).

These certifications play a crucial role in overcoming information asymmetry in the property market, where the energy efficiency and sustainability features of a home are often complex for buyers to observe (Retzlaff, 2009). By providing a credible, standardized signal of a property's green attributes, these labels can influence consumer behavior and market dynamics (Judge et al., 2019). A growing body of research investigates the economic, social, and market impacts of sustainability certifications, examining whether they command a price premium, what factors shape that premium, and how green development influences broader social outcomes (see Panel A of **Table 1** for a summary).

Table 1. Estimated Price Effects of Residential Sustainability and Energy Certifications.

This table compiles estimates from published studies evaluating the effect of environmental certifications on the transaction prices of residential properties. Panel A reviews evidence on voluntary sustainability residential *certifications, which are the focus of this paper. Panel B presents findings related to energy-performance labels such as EPC or Energy Star.*

Study	Year	Methodology	Location	Value Impact
Panel A: Residential Sustainability Certifications				
Heinzle et al.	2012	Conjoint analysis	Singapore	[3.8% – 8%]
Jayantha & Man	2013	Hedonic price model	China	[3.5% – 6.6%]
Kahn & Kok	2014	Hedonic price model	United States of America	2.4%
Liao & Zhao	2019	Hedonic price model	Singapore	4.5%
Martínez et al.	2019	Hedonic price model	Colombia	5.5%
Jiang et al.	2021	Hedonic price model	China	6%
Yeganeh et al.	2024	Hedonic price model	United States of America	[3% – 7%]
Panel B: Residential Energy Certifications				
Brounen & Kok	2011	Hedonic price model	Netherlands	3.6%
Popescu et al.	2012	Sales comparison	Romania	[2% – 3%]
Hyland et al.	2013	Heckman selection model	Ireland	[5.8% – 11%]
Cajias & Piazolo	2013	Hedonic price model	Germany	[1.7% – 3.2%]
Deng & Wu	2014	Hedonic price model	Singapore	[1.3% – 13.9%]
Davis et al.	2015	Hedonic price model	United Kingdom	4.9%
Fuerst et al.	2015	Hedonic price model	United Kingdom	[1.8% – 5%]
Bruegge et al.	2016	Hedonic price model	United States of America	[1.2% – 1.8%]
De Ayala et al.	2016	Hedonic price model	Spain	[5.4% – 9.8%]
Fuerst et al. (a)	2016	Hedonic price model	United Kingdom	[3.5% – 12.8%]
Fuerst et al. (b)	2016	Hedonic price model	Finland	[1.3% – 3.3%]
Fregonara et al.	2017	Hedonic price model	Italy	No effect
Olaussen et al.	2017	Hedonic price model	Norway	No effect
Baumont et al.	2019	Hedonic price model with spatial econometric models	France	9.8%
Dell'Anna et al.	2019	Hedonic price model with spatial econometric models	Spain	[1.9% – 19%]
Copiello & Donati	2021	Hedonic price model and Spatial Autoregressive Model	Italy	[1.7% – 24.3%]
Marmolejo-Duarte & Chen	2022	Hedonic price model with architectural quality controls	Spain	No effect
Deller	2022	Hedonic price model	Germany	[1.5% – 6.8%]
Goh et al.	2022	Survey of real estate professionals	Malaysia	Individual green features, each: [2.0% – 6.5%]
Galvin	2024	Hedonic price model	Germany	12.3%
Jiao et al.	2025	Hedonic price model	United States of America	[0% – 13.2%]

Source: Compiled by authors. For *Hyland et al. (2013), Fuerst et al. (2015), Davis et al. (2015), Baumont et al. (2019), and Dell'Anna et al. (2019), Copiello and Donati (2021)* we use D-rated properties as the reference category. In *Davis et al. (2015),* we compare D- and C-rated properties only, as the remaining categories contain insufficient sample sizes for reliable analysis. *Bassi and Moscatelli (2020)* cite varying appreciation ranges without clarifying whether they pertain to residential or commercial assets, and *Marques et al. (2024)* do not specify whether their findings apply to residential buildings.

2.1. The Price Premium for Sustainable Certified Residential Buildings

A consistent finding across numerous international studies is that homes with green certifications command a meaningful price premium relative to non-certified counterparts. This premium reflects the market's valuation of sustainability attributes, including anticipated reductions in operating costs (e.g., energy and water consumption) and non-financial benefits such as improved indoor air quality, thermal comfort, and environmental signaling. These certifications help mitigate information asymmetries in the housing market by providing credible verification of otherwise unobservable property characteristics, which can influence both buyer preferences and investor behavior.

Empirical estimates from recent studies typically fall within the 2% to 8% range, as summarized in Panel A of Table 1. Heinzle et al. (2012), using conjoint analysis in Singapore, report willingness-to-pay premiums between 3.8% and 8%. Hedonic price models find premiums of 3.5% to 6.6% in China (Jayantha & Man, 2013), 2.4% in the United States (Kahn & Kok, 2014), 4.5% in Singapore (Liao & Zhao, 2019), 5.5% in Colombia (Martínez et al., 2019), 6% in China (Jiang et al., 2021), and between 3% and 7% again in the United States (Yeganeh et al., 2024). While magnitudes vary across contexts and empirical strategies, studies consistently find that markets capitalize on sustainability certifications in residential property prices. Notably, despite the proliferation of certifications across European markets, we are not aware of any peer-reviewed studies that estimate the price effects of sustainability certifications in the European residential sector, a gap this study seeks to address.

2.2. Factors Influencing the Green Premium

The price premium for residential sustainability certifications is not uniform but depends on several key factors. The certification level is a primary determinant; empirical studies consistently show that more stringent certifications command higher premiums. For instance, three-star CGBL-certified homes in China have a 7.87% resale premium (Jiang et al., 2021), while in Singapore, Platinum-rated Green Mark properties sell for a 7.98% premium, more than double that of lower-rated homes (Heinzle et al., 2012).

Geographic and climatic conditions also play a crucial role. The premium is more pronounced in hotter climates like Southern California, reflecting greater expected savings from energy-efficient cooling (Kahn & Kok, 2014). Premiums can also vary within a single city due to local real estate dynamics, as seen in Hong Kong (Jayantha and Man, 2013). Furthermore, cultural and ideological factors, particularly neighborhood-level environmental preferences, moderate the capitalization of these features. Kahn and Kok (2014) documented a positive correlation between green premiums and local hybrid vehicle registrations, suggesting sustainability labels serve as both economic signals of efficiency and social signals of environmental virtue.

Finally, the premium is influenced by market dynamics and temporal trends. An analysis of the Central Virginia housing market revealed that a once-growing premium declined significantly after 2015 (Yeganeh et al., 2024). This attenuation likely reflects the diffusion of green technologies into standard construction practices and rising baseline building codes, which narrow the gap between certified and conventional properties over time.

2.3. Costs, Benefits, and Economic Viability

Although green construction typically requires higher upfront investment, a growing body of evidence suggests that market premiums for certified buildings can generate positive economic returns. These returns are driven by a combination of direct price capitalization, reduced operating costs, and potential regulatory or financing incentives. While the literature on narrow energy-efficiency certifications is relatively mature (see Panel B of **Table 1** for a sample of studies), robust cost-benefit evidence for broader sustainability frameworks like BREEAM or LEED in residential contexts remains limited.

Available data reveals that the incremental cost of building to green standards varies widely. For energy-efficiency labels, estimates range from an 8% cost increase for residential construction in Europe (Schnieders and Hermelink, 2006) to a more modest 0.7% to 3.1% surplus in the United States (Jiao et al., 2025). Evidence on broader sustainability certifications is scarcer but points to similar variability. For instance, achieving LEED standards in a Colombian social housing program was found to raise construction costs by 5.5%, a level that rendered it financially unviable without subsidies (Martínez et al., 2019). Similarly, costs in Singapore for Green Mark certification range from 0.3% for a basic rating to as high as 8% for the top-tier Platinum level (Heinzle et al., 2012), while EarthCraft-certified units in the U.S. carry premiums of 0.5% to 3% (Yeganeh et al., 2024). This highlights that certification costs are highly sensitive to the specific framework, tier, and market context.

Despite these initial outlays, the economic case for green construction can be compelling, particularly in high-demand markets. For developers, the price premium for certified homes can exceed the additional investment; in California, for example, an average premium of $8,400 was found to typically cover the estimated extra costs of $4,100 to $10,000 (Kahn and Kok, 2014). For homeowners, the investment is often recoverable at the point of sale, with one study in China documenting a 6% resale premium for certified green homes (Jiang et al., 2021). However, the financial return is not guaranteed and may depend on the certification tier, as only higher levels of sustainability performance appear to consistently offset the associated construction costs.

2.4. Social and Equity Implications: Green Gentrification

Green-certified residential development, while environmentally advantageous, raises significant concerns regarding social equity through a process known as "green gentrification." The introduction of new, premium-certified housing can act as a catalyst for neighborhood change, where rising property values and an influx of higher-income, environmentally-conscious households displace existing low-income residents and racial minorities. Recent empirical evidence supports this concern. For example, a study by Yeganeh et al. (2024) in Central Virginia found that new green-certified residential units significantly increased local population growth, construction, and overall house prices. While these dynamics are consistent with urban revitalization, they simultaneously create conditions ripe for gentrification.

The displacement implications of this trend are nontrivial. Green-certified housing often enters the market as a premium or luxury product, which places upward pressure on local housing prices and rents, exacerbating affordability constraints for incumbent residents. As a result, long-standing low-income populations and racially marginalized groups risk being priced out of their neighborhoods (Checker, 2011; Goossens et al., 2020). The economic impact extends beyond the certified properties themselves; these projects often generate positive price spillovers that raise costs for adjacent, non-certified buildings, intensifying the affordability challenge across the entire community (Yeganeh et al., 2024). These findings highlight a fundamental tension between environmental objectives and distributive outcomes. If left unaddressed, the pursuit of urban sustainability through market-based certification schemes may inadvertently reproduce and even deepen existing patterns of socioeconomic exclusion.

3. Conceptual Framework: Economic Channels of Sustainability Certification Value

We conceptualize two distinct channels through which sustainability certification may influence a building's market value. The first operates via fundamentals: improvements in expected cash flows arising from reduced operating expenses (OpEx), enhanced rental or sale prices, lower vacancy rates, or diminished maintenance needs. We refer to this as the *cash flow channel*. The second operates through asset pricing mechanisms, whereby certification alters investor perceptions of risk or expands the pool of potential buyers, particularly institutional investors with ESG mandates, thereby increasing valuations independent of changes to income. We term this the *capitalization channel*.

This decomposition builds on a broader body of research showing that broader market dynamics, not just direct income effects, shape certified building value. Certification reduces future CapEx needs (Jayantha & Man, 2013), facilitates regulatory compliance (Liao & Zhao, 2019), and improves financing terms (Jiang et al., 2021), all of which investors capitalize into prices (Heinzle et al., 2012; Leskinen et al., 2020; Espinoza-Zambrano et al., 2024). These studies challenge the traditional view that value stems solely from physical attributes and location, pointing instead to investor preferences, policy alignment, and sustainability performance as increasingly salient factors (Yeganeh et al., 2024).

3.1. Cash Flow Channel

The *cash flow channel* refers to the valuation effect of sustainability certification that operates through changes in a building's expected *net income* (NI). These income effects may arise from a variety of economic improvements: increased tenant demand, reduced operating costs, lower vacancy rates, or diminished long-run depreciation and maintenance needs. Each of these mechanisms affects the recurring cash flows of the asset, which, under standard asset pricing theory, should be reflected in market value.

To formalize this channel, we adopt the equivalent yield model (Brown & Matysiak, 2000), a widely used approach in real estate valuation that expresses property value as the perpetuity of net income, discounted at an asset-specific required rate of return. In its constant-growth form, we define the *fundamental value* of a building as:

Equation 1

$$Building\ Value = \frac{Net\ Income}{(r-g)}$$

Where we calculate *NI* by subtracting all *OpEx* incurred on a property from *gross income*, *r* is the *required rate of return* for the building, and *g* is the expected *constant growth rate* of *NI*. This expression highlights the direct relationship between changes in recurring income and asset valuation under assumptions of perpetual cash flow. Following standard asset pricing theory, this required return can be decomposed into standard components:

Equation 2

$$r = r_f + i + r_p$$

Where r_f is the real *risk-free rate*, i represents *expected inflation*, and r_p captures the *risk premium* associated with the property. Certification does not alter these components directly in the cash flow channel but influences valuation by increasing expected income. To isolate the certification-related contribution to value, we hold *r* and *g* constant and examine the change in net income before and after certification. The resulting increase in value is given by:

Equation 3

$$\Delta\, Building's\, Value\, due\, to\, Fundamentals = \frac{(Post\text{-}certification\ NI - Pre\text{-}certification\ NI)}{r} = \frac{\Delta\, NI}{r}$$

This expression demonstrates that even modest gains in *NI*, whether through higher rental revenue or lower expenses, can produce significant valuation effects, particularly when *r* is small. The convexity of the pricing equation amplifies the impact of operational improvements in low-yield environments, a relevant feature of many urban real estate markets today.

Operational improvements from certification can include efficiency gains in energy or water use, which reduce *OpEx*, or reputational benefits that improve tenant retention or command a rent premium. These micro-level mechanisms collectively contribute to the increase in *NI*, validating the assumption that sustainability upgrades can be financially material in the residential sector.

To illustrate the magnitudes involved, **Table 2** provides a simple sensitivity analysis showing the proportional relationship between increases in *net income* and *building value*. Under constant discounting, a 1.25% increase in annual *NI* yields a 1.25% increase in asset value. While stylized, this result underscores the importance of recurring income changes in driving long-run capital value in certified residential properties.

Table 2. Illustration of the Impact of Increased Income from Sustainability Certification on Residential Building Value.

This table demonstrates how an increase in income generated through sustainability certification can directly influence the value of a residential building under the assumption of constant yield. For example, a 1.25% increase in income translates into an equivalent 1.25% increase in the property's value, showcasing the direct financial benefits of net income increases from such certifications.

% Δ Income	0%	+1.25%	…	+Δ%
% Δ Value	0%	+1.25%	…	+Δ%

Source: Compiled by authors

3.2. Capitalization Channel

Beyond directly impacting a property's cash flows, sustainability certification enhances market value through a *capitalization channel* by lowering its perceived risk. This effect reduces the required rate of return that investors apply in valuation, thereby increasing the asset's price. Certification functions as a powerful signal of a building's quality and future-readiness, mitigating risks related to obsolescence, evolving environmental regulations, and market liquidity. This is particularly salient for institutional investors with ESG mandates, who increasingly use sustainability credentials as a key screening tool for capital allocation.

This risk reduction is grounded in tangible performance benefits. Certified buildings tend to exhibit lower delinquency and vacancy rates, reduced capital expenditure needs, and stronger overall operational performance. These attributes collectively lower both the systematic and idiosyncratic risk of the asset. As a result, certified properties are more attractive to lenders and investors, often receiving better credit assessments and accessing preferential financing conditions. Empirical reviews confirm this pattern; a synthesis of 23 studies found that lower interest charges were a key advantage of certification in 17 of them (Akomea-Frimpong et al., 2022). This dynamic is increasingly influential, as a majority of institutional real estate investors now formally incorporate ESG criteria into their investment frameworks (Barkham et al., 2021).

In asset pricing terms, these dynamics influence the risk-adjusted discount rate used to value properties. Formally, the change in the *required return* $\Delta\, r$ can be decomposed into three components:

Equation 4

$$\Delta\, r = \Delta\, r_f + \Delta\, i + \Delta\, r_p$$

where, $\Delta\, r_f$ is the change in the real risk-free rate, $\Delta\, i$ is the change in expected inflation, and $\Delta\, r_p$ reflects changes in the asset-specific risk premium. Sustainability certifications are unlikely to affect the first two terms directly but may significantly reduce $\Delta\, r_p$ through risk reclassification or enhanced liquidity.

To quantify the valuation implications of such a shift, we compute the change in *asset value* by multiplying the change in the *required return* ($\Delta\, r$) by the initial property value:

Equation 5

$$\Delta\, Building's\, Value\, due\, to\, Capital\, Markets \;=\; \Delta\, r \;\cdot\; Property\, Value$$

This formulation captures the direct *capital market channel* through which certification affects asset prices, holding cash flow expectations constant. Two mechanisms are particularly salient. First, if green-certified buildings are associated with *lower vacancy* and *delinquency* rates, investor models will treat them as less risky, reducing r_p. Second, certification expands the eligible investor base, particularly among ESG-focused funds, thereby increasing liquidity and reducing the required return. These effects are well documented in the emerging literature on green asset pricing. Certified properties tend to receive lower borrowing rates and face tighter bid-ask spreads, consistent with reductions in both systematic and idiosyncratic risk (Barkham et al., 2021; Akomea-Frimpong et al., 2022). These attributes are increasingly priced by institutional investors, particularly those with long-maturity mandates.

Table 3 illustrates the sensitivity of asset value to small changes in capital rates. A reduction of 45 basis points—from 5.00% to 4.55%—yields a 9.9% increase in property value. This convex response reflects the powerful effect that modest re-evaluations of risk can have on valuation, especially in low-yield environments.

Table 3. Impact of Required Rate of Return Variation on Property Value.

This table displays the sensitivity of property values to changes in the discount rate, specifically the impact of a variation in the capital rate ($\Delta\, r$) due to a variation in the risk premium ($\Delta\, r_p$). The analysis highlights how even modest decreases in the capital rate can lead to substantial increases in property value. For example, a 45-basis-point reduction in the discount rate (from 5% to 4.55%) raises property value by 9.9%.

Initial capital rate, *r*	5%	4.85%	4.70%	4.55%	4.40%	4.25%	4.10%
Δ Value (%) = Δ *r* (%)	0.0%	3.1%	6.4%	9.9%	13.6%	17.6%	22.0%

Source: Compiled by authors

4. Methodology

We use a dual methodological approach to assess how sustainability certifications influence residential building values and stakeholder perceptions. First, we carry out a multiple-case study of six certified residential buildings, analyzing audited financial, property, and market data to quantify the economic outcomes of sustainability investments. Second, we perform a mixed-methods stakeholder analysis, combining qualitative interviews, professional valuations, and spatial data to capture expert perceptions and regional dynamics related to green building certifications. As part of this stakeholder analysis, we analyzed interview transcripts with an LLM (OpenAI's GPT-4o) to extract key topics and sentiments. We additionally mapped public interest in certifications using Google Trends data and geospatial techniques. Together, these complementary methods provide a multidimensional understanding of both the actual financial impacts and the perceived value of sustainable real estate.

4.1. Case Studies

To capture real-world variation in certification dynamics, we employ a multiple-case study design, analyzing six residential buildings in parallel. This comparative structure enables us to surface recurring patterns as well as site-specific distinctions, offering a robust empirical basis for generalization (Yin, 1994). The method is well-suited to evaluating complex, context-dependent phenomena such as building retrofits and certification processes (Llewellyn, 1948). We selected the six buildings based on the depth and quality of their available data, which is rarely accessible in real estate research due to confidentiality restrictions. Each case features a uniquely detailed and audited dataset, allowing for precise measurement of investment, operating performance, and sustainability outcomes. Most of the data was provided by asset managers, who granted access to internal financial and operational records. **Table 4** summarizes the key data sources compiled for each case.

Table 4. Data Sources.

This table details the data used in the analysis by specifying the type, purpose, source, and content of each dataset. It reports information on property income and expenses, certification-related CapEx, building characteristics, sustainability certifications, property valuations, municipal housing market data in Spain, and international city benchmarks. It also identifies whether the data came from asset managers, public sources, or other providers, and indicates the relevant years covered.

Data	Used for	Source	Received from	Year	Description
Property Gross Incomes, Operating Expenses, and Capital Expenses	All property income, such as rent or rechargeable expenses. Property operating expenses, which, once deducted from gross income, enable obtaining net income. CAPEX for obtaining a sustainable certification.	Property audited accounting data.	Asset Managers	2019 - 2022	Classifies all property incomes by category and year; details net rent and expenses; records all incurred costs; separates CapEx into hard (direct) and soft (indirect) components.
Property information	Information used to contextualize case studies and assess CapEx requirements.	Cadastral and registral information, direct site visit by authors, and architectural projects.	Asset Managers, Public Information, and Site Visits	2024	Basic information of the property, such as surface, number of residential units by building, bedrooms, the energy performance certificate, among others.
Sustainable Certifications	Identify the level of case study sustainability based on a global benchmark.	BREEAM Accredited Certifier and BREEAM	Asset Managers	Certification Date	BREEAM certification report, all documentation required by the certifier to analyze the

		Organization Data.			accomplishment of sustainable standards required.
Case Study Property Valuations	Comparative data to assess the capex required to invest in sustainability compared to the property valuation.	Official Property Appraisals Accredited by the Bank of Spain.	Asset Managers	2022	Official appraisal comprehensive report for each case study, including property data, market analysis, valuation methodology, and valuation appraisal.
Spanish Property Data by Municipality	Understand market prices.	Instituto Nacional Estadística, Colegio de Registradores, Banco de España, Idealista.	Source public data.	Different years	Price, average surface, average building height, number of bedrooms, and other property market information that can help to identify the case studies' representativeness in comparison to the market
Global Cities Property Data	Knowledge of the characteristics of buildings in other cities to assess the representativeness of the case studies analyzed.	Global property guide, Statista, and other country-specific sources.	Public data.	Different years	Price, average surface, average building height, number of bedrooms, and other property market information that can help to identify the case studies' representativeness in comparison to the market

Source: Compiled by authors

Consolidating all the above information into a comprehensive data matrix for each case (organized by year, where applicable) allowed us to track the timeline and evolution of sustainability interventions and to perform detailed comparisons with market standards. Notably, all six buildings in our sample are BREEAM-certified residential properties, ensuring a standard benchmark for sustainability performance across the cases.

4.2. Case Building Representativeness

Our case study buildings are all multifamily apartment properties managed by professional asset managers and leased to residential tenants. Their physical characteristics place them squarely within the mainstream of Spanish urban housing, rather than being atypical or niche examples. **Table 5** highlights this alignment, comparing key attributes of our case buildings (Panel A) with aggregate statistics for residential buildings in major Spanish cities (Panel B).

Panel A shows that the six case study buildings follow a consistent typology. Except for one recently built property, developers constructed all between the 1950s and 1970s, with mid-rise profiles averaging six floors and residential units around 65 m². These traits are characteristic of the mid-century, mid-rise apartment blocks prevalent in dense neighborhoods of Spanish cities like Barcelona and Madrid. The uniformity in building height and unit size across the cases suggests that they are representative examples of the compact, multifamily urban housing commonly found in Spain's metropolitan centers.

Table 5. Characteristics of Residential Properties: Case Studies vs. Spanish City Averages.

This table compares the characteristics of residential properties across major Spanish cities and selected case studies. Metrics include the total number of residential units, the average year of construction, the average residential surface area per unit (in m²), the average surface area per person (in m²), and the average number of floors per building. It also reports the percentage of residential buildings with five or more floors and the average *price per square meter (€ / m²). Panel A details the case studies Panel B aggregates data from major cities across Spain, offering a benchmark for understanding differences in urban residential structures and pricing.*

Municipality	Residential Units	Average Year of Construction	Average Residential Surface	Average Surface per Person	Average Number of Floors	% with 5 Floors or more	Price (€ / m^2)
Panel A: Case Studies							
Case 1	32	1954	64.8	-	7.0	-	6,106
Case 2	70	1964	48.0	-	8.0	-	8,079
Case 3	51	1964	66.9	-	6.0	-	5,232
Case 4	7	1963	57.6	-	4.0	-	7,184
Case 5	59	2020	81.8	-	7.0	-	6,728
Case 6	14	1970	60.3	-	5.0	-	6,012
Case studies Total / Average	**233**	**1973**	**64.8**	**-**	**6.2**	**-**	**6,692**
Panel B: Spanish Cities							
Madrid	1,533,222	1974	68.4	36.3	6.2	76%	4,016
Barcelona	808,749	1963	66.6	36.5	6.2	77%	3,768
Valencia	414,987	1975	81.1	43.1	6.3	81%	2,068
Sevilla	327,510	1980	76.6	39.1	5.3	56%	2,140
Zaragoza	338,961	1982	74.1	39.6	6.1	67%	1,670
Málaga	261,855	1985	79.0	38.9	6.0	69%	2,401
Murcia	219,741	1989	88.8	41.4	3.9	37%	1,270
Palma de Mallorca	186,483	1977	83.2	39.6	4.1	39%	2,878
Las Palmas de Gran Canaria	175,203	1981	80.7	39.4	5.0	53%	1,836
Alicante	187,659	1984	82.5	43.2	5.9	66%	1,705
Bilbao	165,684	1970	79.9	44.9	7.6	95%	2,817
Córdoba	155,454	1985	82.0	39.9	3.8	35%	1,432
Valladolid	159,363	1982	77.2	42.7	5.9	70%	1,491
Vigo	144,294	1980	82.9	41.1	5.4	60%	1,842
Hospitalet de Llobregat	110,487	1975	54.2	28.6	5.8	64%	2,466
Gijón	148,956	1982	72.6	41.4	5.6	74%	1,714
Vitoria	119,853	1986	83.2	46.3	6.9	89%	2,266
A Coruña	136,230	1981	74.6	41.5	5.9	71%	2,078
Elche	116,079	1987	90.2	42.8	4.6	57%	1,175
Granada	141,258	1981	87.2	47.4	5.0	58%	1,891
Guadalajara	41,937	1990	84.4	42.7	5.1	53%	1,508
Huelva	68,715	1986	75.6	38.7	5.4	56%	1,298
Logroño	78,909	1985	79.1	43.2	5.8	73%	1,549
Toledo	40,497	1987	87.3	43.2	4.1	43%	1,503
Total / Average	**6,082,086**	**1977**	**75.1**	**39.3**	**5.8**	**69%**	**2,701**

Source: Compiled by authors using data from Instituto Nacional de Estadística - Censo de Población y Viviendas and from Ministerio de Transporte y Movilidad Sostenible.

Panel B of **Table 5** reinforces the representativeness of our sample by comparing it to broader urban housing trends in Spain. Aggregated data for Spain's largest cities show national averages of approximately 5.8 floors per building, an average unit size of 75 m², and a median construction year of around 1977. These figures closely mirror the case studies' structural profile. In cities such as Madrid, Barcelona, and Bilbao, the typical residential building is very similar to our cases, with average floor counts and dwelling sizes nearly identical to those in Panel A. Moreover, over 70% of residential buildings in those major cities have five or more floors, underscoring the dominance of vertical apartment living. These parallels in age, height, and unit dimensions indicate that our case study buildings are not outliers but instead exemplify the common urban residential form in Spain.

However, one aspect where our case studies depart from national averages is market value, as they command an average price of about €6,692 per m²—more than double the Spanish urban average. This places our buildings firmly in the prime segment, reflecting their central, high-demand locations in Barcelona and Madrid (Lasose, 2022). While this bias toward high-value properties means our findings might not directly generalize to lower-priced housing, the buildings remain physically representative of typical Spanish urban apartments. This combination of structural representativeness and prime market positioning makes them well-suited for analyzing sustainability certifications in the dense, investment-grade housing stock where green retrofitting is most feasible.

To place our cases in a broader international context, we also compare their characteristics to housing data from other global and European cities. **Table 6** summarizes key residential property metrics for selected major cities worldwide. Panel A lists global megacities (London, Paris, Tokyo, New York), while Panel B focuses on several large European cities. This comparison allows us to evaluate whether our case buildings reflect typical urban housing patterns beyond Spain.

Table 6. Characteristics of Residential Properties in Global and European Cities.

This table compares the characteristics of residential properties across global (Panel A) and major European cities (Panel B). Metrics include the average residential surface, average year of construction, average height in meters, average number of floors per building, and average residential price in € / m².

Municipality	Average Residential Surface (m)	Average Year of Construction	Average Height (m)	Average Number of Floors	Price (€ / m2)
Panel A: Global Cities					
London	81	1930	-	4.0	10,806
Paris	71	1900	-	6.0	10,295
Tokyo	64	1990	-	5.0	4,473
New York	87	1930	-	7.0	17,732
Average	76	**1938**	-	**5.5**	**10,827**
Panel B: European Cities					
Berlin	82	1930	9	3.4	5,039
Rome	93	1945	9	3.4	3,017
Vienna	74	1910	11	4.1	7,555
Hamburg	82	1955	10	3.8	4,476
Warsaw	55	1970	10	4.0	3,539

Budapest	78	1925	9	3.3	2,716
Munich	80	1950	7	2.8	7,119
Milan	96	1940	15	5.7	5,433
Prague	65	1935	9	3.4	4,987
Brussels	152	1930	8	3.2	3,481
Cologne	85	1955	10	3.9	3,531
Average	**86**	**1940**	**10**	**3.7**	**4,627**

Source: Compiled by authors using data from OECD (2022), Statistisches Bundesamt (2021), Robyn (2023), Bavarian State Office for Statistics, Brussels-Capital Region building stock reports, Czech Statistical Office, Eurostat, Hamburg's Urban Development and Housing Department reports, Hungarian Central Statistical Office, Italian National Institute of Statistics, North Rhine-Westphalia State Office for Information and Technology, Statistics Poland, and Statistik Austria.

To situate our findings, we compare our Spanish case studies to two distinct groups of cities: global capitals and other major European centers. The global cities in Panel A, such as London, Paris, and New York, are characterized by markedly older housing stocks, significantly higher residential prices (often exceeding €10,000 per m²), and divergent building typologies. In contrast, our Spanish cases—with an average construction year of 1973 and prices around €6,700/m²—typify the dense, mid-rise urban fabric common across much of Europe, which is less extreme in value and scale than these premier global capitals.

When compared to other European cities in Panel B, the alignment is much stronger. While our case study dwellings are somewhat smaller and taller on average (65 m² and 6 floors vs. 86 m² and 3-4 floors), their core characteristics are highly comparable. Major cities like Berlin, Rome, and Vienna feature similar mid-20th-century housing stock with buildings in the 4–7 floor range. Furthermore, our cases' average price point falls within the range of high-cost European centers like Munich and Vienna. This indicates that our case studies are broadly representative of the compact, vertically oriented residential stock typical of large European metros, which enhances the generalizability of our findings.

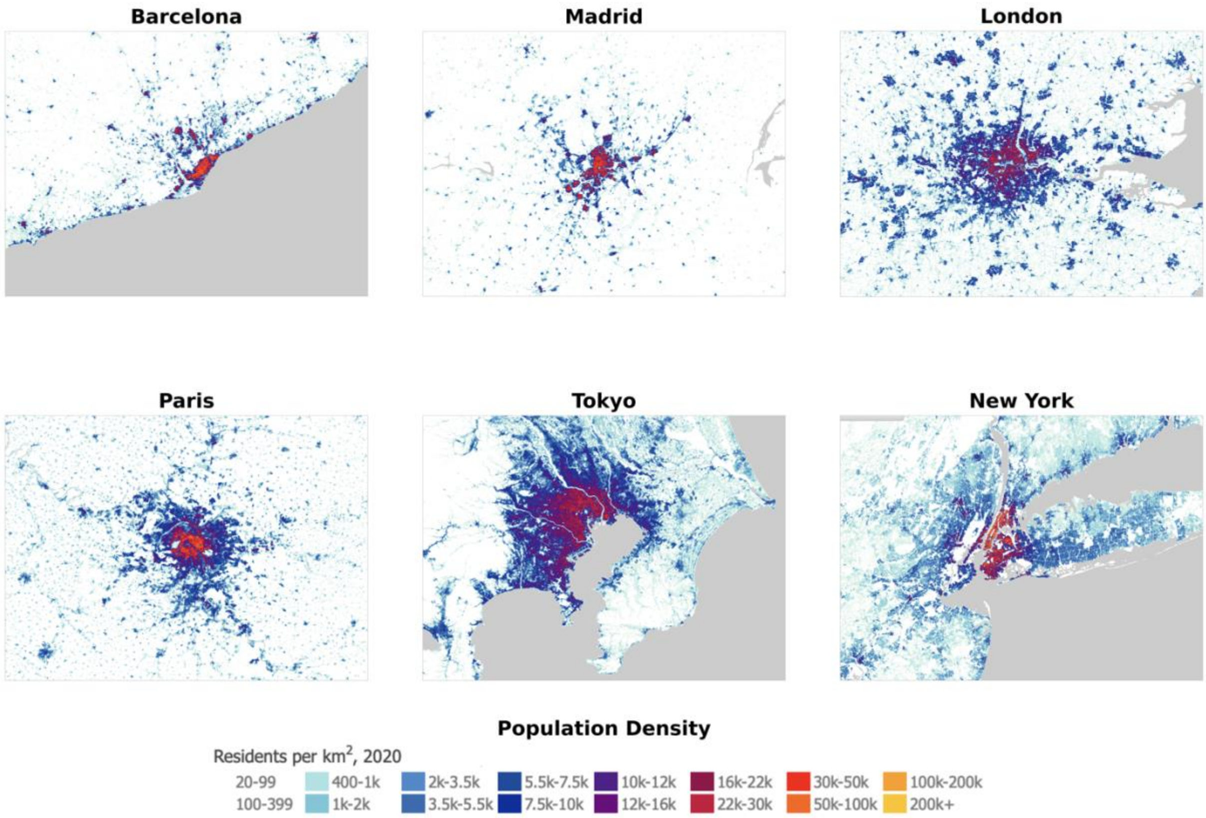


Figure 1: Population density distribution in case study cities vs. global cities. This figure presents the population density (residents per km²) across six major cities: Barcelona, Madrid, London, Paris, Tokyo, and New York. The color gradient, ranging from light blue to yellow, indicates varying population densities, with cooler colors representing lower densities and warmer colors denoting higher densities. Source: Luminocity3D (base maps) and authors' elaboration.

The urban form of our case cities, illustrated by the population density maps in **Figure 1**, provides further nuance. Both Madrid and Barcelona exhibit the pronounced central density characteristic of major European hubs. However, they display different growth patterns: Barcelona is exceptionally compact, with a steep density drop-off at its periphery, while Madrid's density tapers more gradually into a more expansive suburban footprint. This distinction highlights that our analysis captures key variations in urban morphology, from hyper-dense cores to more sprawling metropolitan patterns, reflecting the diverse contexts in which sustainability certifications are being adopted across Europe.

4.3. Case Building Characteristics

Our analysis is grounded in six case studies, five in Barcelona and one in Madrid, that represent a diverse mix of building ages, sizes, and sustainability performance levels. A full overview is provided in **Table 7**, with key characteristics summarized below.

The first group of cases consists of large, mid-20th-century buildings that have undergone varying degrees of renovation.

Case 1 (Barcelona – Sarrià–Sant Gervasi): An eight-story building from 1954, extensively renovated in 2019. It comprises 32 apartments with a total leasable area of 2,073 m². The renovation yielded high performance, achieving an energy rating of B and a BREEAM certification of "Very Good."

Case 2 (Barcelona – Ronda General Mitre): A larger, mixed-use building from 1966 containing 70 smaller apartments across ten levels (3,359 m² leasable area). Despite several refurbishments, it holds a low energy performance rating of G, and its BREEAM certification is in progress and currently pending.

Case 3 (Barcelona – Plaza Villa de Madrid): Built in 1964, this building contains 51 apartments over seven floors (3,413 m² leasable area). It underwent interior renovations in 2018 but still holds an energy performance rating of F, with its BREEAM certification also in progress and pending.

The next two cases in Barcelona represent distinct archetypes: a smaller-scale retrofit and a modern, new construction.

Case 4 (Barcelona – Sarrià–Sant Gervasi): Representing a smaller asset, this four-story building from 1963 was renovated in 2013. It contains just seven apartments (403 m² total area) and, despite a modest energy performance rating of E, has achieved a BREEAM certification of "Very Good."

Case 5 (Barcelona – Sant Martí): The only new construction in our sample, this eight-story building (2020) features 59 larger apartments (4,825 m² total area) and extensive amenities, including a rooftop pool. As a modern build with an aerothermal system, it boasts a top-tier energy rating of A and a BREEAM "Very Good" certification.

Finally, the Madrid case represents a comprehensive energy-focused renovation.

Case 6 (Madrid – Prosperidad): This six-story building, originally from 1970, underwent a full renovation in 2019 that incorporated an advanced aerothermal system with solar panels. It contains 14 apartments (844 m² total area) and achieved a BREEAM "Very Good" construction certification, though its final energy performance rating is D.

Table 7. Summary Characteristics of Case Study Buildings.

This table provides detailed characteristics of six residential properties in Barcelona and Madrid, highlighting their location, year of construction or renovation, number of floors, apartment distribution, and surface area metrics.

Property	Location	Year of construction / Renovation	Floors	Units	Rooms	Gross surface area for rent	Average surface area per apartment
Case 1	Barcelona	1954 / 2019	Ground-floor + 7 floors	32	- 26 two-room - 1 three-room - 5 four-room	2,073 m²	65 m²
Case 2	Barcelona	1964 /	Ground-floor + Mezzanine + 8 floors + terrace	70	- 23 one-room - 26 two-room - 6 three-room	3,359 m²	48 m²
Case 3	Barcelona	1964 / 2018	6 floors + attic	51	- 7 two-room- 28 three-room- 16 four-room	3,413 m²	67 m²
Case 4	Barcelona	1963 / 2013	4 floors	7	- 3 one-room - 3 two-room - 1 three-room	403 m²	58 m²

Case 5	Barcelona	2020 /	Ground-floor + 7 floors	59	- 4 one-room - 30 two-room - 25 three-room	4,825 m²	82 m²
Case 6	Madrid	1970 / 2019	Ground-floor + 5 floors	14	- 4 one-room - 8 two-room - 2 three-room	844 m²	60 m²

Source: Compiled by authors.

4.4. Stakeholder Perceptions, Appraiser Valuations, and Spatial Analysis

In parallel with our case study analysis, we employed a multi-pronged approach involving stakeholder interviews, expert valuations, and spatial data analysis to provide a comprehensive understanding of sustainability certifications.

First, to capture broad industry perceptions, we conducted 18 semi-structured interviews with senior real estate professionals between November 2023 and January 2024. This qualitative inquiry aimed to identify the perceived benefits, challenges, and market drivers of sustainability labels. The panel was composed of four key stakeholder groups—Technical Consultants, Real Estate & Financial Consultants, Landlords/Investors, and Certification Professionals—from both local and international firms. These experts held senior roles (e.g., Managing Director, Head of Unit) and possessed extensive industry experience, ranging from 11 to 35 years (participant profiles are summarized in **Table 8**). Each interview lasted approximately 45 minutes. With consent, 17 interviews were audio-recorded, while detailed notes were taken for one. All participants were informed of the research objectives and assured of confidentiality and non-attribution.

Second, to specifically quantify the "green premium," we conducted nine in-depth teleconference interviews in late July 2024 with experienced real estate appraisers from Barcelona and Madrid. During each session, we asked these experts to estimate the percentage increase in a residential building's price attributable to obtaining a sustainability certification like BREEAM. The group was highly qualified, with an average of over 20 years of industry experience, advanced degrees in relevant fields, and senior positions at a mix of global and local firms. The panel was balanced, with approximately 44% female appraisers (further details are provided in **Section 4.2**). These expert valuations provide a crucial market-based benchmark that we later compare against the financial data from our case studies.

Finally, to understand how geographic context and public awareness might influence the value of certifications, we analyzed spatial patterns of search interest using Google Trends. We gathered eight years of search query data (June 7, 2016, to June 8, 2024) for terms like “BREEAM” and “LEED” across Spain’s autonomous communities and major cities. Using Python libraries (Pandas, GeoPandas, and Matplotlib), we processed this publicly available, aggregate data to create choropleth maps. These maps visualize the relative popularity of certifications (scaled 0–100) and allow us to identify regional clusters of high public interest, which may correlate with local market receptiveness and the capitalization of ecolabels into property values.

Table 8. Profile of Interviewed Expert Panel.

This table summarizes the composition of the 18 experts interviewed about sustainability certifications. It is organized by stakeholder segment (Technical Consultants, Real Estate & Financial Consultants, Landlords, and Certifiers). For each interviewee, it notes whether their organization's scope is local or global, their job position (e.g., Managing Director, Head of Unit, Associate Director), years of professional experience, and gender.

Segment	Capital	Position	Industry Experience (Years)	Gender
Technical Consultants	Local	Managing Director	16	Female
	Global	Managing Director	18	Female
	Local	Head of Unit	23	Female
	Local	Managing Director	30	Female
	Local	Managing Director	23	Female
Real Estate & Financial Consultants	Local	Associate in Capital Markets	31	Male
	Global	Head of Living Spain	25	Male
	Local	Managing Director	11	Male
	Global	Associate Director	26	Male
Landlords	Global	Managing Director	20	Male
	Local	Asset Manager Director	23	Male
	Global	Asset Manager Director	22	Male
	Global	Managing Director	18	Male
	Global	Managing Director	25	Male
	Local	General Director	35	Male
	Local	General Director	30	Female
Certifiers	Global	Managing Director	31	Male
	Global	Managing Director	20	Male

Source: Compiled by authors.

Our qualitative analysis of the interview transcripts focused on three primary questions concerning the perceived financial impact and adoption drivers of sustainability certifications. These questions prompted experts to discuss how certifications like BREEAM influence property value, marketability, tenant demand, and overall investment strategy. To systematically analyze the responses, we employed a natural language processing approach. After anonymizing all transcripts by replacing personal and company names with generic role descriptors (e.g., "Technical Consultant"), we utilized OpenAI's GPT-4o model via its API to code the text. The model was prompted to identify recurring topics or "impact vectors" (such as location) and to classify the overall sentiment (positive or negative) associated with them.

To validate the AI-assisted analysis, we first established a human "gold standard" by having two research assistants independently code the interview transcripts and reconcile their results. This benchmark was then compared against the outputs from GPT-4o. The agreement on both topic detection and sentiment classification was statistically robust, with Cohen's kappa and intraclass correlation coefficients exceeding 0.75, confirming a strong alignment between the human coders and the AI.

This entire process was governed by data security and ethical protocols. We used an OpenAI API account specifically configured to prohibit data logging and the use of our data for model training, thereby eliminating risks of third-party data retention or unintended use. All participants provided informed consent, fully aware that their anonymized responses would be used for this research. By operating under a secure contractual framework and communicating our goals transparently, we upheld participant confidentiality and autonomy while adhering to emerging best practices for AI-assisted qualitative research.

5. Empirical Results

5.1. Investment Required for Residential Sustainability Certification

Our first set of results quantifies the capital investment needed to obtain a sustainability certification, contextualizing it against each building's income and value. As summarized in **Table 9**, the total *CapEx* for achieving BREEAM certification across the six case studies was €0.79 million. This figure amounts to only 0.8% of the combined property value and roughly 21.5% of one year's gross rental income, equivalent to approximately two to three months of rent. These relatively low figures indicate that in prime urban settings like Madrid and Barcelona, the one-time sustainability upgrade cost represents a small upfront expenditure in proportion to the asset's value, making it an attractive option for developers and investors. Overall, the required investment is modest for large urban residential buildings.

Table 9. Capital Expenditure, Gross Income, and Valuation of Six Residential Buildings Undergoing Sustainability Certification

This table presents a detailed breakdown of capital expenditures (CapEx), gross income, and property valuations for six residential case studies located in Barcelona and Madrid. The CapEx is further divided into hard and soft costs, providing insights into the investment required to enhance the sustainability of these properties. The table also compares the resulting gross income and the overall valuation of each property with the CapEx. The totals at the bottom summarize the combined financial metrics across all cases and segment them by asset size and type.

Property	Location	Units	Average surface area per unit	CapEx (M€)			Gross income (M€)	Valuation (M€)	% CapEx / Annual gross income	% CapEx / Property value
				Hard costs	Soft costs	Total				
Case 1	Barcelona	32	65 m²	0.10	0.04	0.14	0.49	12.7	28.04%	1.09%
Case 2	Barcelona	70	48 m²	0.25	0.03	0.28	1.09	27.1	26.06%	1.05%
Case 3	Barcelona	51	67 m²	0.13	0.03	0.15	0.69	17.9	22.10%	0.85%
Case 4	Barcelona	7	58 m²	0.03	0.02	0.05	0.10	2.9	49.49%	1.69%
Case 5	Barcelona	59	82 m²	0.03	0.04	0.08	1.10	32.5	6.94%	0.24%
Case 6	Madrid	14	60 m²	0.05	0.05	0.09	0.22	5.1	43.15%	1.83%
Total	**-**	**233**	**63 m²**	**0.59 M€**	**0.21 M€**	**0.79 M€**	**3.68 M€**	**98.08 M€**	**21.50%**	**0.81%**
Sizable	-	**153**	**60 m²**	**0.48 M€**	**0.1 M€**	**0.57 M€**	**2.27 M€**	**57.65 M€**	**25.3%**	**1.0%**
Small	-	**21**	**59 m²**	**0.08 M€**	**0.07 M€**	**0.14 M€**	**0.31 M€**	**7.97 M€**	**45.2%**	**1.8%**
New	-	**59**	**82 m²**	**0.03 M€**	**0.04 M€**	**0.08 M€**	**1.10 M€**	**32.46 M€**	**6.94%**	**0.24%**

Source: Compiled by authors.

However, **Table 9** also highlights substantial cost differentials associated with building size and construction phase. Larger buildings with more than 30 units (Cases 1–3) incurred significantly lower relative expenditures, with certification costs averaging 1.0% of total asset value. In contrast, smaller buildings (Cases 4 and 6) faced a much higher cost burden, averaging 1.8% of property value. This disparity reflects economies of scale, where fixed expenses are distributed across more units. Newly constructed properties demonstrate a clear cost advantage as well; Case 5, the only new development, required just 0.24% of its property value to achieve certification. This efficiency stems from embedding sustainability features during the design stage and adhering to modern building regulations, which minimizes the need for capital-intensive retrofitting common in older properties.

Table 10. Required Investment to Certificate Categorized by BREEAM Certification Standards.

This table presents a detailed breakdown of investment costs (CapEx) across six residential case studies, categorized according to BREEAM certification standards. It separates expenditures into hard and soft costs and further classifies them under BREEAM categories such as management, health and wellbeing, energy, and materials. The table also presents the CapEx impact relative to annual gross income and property value.

Sections	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Total (M€)	% CapEx / Annual gross income	% CapEx / Property value
Hard costs	**0.099**	**0.252**	**0.124**	**0.030**	**0.033**	**0.046**	**0.59 M€**	**15.88%**	**0.60%**
BREEAM certification	**0.079**	**0.240**	**0.094**	**0.015**	**0.033**	**0.014**	**0.47**	**12.88%**	**0.48%**
Management (MNG)	0.006	0.003	0.045	0.012	0.028	0.006	0.10	2.71%	0.10%
Health and wellbeing (HWB)	0.023	0.218	0.022	0.001	0.002	0.001	0.27	7.25%	0.27%
Energy (ENE)	0.046	0.009	0.002	0.001	0.002	0.004	0.06	1.71%	0.06%
Materials (MAT)	0.005	0.011	0.025	0.001	0.001	0.002	0.04	1.21%	0.05%
Photovoltaic panels	**0.020**	**0.012**	**0.032**	**0.015**	**-**	**0.032**	**0.11**	**3.01%**	**0.11%**
Soft costs	**0.038**	**0.032**	**0.027**	**0.019**	**0.043**	**0.047**	**0.21 M€**	**5.62%**	**0.21%**
Rates or licenses	0.011	0.006	0.008	0.003	0.006	0.004	0.04	1.00%	0.04%
Fees and certification	0.026	0.025	0.016	0.015	0.036	0.040	0.16	4.28%	0.16%
Document management	0.002	0.002	0.003	0.002	0.002	0.003	0.01	0.34%	0.01%
Total	**0.137**	**0.284**	**0.152**	**0.049**	**0.076**	**0.093**	**0.79 M€**	**21.50%**	**0.81%**

Source: Compiled by authors.

A breakdown of the required investment, detailed in **Table 10**, shows that approximately 74% of the cost (€0.59 million) went into hard costs for tangible upgrades, while 26% (€0.21 million) covered soft costs for fees, design, and consulting. The most significant hard-cost investments were related to health and wellbeing improvements and energy systems. The soft costs, including the direct one-off fee for the BREEAM certificate itself, were also substantial, emphasizing that the certification process carries costs beyond the physical upgrades. Further reinforcing the theme of scale, **Table 11** reports that the *CapEx* per square meter was significantly lower for larger multifamily buildings (€65/m²) compared to smaller ones (€110–122/m²). The newly-built project required an exceptionally low €16 per square meter, underscoring how building size, compliance with new construction standards, and intervention timing greatly influence the cost-effectiveness of pursuing green certification.

Table 11. Required Investment to Certificate Relative to Gross Surface Area and Number of Units.

This table presents a detailed analysis of capital expenditure (CapEx) relative to the gross rentable surface area and the number of apartments in each case study. The data highlights the variation in CapEx per square meter and unit, providing insights into the efficiency and financial impact of sustainability investments across different property sizes and conditions. The analysis demonstrates that both sizable existing and smaller existing properties tend to have higher CapEx per square meter and apartment. In comparison, newer properties show lower CapEx values, reflecting potentially more efficient or modernized investments.

Property	Units	Gross surface area for rent	CapEx (M€)	CapEx / Gross surface area for rent	CapEx / Unit
Case 1	32	2,073 m²	0.14	66 €/sq.m.	4,295 €/ apartment
Case 2	70	3,359 m²	0.28	85 €/sq.m.	4,061 €/ apartment
Case 3	51	3,413 m²	0.15	45 €/sq.m.	2,985 €/ apartment
Case 4	7	403 m²	0.05	122 €/sq.m.	7,008€/ apartment
Case 5	59	4,825 m²	0.08	16 €/sq.m.	1,294 €/ apartment
Case 6	14	844 m²	0.09	110 €/sq.m.	6,628 €/ apartment
Total	**233**	**14,918 m²**	**0.79 M€**	**53 €/sq.m.**	**3,400 €/ apartment**
Sizable	**153**	**8,845 m2**	**0.57 M€**	**65 €/sq.m.**	**4,295 €/apartment**
Smaller	**21**	**1,247 m2**	**0.14 M€**	**114 €/sq.m.**	**6,755 €/apartment**
New	**59**	**4,825 m2**	**0.08 M€**	**16 €/sq.m.**	**1,294 €/apartment**

Source: Compiled by authors.

In summary, while upfront investments for certification are financially feasible in large urban residential buildings, typically representing well under 1% of property value, smaller or lower-value properties face higher proportional costs. These findings provide crucial context for the profitability of sustainability certifications, which we examine next.

5.2. Impact of Sustainability Certification on Property Values

We next evaluate whether sustainability certifications translate into higher market valuations. Based on in-depth interviews with professional appraisers, whose profiles are summarized in **Table 12**, we find that green-certified buildings do achieve a positive but modest "green premium." On average, obtaining a BREEAM certification is associated with an estimated +1.2% increase in a building's market value, with a +0.4% increase per individual apartment. These figures confirm a positive valuation impact, though it is smaller in magnitude than the 3–7% premiums reported in some earlier literature, suggesting the green premium in the Spanish residential context may be more muted possibly reflecting the nascent stage of green certification in this market or conservative expectations among local buyers.

Table 12. Appraisers' Profile and Expected Value Increase for Buildings and Apartments with BREEAM Certification.

This table details the profiles of the surveyed appraisers, including their industry experience, position, educational background, gender, and company type (global or national). It further illustrates the anticipated variation in sale prices for homes and buildings that have achieved BREEAM certification. The results indicate a higher expected price increase associated with BREEAM certification for properties evaluated by global appraisers compared to those assessed by national appraisers, highlighting the perceived value of sustainability certifications in the worldwide market.

Company Profile	Industry Experience (Years)	Position	Education	Gender	Sale Price Variation of a Home with BREEAM (Percentage points)	Sale Price Variation of a Building with BREEAM (Percentage points)
Global	13	Associate Director	Business Administration	Female	1.25	3
	12	Associate Director	Business Administration	Male	1	2.5
	16	Managing Director	Business Administration	Female	1.5	4
Global Average					*1.25*	*3.17*
National	43	Associate Director	Architecture	Male	0	0.5
	22	Technical Director	Architecture	Female	0	0
	27	Business Line Manager	Business Administration	Male	0	0
	22	Senior Consultant	Architecture	Male	0	0
	31	Business Line Manager	Business Administration	Female	0	0
	30	Business Line Manager	Architecture	Male	0	1
National Average					*0*	*0.25*
Global & National Average					**0.42**	**1.22**

Source: Compiled by authors.

Crucially, **Table 12** reveals a clear difference in perspective between international and domestic valuation professionals. Appraisers from global firms anticipated significantly larger value boosts from certification, averaging +3.2% for whole buildings. These professionals, who often advise global investors, view sustainability credentials as a noteworthy value enhancer. In stark contrast, national appraisers focused on the local Spanish market generally expected minimal to zero value change, with an average uplift of just +0.25%. This disparity suggests the realized value premium depends heavily on the buyer audience; internationally-minded investors may be willing to pay more for certified assets, while the typical local participant may not yet fully recognize this attribute. The overall +1.2% premium is therefore a blend of these views, indicating a modest market gain driven primarily by globally active stakeholders.

It is important to note that even a 1–3% increase in value can be economically meaningful when weighed against the low costs of certification. For an average €16 million building in our case studies, a 1.2% gain equals roughly €192,000 in added value from an investment of only ~€79,000. In higher-end scenarios (or under global investor assumptions of ~3% premium), the value added could be several times the cost, a point we explore in the profitability analysis below. Nonetheless, the heterogeneity in appraisers' expectations highlights an important caveat: sustainability features are not yet universally capitalized into pricing, especially in traditionally conservative markets. Therefore, from a results standpoint, we can conclude that certification has a positive but context-dependent effect on property values.

5.3. Profitability of Residential Sustainability Certification

By combining the cost and value impacts, we assess the financial viability of sustainability certifications. As presented in **Table 13**, the return on investment (ROI) is strong even under conservative assumptions. Using the observed average value increase of +1.22% against the average CapEx of 0.8% of property value, we estimate an ROI of approximately 151.5%, meaning each euro invested yields more than €1.50 in added value. The returns become even more compelling under slightly more optimistic scenarios; a 2.0%–3.0% value increase corresponds to yields between 248% and 373%. In scenarios where the uplift reaches 5.0% or more, as documented in other studies, yields can exceed 620%.

These high ROI figures are primarily a function of the small size of the investment relative to the overall property value. Because certification costs represent less than 1% of total asset value, even modest absolute gains in property price produce disproportionately large percentage returns. For instance, if a €10 million building undergoes €80,000 in upgrades and gains €200,000 in value, the ROI exceeds 250%. This dynamic makes green certification a highly efficient, high-leverage capital improvement strategy, particularly in high-value urban markets.

Table 13. Return on Investment from Sustainability Certification under Varying Property Value Uplift Scenarios.

This table estimates the return on investment (ROI) for residential sustainability certifications using both observed case data and alternative value uplift scenarios commonly reported in the literature (see Table 1). We calculate ROI by dividing the increase in property value following certification by the total capital expenditure (CapEx) invested across the six case studies. For example, using the appraiser-estimated average value increase of 1.22%, applied to the total pre-certification property value of €98.08 million, the resulting gain is approximately €1.20 million. Dividing this gain by the total CapEx of €0.79 million yields an ROI of 151.5%.

Cases' buildings (Cases 1–6)										
Pre-ecolabel total building value of €98.08 million & CapEx required for certification of €0.79 million										
Increase in value (%)	**1.22%**	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10%
Value post ecolabel	**99.3**	100.0	101.0	102.0	103.0	104.0	105.0	105.9	106.9	107.9
Increase in value	**1.20**	1.96	2.94	3.92	4.90	5.88	6.87	7.85	8.83	9.81
ROI (%)	**151.5%**	248.3%	372.5%	496.6%	620.8%	744.9%	869.1%	993.2%	1,117.4%	1,241.5%

Source: Compiled by authors.

5.3.1. Influence of Building Size and Type on Certification Profitability

The profitability of sustainability certification varies markedly by building *size* and *type*, as detailed in **Table 14**. *Large existing* multifamily buildings (Cases 1–3) achieve a robust ROI of 123.4% under the baseline 1.22% value uplift. At a 3.0% uplift, which reflects international appraiser expectations, the return more than doubles to 303.4%, illustrating a compelling financial case for sizable assets. In contrast, *smaller existing* buildings (Cases 4 and 6) yield more modest returns due to their higher relative costs, generating a 69.5% ROI at the same 1.22% uplift. This suggests the business case for certification in small-scale properties may be weaker without external support.

Table 14. Return on Investment from Sustainability Certification by Building Type.

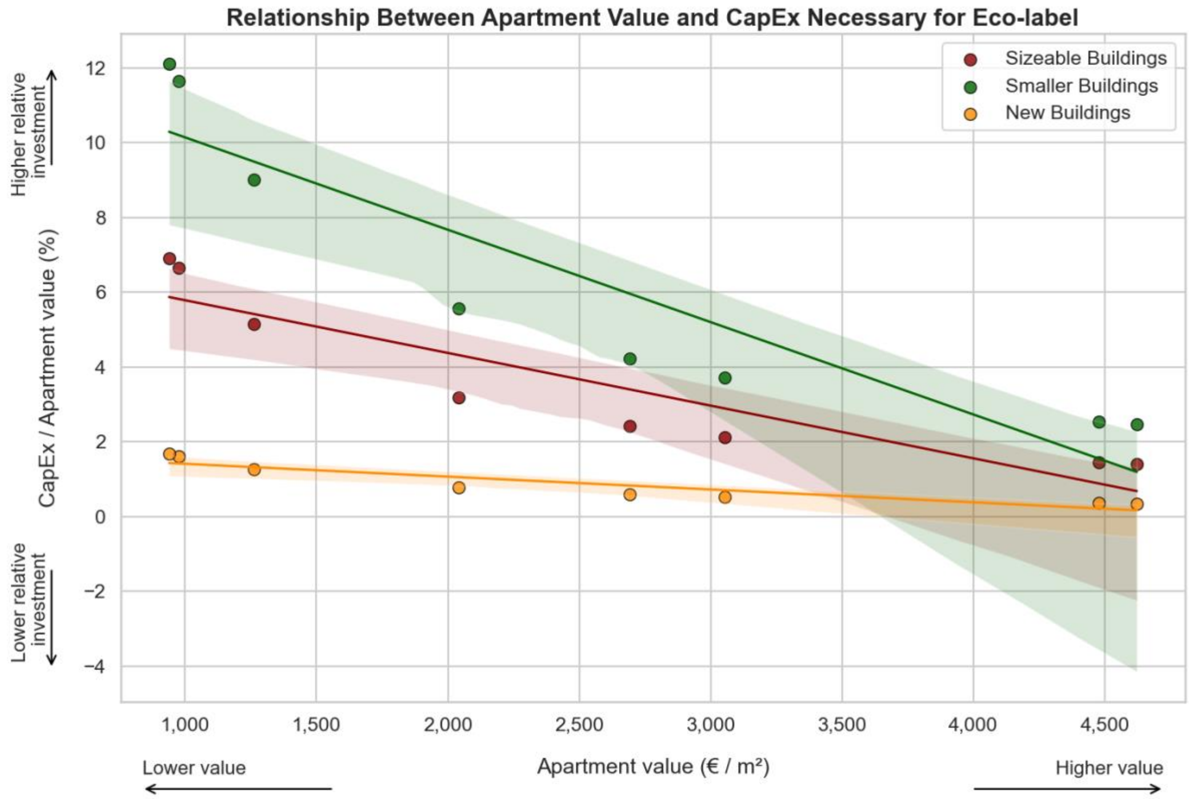
This table presents estimated return on investment (ROI) figures for three categories of residential buildings: sizable buildings (Cases 1–3), small buildings (Cases 4 and 6), and a newly constructed building (Case 5). We calculate ROI by dividing the increase in property value following certification by the total capital expenditure (CapEx) required to obtain certification. For example, in the sizable buildings category, the pre-certification combined asset value is €57.65 million, and the total CapEx is €0.57 million; applying a 1.22% uplift results in a gain of approximately €0.70 million, which translates into an ROI of 123.4%. The data demonstrate that newly built projects and sizeable existing ones, which typically require minimal additional investment to achieve certification or benefit from economies of scale, generate significantly higher returns.

Sizeable buildings (Cases 1–3)										
Pre-ecolabel total value of €57.65 million & CapEx required for certification of €0.57 million										
Increase in value (%)	**1.22%**	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
Total value post ecolabel	**58.35**	58.80	59.38	59.96	60.53	61.11	61.69	62.26	62.84	63.42
Increase in value	**0.70**	1.15	1.73	2.31	2.88	3.46	4.04	4.61	5.19	5.77
ROI (%)	**123.4%**	202.3%	303.4%	404.6%	505.7%	606.8%	708.0%	809.1%	910.3%	1,011.4%
Small buildings (Cases 4 and 6)										
Pre-ecolabel total value of €7.97 million & CapEx required for certification of €0.14 million										
Increase in value (%)	**1.22%**	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
Total value post ecolabel	**8.07**	8.13	8.21	8.29	8.37	8.45	8.53	8.61	8.69	8.77
Increase in value	**0.10**	0.16	0.24	0.32	0.40	0.48	0.56	0.64	0.72	0.80
ROI (%)	**69.5%**	113.9%	170.8%	227.7%	284.6%	341.6%	398.5%	455.4%	512.4%	569.3%
New construction building (Case 5)										
Pre-ecolabel total value of €32.46 million & CapEx required for certification of €0.08 million										
Increase in value (%)	**1.22%**	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
Total value post ecolabel	**32.86**	33.11	33.43	33.76	34.08	34.41	34.73	35.06	35.38	35.71

Increase in value	**0.40**	0.65	0.97	1.30	1.62	1.95	2.27	2.60	2.92	3.25
ROI (%)	**495.0%**	811.5%	1,217.3%	1,623.0%	2,028.8%	2,434.5%	2,840.3%	3,246.0%	3,651.8%	4,057.5%

Source: Compiled by authors.

The significant advantage of *new construction* is best illustrated by its exceptional profitability. Case 5, for instance, yields an ROI exceeding 490% even under a conservative 1.22% value uplift, a result of the substantial cost-effectiveness of integrating sustainability during the design phase. **Figure 2** generalizes this dynamic, illustrating the strong negative correlation between local apartment values and the relative cost of certification across eight Spanish geographical areas by building type. In prime markets like Madrid, where prices exceed €4,500/m², the €16/m² investment for a *new build* (from **Table 11**) is less than 0.5% of its value. In stark contrast, for a *small existing* building in a *low-value* region like Castilla La Mancha or Extremadura, where prices can be below €1,000/m², the €114/m² investment can surpass 11% of the asset's value. This sharp gradient confirms that green investment viability is determined by the interplay of *building size*, *location*, and *construction stage*.



Source: Compiled by authors

Figure 2: Relationship between buildings' apartment values and CapEx necessary for ecolabel certification. This figure illustrates the relationship between local apartment value (€/m²) and the relative financial burden of sustainability certification, calculated as the required capital expenditure (CapEx) as a percentage of property value. The analysis covers three distinct building categories, each with a fixed CapEx derived from our case studies: smaller existing buildings (€114/m²), sizable existing buildings (€65/m²), and new constructions (€16/m²). The regression lines and scatter plots show relative investment levels for each building type: dark green for small existing buildings, dark red for sizable existing buildings, and dark orange for new construction. Average apartment prices (€/m²) were sourced from idealista.com and reflect market values across eight regions from lower to higher priced: Castilla-La Mancha, Extremadura, Murcia, the national average (Spain), the Barcelona Province, the Madrid Province, the City of Barcelona, and the City of Madrid. The regression lines reveal three key findings: (i) smaller buildings face a significantly higher relative investment burden than larger ones across all market values;

(ii) for all building types, the relative cost of certification is much higher in non-prime, lower-value areas; and (iii) new construction offers a substantial cost advantage over retrofitting any type of existing building. Source: idealista.com and own elaboration.

5.3.2. Influence of Property Prices and Location on Certification Profitability

Local *property prices* are a primary factor driving this disparity, a relationship quantified directly in **Figure 2**. By holding building type constant, the figure isolates the role of market value and reveals a statistically significant negative correlation across all building categories: as apartment values decline, the relative investment burden of certification rises. The impact is substantial; for small existing buildings, the difference in relative cost between the cheapest and most expensive regions can approach 10% of the property's value. These conditions render certification economically unattractive in many interior regions, despite its technical feasibility.

Figure 3 displays the *spatial distribution of apartment prices* at two levels of aggregation. The left panel shows province-level averages, while the right panel offers a municipality-level view limited to areas with at least 25,000 residents. The figure reveals stark regional disparities: Madrid, Barcelona, and select coastal cities exhibit average prices above €3,000/m², while provinces such as Castilla-La Mancha, Extremadura, and parts of Galicia report prices below €1,200/m². These differentials, by a factor of 2.5 or more, have direct implications for certification economics. When certification costs are relatively fixed in absolute terms (approximately €53/m² in our sample), they represent a much larger fraction of asset value in lower-price markets. In high-value areas, CapEx-to-value ratios are generally below 1.5%, while in lower-value areas they often exceed 4–5%.

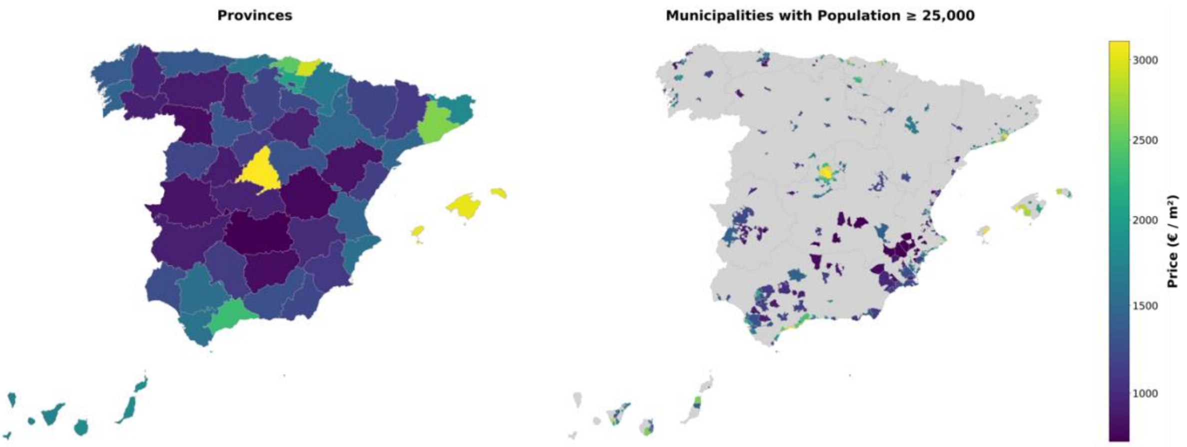


Figure 3: Spatial Distribution of Residential Property Prices in Spain: A Comparison of Province-Level and Municipality-Level Data. The left panel illustrates average apartment prices per square meter across Spanish provinces, highlighting regional disparities with higher prices concentrated in major urban and coastal areas. The right panel shows apartment prices in municipalities with populations greater than 25,000, offering a more granular view that emphasizes the variability within provinces, particularly in densely populated and economically dynamic cities. The color scale ranges from lower prices in dark purple to higher prices in bright yellow, reflecting the diverse economic landscape of Spain's real estate market. Source: Own elaboration based on data from the Spanish Ministry of Transport and Sustainable Mobility for the first quarter of 2024.

The adoption of residential sustainability certifications in Spain is highly concentrated geographically, driven by local housing market conditions. As illustrated in **Figure 4**, which maps the residential stock of LEED and BREEAM-certified buildings by municipality, most certified buildings are in the metropolitan areas of Madrid and Barcelona, with additional clusters in high-amenity coastal municipalities. In contrast, Spain's interior regions, while encompassing a large share of the national housing stock and geographic area, exhibit limited certification activity. This spatial imbalance suggests that location-specific economics, including property values, investor presence, and market liquidity, are key drivers of adoption.

These cost disparities gain further traction from asymmetric information and investor attention. **Figure 5** presents *Google Trends* data for the search terms "BREEAM" and "LEED" across Spain from 2016 to 2024. Interest is concentrated in Madrid, Catalonia (including Barcelona), and some other coastal areas—regions that also report high property values and certification rates. In contrast, search interest is significantly lower in lower-income regions such as Andalucia, Castilla-La Mancha, and Extremadura. This spatial alignment between investor attention, local demand, and certification prevalence suggests that liquidity, awareness, and buyer willingness-to-pay cluster where underlying market fundamentals are strongest.

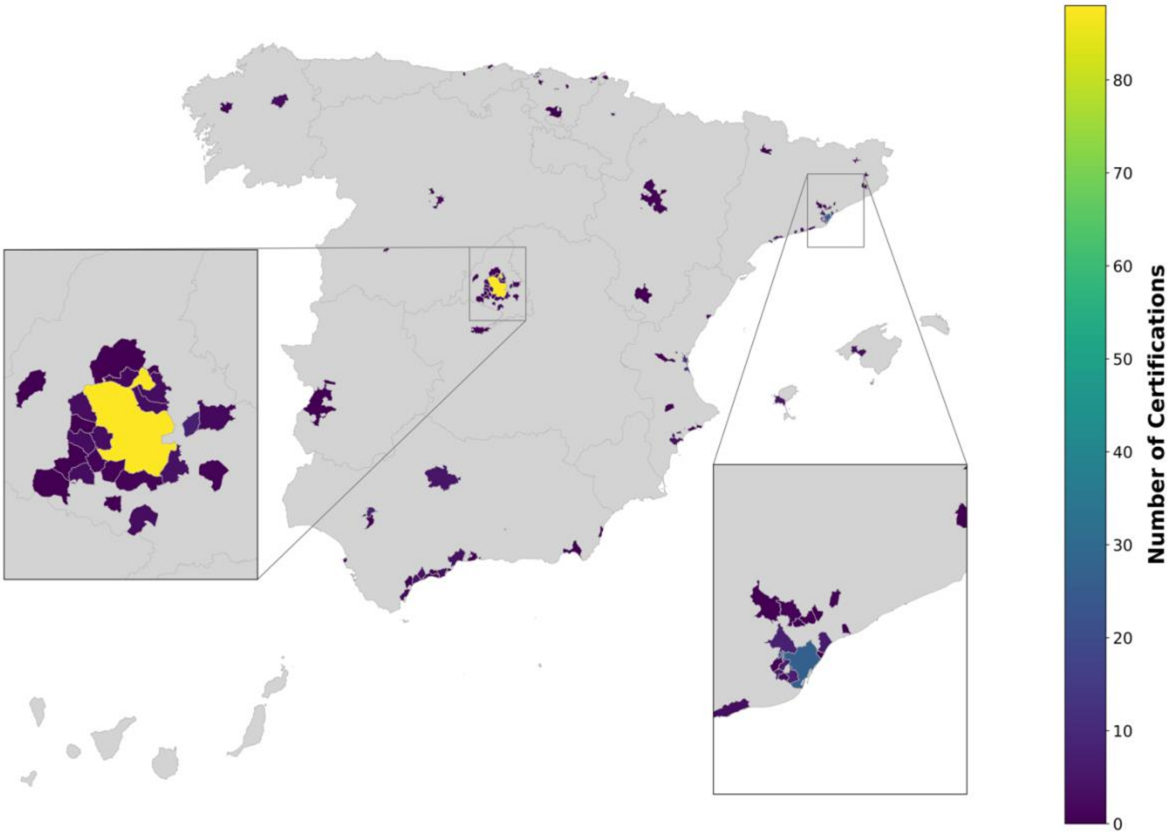


Figure 4: Distribution of LEED and BREEAM Certified Residential Buildings Across Spain. This map illustrates the spatial distribution of LEED and BREEAM-certified residential buildings by municipality within Spain. The color gradient represents the number of certifications, with a higher concentration of certifications indicated by brighter colors. Inset maps provide a detailed view of two regions with the highest concentration of certifications: Madrid and Barcelona. Source: Own elaboration based on data from www.usgbc.org and https://breeam.es.

Taken together, **Figures 2–5** collectively demonstrate that the profitability and uptake of certification do not occur randomly but follow patterns shaped by local market fundamentals. High-value, high-liquidity urban and coastal markets combine low relative certification costs with strong ESG-driven demand, which makes certification financially viable even in the absence of incentives. In contrast, low-income or stagnant housing markets face higher cost burdens relative to property value and attract less investor attention, which reduces the likelihood of voluntary adoption. As a result, secondary locations risk falling further behind on green retrofits.

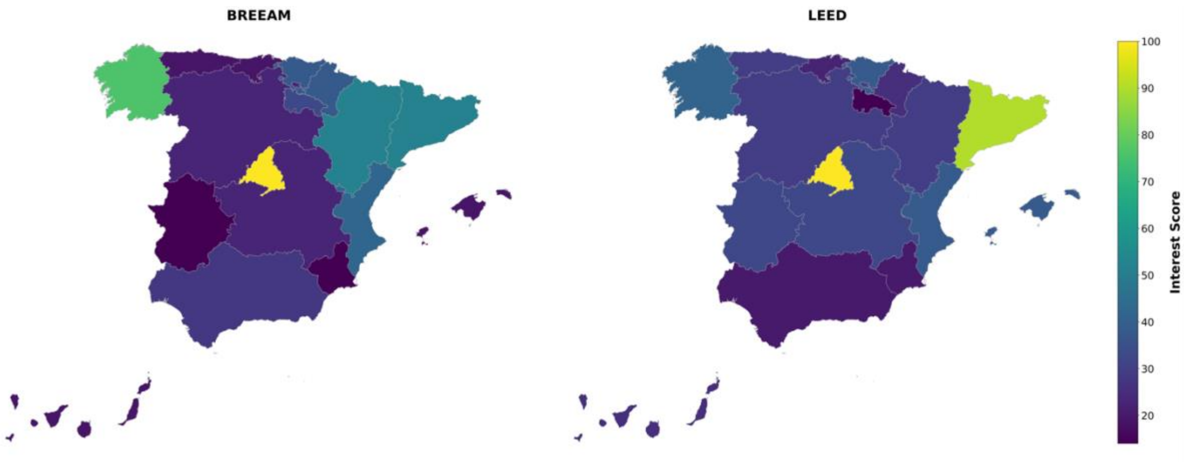


Figure 5: Geographic Distribution of Relative Interest in Green Building Certification in Spain. The maps illustrate the relative popularity of BREEAM and LEED building sustainability certifications across different regions in Spain, based on Google Trends data from June 7, 2016, to June 8, 2024. The color intensity represents the normalized search interest score for each certification, with darker shades indicating higher relative popularity within a given period. Note that these scores reflect relative search interest within each certification category and do not directly compare the overall popularity of different certifications. Source: Own elaboration.

5.4. Stakeholder Perceptions of Costs and Benefits

While the preceding sections establish that sustainability certifications can be financially viable across specific building types, sizes, and market segments, the decision to pursue certification ultimately hinges on stakeholder beliefs and perceptions. To investigate this dimension, we systematically analyzed qualitative interviews with real estate professionals and used a large language model to extract structured insights from their open-ended responses. This analysis allows us to assess whether stakeholders' views align with observed economic returns and to uncover adoption barriers not evident in certification-level data.

5.4.1. Topic Detection Analysis: Location as a Factor

The first analysis tests whether professionals spontaneously associate location quality with the likelihood of green certification adoption. Without directly prompting about location, we examine if interviewees brought up the idea that prime, high-value locations are more prone to have certified buildings (versus secondary or low-value locations). To assess whether stakeholders spontaneously associate location quality with certification likelihood, we used a topic detection protocol implemented via OpenAI's GPT-4o model. Each interviewee responded to three open-ended questions:

- **Question 1:** "*Based on your experience, do you think that the investment to obtain a label/certificate is offset by the financial benefits obtained from the green building in terms of sale value, rental value, time to market, vacancy, or tenant turnover rates, OpEx, Maintenance, supplies costs, cost of capital or yield, divestment, ease of financing (credits/mortgages) associated with the certification of the building and access cost and impact on the carbon footprint of the building?*"
- **Question 2:** "*Do you think that the search for certified buildings is a response to genuine environmental awareness on the part of companies (which request your services, in the case of consultants), or is it rather a question of complying with certain standards that improve the image of companies?*"

- **Question 3:** "*Do you think there is a natural awareness towards sustainability and green labels compared to the past, or is it due to current regulations?*"

Although none of these questions explicitly referred to location, they encouraged broad reflections on the drivers of certification. After obtaining the answers to the questions above, we fed each respondent's answers into the classification prompt presented in **Figure 6**, designed to detect whether the respondent spontaneously mentioned location quality as a determinant of certification.

```
API prompt call
Model: gpt-4o
{"role": "system", "content": "You are an expert in topic detection."},
{"role": "user", "content": "Analyze the following text in the context of the topic:
'Compared to subprime, secondary, non-prime, non-prime assets, non-liquid, low-value
locations or non-international, locations that are prime, prime assets, primary, liquid,
high-value or international locations are more likely to obtain a sustainability
certification (e.g., LEED or BREEAM.).' Identify if the text discusses this topic and provide
a unique score of 0 if it does not discuss it and 1 if it does discuss it and write it as the
last piece of information of your response: {text}"}
```

Figure 6: Topic Detection OpenAI API's prompt call. This figure displays the exact prompt used with OpenAI's GPT-4o to perform topic detection on stakeholder interviews. We instructed the model to classify whether a respondent spontaneously mentioned location quality, such as being in a prime or high-liquidity area, as influencing the decision to pursue green building certification. We based the analysis on open-ended responses to three interview questions that did not explicitly reference location. This prompt allowed us to classify responses consistently across participants and underpins the results reported in Figure 7. Source: Own elaboration using OpenAI's API (ChatGPT-4o) and qualitative interview data.

Figure 7 summarizes the results obtained. The topic detection analysis reveals that a substantial share of stakeholders link *location quality* to certification adoption. Out of 17 experts who answered at least one of the above questions (one interviewee provided no usable answer), the LLM classified nine interviewees as having mentioned that prime locations are more likely to have certified buildings. Importantly, interviewees were not prompted on this issue, meaning the association between location and certification was made independently by more than half of the respondents. This finding reinforces the argument that prime locations not only experience lower relative CapEx burdens for certification (as shown in **Figure 2**) but are also perceived as structurally more conducive to green investment.

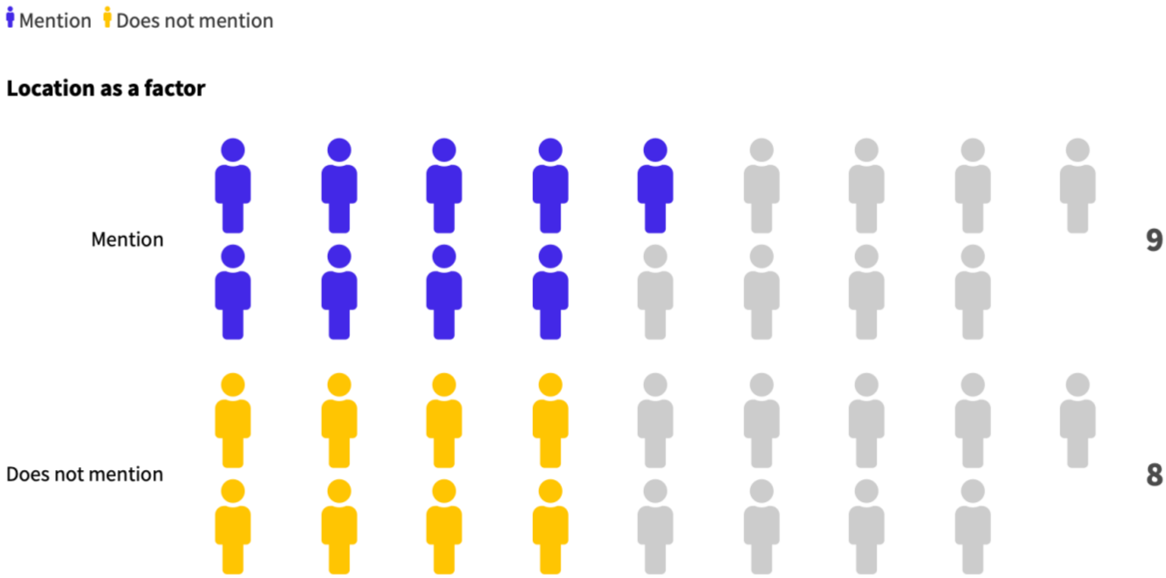


Figure 7: Location as a factor. The number of interviewees that the large language model classifies as having mentioned (blue) or not having mentioned (yellow) that a prime or liquid location increases the likelihood of buildings receiving sustainable certifications. Source: Own elaboration using OpenAI's ChatGPT-4o model and the answers to three questions in semi-structured interviews that refer to sustainable certifications. Source: Own elaboration.

5.4.2. Sentiment Analysis: Certification Subjective Financial Value

To quantify stakeholder views on the financial return of certification, we applied *sentiment analysis* to interview responses using OpenAI's GPT-4o model. We do this by estimating the sentiment valence and intensity each interviewee expressed regarding the profitability of obtaining a green certification and analyzing how this sentiment varies by stakeholder type and personal attributes. This approach allows us to test whether certain groups (e.g., investors vs. certifiers) are systematically more optimistic about the financial returns of sustainability certification.

Each interviewee's answer to Question 1 (on the economic benefits of certification) was scored by the LLM on a scale from 0 (very negative) to 100 (very positive), using the sentiment analysis prompt presented in **Figure 8**. In practice, the model read each respondent's answer to Question 1 and produced a *sentiment score* on a 0–100 scale, where 0 indicates a strongly negative view (i.e., costs far outweigh benefits) and 100 a strongly positive view (benefits far outweigh costs). These LLM-generated sentiment scores (one per interviewee) form the dependent variable for our regression analysis that follows.

```
Model: gpt-4o
{"role": "system", "content": "You are a sentiment analysis assistant."},
{"role": "user", "content": "Analyze the sentiment of the following text and return only a
score from 0 to 100, where 0 is very negative and 100 is very positive: {text}"}
```

Figure 8: Sentiment Analysis OpenAI API's prompt call. This figure illustrates the prompt used to conduct sentiment analysis of real estate professionals' qualitative assessments regarding the economic return of sustainable certification. The large language model (ChatGPT-4o) scored each interviewee's response to a central open-ended question on a scale from 0 (strongly negative) to 100 (strongly positive), capturing perceived net economic benefits of certification. These sentiment scores form the dependent variable in the regression presented in Table 15. Source: Own elaboration using OpenAI API (ChatGPT-4o) and qualitative interview data.

We then regressed the sentiment score, *$Sentiment_i$,* on a set of dummy variables representing the interviewee's stakeholder profile, along with other controls, using Ordinary Least Squares with robust standard errors. **Equation 6** illustrates the model. The independent variables included in the model are indicator variables referring to the professional group: *Financial $Consultant_i$*, *$Landlord_i$*, and Technical *$Consultant_i$*. The omitted base category is Certifier. These indicator variables take a value equal to one if interviewee *i* is in that professional group and zero if they are not. *$Manager_i$* is an indicator variable that takes the value one if interviewee *i* is a manager and zero if they are not. *ESG linked $bonus_i$* is an indicator variable that takes the value of one if interviewee *i* has a bonus related to ESG metrics and zero if they do not. Sector *$Experience_i$* is the number of years of experience of the interviewee in the sector. *$Multinational_i$* is an indicator variable that takes the value of one if interviewee *i* works for a multinational company and zero if they do not.

Equation 6

$$Sentiment_i = \alpha_0 + \beta_1 Financial\ Consultant_i + \beta_2 Landlord_i + \beta_3 Technical\ Consultant_i + \beta_4 Manager_i + \beta_5 ESG\ linked\ Bonus_i + \beta_6 Sector\ Experience_i + \beta_7 Multinational_i + \varepsilon_i$$

Results reported in **Table 15** point to marked heterogeneity in sentiment across professional groups, while individual-level covariates carry little explanatory power. The mean sentiment in the sample is 63 on a 0–100 scale, indicating a mildly favorable assessment of certification profitability. This average, however, masks large and statistically significant role-specific effects. Relative to the reference category of *Certifiers*, the estimated coefficients for *Financial $Consultants_i$* and *$Landlords_i$* are –28.8 ($p < 0.05$) and –26.5 ($p < 0.01$), respectively, statistically significantly lower than that of *Certifiers*. By contrast, the coefficient for *Technical $Consultants_i$* is much lower at –4.0 ($p > 0.10$) and not significantly different than zero. Hence, actors directly engaged in certification or technical implementation with vested financial incentives exhibit broadly similar views. In contrast, business-oriented stakeholders discount the financial payoff significantly compared to the former.

Table 15. Sentiment analysis regression results.

*This table presents the results of a sentiment analysis conducted on various roles within the real estate and financial sectors. The dependent variable $Sentiment_i$ is the sentiment score produced by OpenAI's GPT-4o large language model. The coefficients (Coef.) referring to the professional group, Financial $Consultant_i$, $Landlord_i$, and Technical $Consultant_i$ indicate the impact of each role on sentiment relative to the baseline category, $Certifier_i$. Financial Consultants and $Landlord_i$ show significant adverse effects on sentiment, as evidenced by their negative coefficients and p-values below the 5% significance level. The analysis demonstrates the varying perceptions and attitudes towards different roles within the sector. ***, **, and * for significance at the 1%, 5%, and 10% levels, respectively. The model explains approximately 62.9% of the variation in sentiment using robust standard errors to heteroscedasticity.*

$Sentiment_i$	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
: base $Certifier_i$	0	.	.	.	.	.	
Financial $Consultant_i$	-29.836	10.987	-2.72	.024	-54.69	-4.982	**
$Landlord_i$	-26.516	7.282	-3.64	.005	-42.989	-10.043	***
Technical $Consultant_i$	-4.014	9.993	-0.40	.697	-26.621	18.593	
$Manager_i$	-17.066	10.349	-1.65	.134	-40.478	6.345	

ESG bonus$_i$	5.564	9.629	0.58	.578	-16.219	27.346	
Sector Experience$_i$	-.588	.98	-0.60	.563	-2.805	1.629	
Multinational$_i$	4.143	8.075	0.51	.62	-14.123	22.408	
Constant	105.419	23.089	4.57	.001	53.189	157.649	***
Mean dependent variable		63.059	SD dependent var			15.482	
R-squared		0.629	Number of observations			17	

Standard errors are robust to heteroskedasticity. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

Source: Compiled by authors.

To visualize these patterns, **Figure 9** provides a heatmap of the average sentiment score broken down by stakeholder *type* and *gender*. This figure reinforces the regression findings: *Certifiers* and *Technical Consultants* exhibit the highest optimism, with average sentiment in the mid-to-high 70s (on the 0–100 scale), whereas *Consultants* and *Landlords*/*Investors* show much lower sentiment, around the mid-50s. Notably, these patterns hold regardless of gender–for example, male and female certifiers both express high positive sentiment (~78 points), while male and female investors are similarly muted (~55 points). Thus, the *key divide is along professional lines*: those focused on the financial performance of assets (investors and consultants) are less convinced of the private returns to certification, whereas those involved in delivering or technically implementing certifications (certifiers and technical consultants) are more optimistic about the benefits. This divergence may be related because the latter group has a “vested interest” or closer engagement with sustainability initiatives, and may more readily see their advantages, whereas the former group prioritizes hard financial metrics and may be unconvinced of the payoff. In summary, our sentiment analysis reveals a significant perceptual asymmetry between business-oriented and technical stakeholders regarding the return on green building investments.

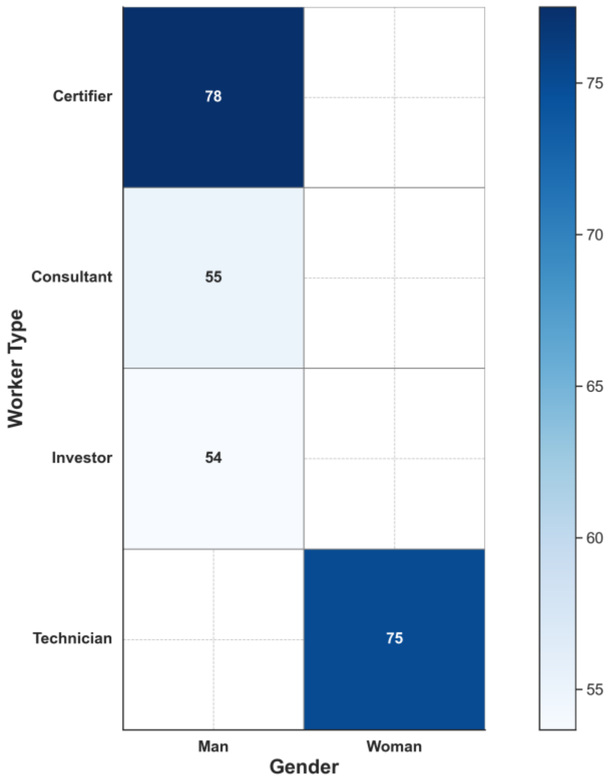


Figure 9: Heatmap of sentiment score by worker type and gender. This heatmap presents the average sentiment scores of different worker types across gender categories. We used OpenAI's GPT-4o model to conduct sentiment analysis and measure how each group perceives sustainability initiatives. Darker shades indicate higher average sentiment scores. The analysis distinguishes between 'Man' and 'Woman' and categorizes worker types as 'Certifier', 'Consultant', 'Investor', and 'Technician'. Source: Own elaboration.

5.4.3. Lexical Analysis: Divergence Across Professional Camps

Finally, we investigate how different stakeholders talk about costs and benefits by analyzing the language and framing used by business-oriented versus technical professionals. The goal is to see whether there is a qualitative difference in emphasis–for instance, do business stakeholders focus on financial terms while technical stakeholders emphasize environmental or social aspects? Such differences could reveal underlying biases in how each group perceives the benefits of certification (purely economic vs. broader impacts).

We split the interviewees into two broad categories based on their professional orientation: "Business" profiles (investors/landlords and real estate financial consultants), and "Technical" profiles (sustainability certifiers and technical consultants). This grouping is motivated by the sentiment results above, which showed similar attitudes within these pairs. We then performed a text analysis of the responses to *Question 1* for each group. Using Python's *wordcloud* library (an NLP tool), we generated two word clouds. One for all responses from the business-oriented group, and another for all responses from the technical group. In each word cloud, the size of a word corresponds to its frequency in the interview answers, after removing common stop words. By comparing the two word clouds (presented side by side in **Figure 10**), we can visually identify which concepts and terms are most salient to each group when discussing the perceived profitability of sustainable certifications.

The word clouds in **Figure 10** reveal a clear contrast in framing between business and technical stakeholders. On the business side (left panel of **Figure 10**), the most prominent words are those tied to real estate assets and financial performance. For example, business-oriented interviewees frequently used terms like “building”, “asset”, “market”, “investment”, “value”, and “impact”. This vocabulary suggests that landlords and financial consultants primarily focus on asset value, investment returns, market positioning, and property performance—emphasizing tangible financial outcomes tied to real estate.

In contrast, the technical group’s language (right panel of **Figure 10**) centers more on sustainability concepts and normative benefits beyond financial returns. Certifiers and technical consultants frequently mention words like “sustainability,” “health,” “environment,” “people,” “comfort,” and “energy,” emphasizing environmental performance and occupant wellbeing. They refer less often to terms like “asset” or “value,” which are more common in business discourse. This contrast suggests that technical stakeholders frame certification in broader, value-driven terms, while business stakeholders focus more narrowly on investment and asset performance. **Figure 10** captures this divide: the business word cloud highlights financial terminology, whereas the technical word cloud prioritizes sustainability and social impact.

Figure 10: Word clouds. The size of each word corresponds to the frequency with which the interviewees use the word in their answer to question number 1. Specifically, the question asks about the perceived financial profitability of sustainable certifications. On the left panel, we have the word cloud for interviewees with a business profile (investors and financial consultants); on the right panel, the word cloud refers to technical profiles (certifiers and technicians). Source: Own elaboration.

6. Discussion

Our findings indicate that residential sustainability certification involves modest capital outlays, averaging just 0.81% of property value in prime urban locations, yet yields substantial average returns exceeding 150%. Despite this favorable financial profile, the direct price effect in Spain’s early-stage residential market is muted, with BREEAM-certified units commanding a premium of only 1.22%, well below the 2.4%–8% range observed in more mature American and Asian markets (Heinzle et al., 2012; Kahn & Kok, 2014). This likely reflects limited consumer awareness and early-stage demand.

The viability of certification is highly conditional, varying significantly by building type, scale, and location. It is most profitable when integrated at the design stage of large, high-value developments, where economies of scale and high asset values compress relative costs. In these prime market projects, new constructions yield average returns exceeding 495%, compared to 123% for existing large buildings and just 70% for small properties. These disparities are magnified by location-specific cost-to-value ratios; in lower-value areas, capital expenditure can escalate to over 6-11% of property value, rendering market-driven adoption financially unfeasible. This underscores that market forces alone are unlikely to deliver widespread certification, a finding consistent with prior evidence on the spatially uneven uptake of sustainability standards (Yeganeh et al., 2024) and the need for policy interventions (Liao & Zhao, 2019).

Valuation data reveal that the green premium is critically dependent on investor perception. A sharp divergence exists between international, ESG-focused firms, which report value uplifts exceeding 3.1%, and national firms, which report a negligible 0.25%. This helps explain why certifications cluster in globalized urban cores, driven by the specific mandates of international capital. While prior work has emphasized environmental ideology (Kahn, 2007) and "conspicuous conservation" (Sexton & Sexton, 2014) in shaping demand, our findings point to an additional split driven by investor type and ESG screening norms.

This divergence extends to certification type. Unlike energy efficiency labels, whose documented positive effects are contested and often dissipate after controlling for spatial and design variables (Fregonara et al., 2017; Olaussen et al., 2017; Molina et al., 2020; Copiello & Donati, 2021; Marmolejo-Duarte & Chen, 2022), broad sustainability certifications appear to provide a more comprehensive and stable quality signal. Their multidimensional design reduces information asymmetries (Liao & Zhao, 2019), while third-party verification reinforces credibility (Jayantha & Man, 2013) and reputational spillovers may enhance long-run market recognition (Suh et al., 2019).

Qualitative evidence uncovers additional asymmetries that inhibit market uptake. A significant perception gap exists between sell-side actors, such as certifiers and consultants, who express strong confidence in profitability, and buy-side stakeholders, like landlords and investors, who remain more skeptical. This reflects divergent incentive structures and a misalignment in how financial and non-financial benefits, such as occupant health, are valued (Ahn et al., 2013; Jayantha & Man, 2013; Jiang et al., 2021). While these ancillary benefits are well-documented (Kahn & Kok, 2014), their under-recognition in financial decision-making can deter investment even where returns are demonstrably positive.

Overall, our results highlight the promise and limitations of a market-led approach. While certification can generate substantial private returns, these accrue disproportionately to buildings already advantaged by scale, location, and access to institutional capital. In secondary markets, costs often exceed 6–7% of property value, a prohibitive level also observed elsewhere (Martínez et al., 2019). Absent policy intervention (e.g., Zhang et al., 2024), these disparities risk reinforcing spatial inequality and fueling “green gentrification” (Yeganeh et al., 2024). A purely market-driven strategy is therefore unlikely to yield socially optimal outcomes or a broad-based transition to urban sustainability.

7. Conclusions and Policy Implications

This study provides the first comprehensive economic analysis of sustainability certifications in the European residential sector. Drawing on professionally audited financial data, certified appraisals, and stakeholder interviews from Madrid and Barcelona, we quantify the capital expenditures, estimate the returns, and assess the drivers of adoption. The results indicate that certification is economically viable in high-value, multifamily buildings, particularly for new developments in prime urban locations. The average investment required—approximately €53 per square meter, amounting to just 0.79% of property value and 21.5% of one year’s gross rental income—yields ROI estimates exceeding 150% under conservative assumptions. These figures suggest that in premium urban housing markets, sustainability upgrades offer attractive private returns, even before accounting for broader environmental and regulatory benefits.

However, this viability is highly conditional. Financial returns vary systematically by asset type, building scale, and location, with adoption spatially concentrated in high-value, high-liquidity markets where elevated property values compress the relative costs. In stark contrast, required capital expenditure in lower-value markets can exceed 6% of property value, presenting a significant financial barrier that dampens voluntary uptake. This dynamic risks entrenching a two-tiered system where environmental and health benefits accrue primarily to affluent urban cores, while peripheral and lower-income areas remain locked into aging, inefficient building stock. Without intervention, sustainability certification may reinforce existing spatial inequalities, making targeted policy instruments essential to broaden access and align private incentives with public goals.

To foster a broader and more effective adoption, policymakers should eschew uniform subsidies in favor of a nuanced set of interventions. Our evidence highlights the need for differentiated financial mechanisms, such as tiered grant programs or tax credits scaled to property value, building vintage, and renovation depth. To ensure accountability, disbursements must be conditioned on performance-based metrics, including verifiable certification outcomes and measured operational improvements. To further de-risk private investment where collateral values are weaker, these incentives should be complemented by public-private financing instruments. Mechanisms such as first-loss guarantees, interest-rate buy-downs, on-bill repayment, and property-assessed financing can effectively lower the cost of capital for cash-constrained owners.

Beyond direct financial support, substantial efficiency gains can be achieved by systematically reducing transaction costs and addressing critical information asymmetries. This includes the establishment of municipal one-stop technical assistance centers, the provision of pre-approved retrofit packages, and the launch of public information campaigns. To correct the perceptual asymmetries between sell-side and buy-side stakeholders, a concerted effort is needed to enhance market transparency. Public agencies, in collaboration with professional appraisal bodies, should spearhead standardized valuation methodologies to ensure the financial benefits of certification are consistently capitalized. Furthermore, mandating the disclosure of certification status in property listings and incentivizing "design-for-certification" in new construction would significantly reduce informational frictions.

Finally, to counteract the tendency for voluntary adoption to reinforce existing patterns of economic advantage and to mitigate adverse distributional outcomes, these policy instruments must be integrated with careful planning and governance. The provision of financial incentives can be conditioned on affordability covenants or rent stabilization commitments in at-risk neighborhoods, while proactive geographic targeting of funds toward census tracts with older housing stock can counter spatial inequities. Policymakers can also create more durable drivers of adoption by linking sustainability standards to municipal planning frameworks using tools such as density bonuses, inclusionary zoning credits, or reduced parking requirements. To ensure long-term effectiveness, all public interventions must embed rigorous monitoring, evaluation, and mandatory open reporting to build the evidence base and enable adaptive policy calibration over time.

8. Limitations and Future Research

While this study provides a detailed, audit-based assessment of sustainability certification, several limitations constrain the generalizability of its findings and highlight important avenues for future research. The empirical analysis is geographically concentrated, drawing on a small sample of buildings in the high-value, liquid markets of Madrid and Barcelona. This context may not be representative of secondary cities or other national housing markets where economic conditions and regulatory frameworks differ, thus limiting the external validity of the cost and return estimates. The case-study selection itself, focused on successful projects with rich data access, also risks selection bias, as less successful or abandoned certification efforts remain unobserved.

A second set of constraints arises from the valuation data. The reliance on professional appraisals rather than observed transaction prices introduces potential subjectivity and perception bias, as evidenced by the significant divergence between valuations from global and domestic firms. While this reveals important market heterogeneity, it underscores the need for complementary analyses. Future research should prioritize large-scale, multi-market studies that employ quasi-experimental designs on transactional data to identify the causal effects of certification on property values and liquidity with greater statistical precision.

Furthermore, the analysis is static, capturing ex-ante financial projections at the point of certification rather than realized, long-term performance. It does not track actual operational savings, tenant turnover, or asset value resilience across economic cycles. Longitudinal studies that follow certified properties over time are needed to validate whether the anticipated benefits materialize and persist, providing a more complete picture of the lifecycle returns on investment in sustainability.

Finally, this study's focus on a single certification scheme, BREEAM, precludes a comparative analysis of competing standards. Subsequent research should conduct head-to-head comparisons of various certification schemes to determine if multidimensional standards command different premiums than those focused solely on energy. A critical extension would be to investigate the distributional consequences of certification, including the risk of "green gentrification," and to rigorously evaluate the effectiveness of the targeted policy interventions designed to promote a broader and more equitable adoption of sustainable building practices.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used OpenAI's chat GPT-4o in order to improve the readability and language of the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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