Sustainable Cities: Residential Certifications and Urban Transformation

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ABSTRACT

This paper evaluates the economic impacts of sustainability certifications for urban buildings, assesses the sentiment of real estate professionals towards the return of these certifications, and identifies the drivers of sustainable certification adoption. Using the case study method, natural language processing of semi-structured interviews to real estate professionals, and valuations by professional appraisers, we show that sustainability certifications enhance the value and profitability of buildings, though with notable variation across different segments. Specifically, profitability is higher in larger buildings compared to smaller ones, in new buildings versus old ones, and in prime areas versus non-prime ones. Real estate professionals' interviews indicate heterogeneity in the views of the financial return of sustainability certifications. Specifically, sell-side stakeholders display a more positive attitude toward its economic return, which professional appraisers corroborate, while the buy-side is less enthusiastic. This study provides insights for policymakers and urban planners on whether further intervention is needed to promote sustainable urban development and concludes with relevant policy recommendations.

Keywords: Green residential buildings, sustainable cities, sustainability certifications, co2, climate change, urban, public-private collaboration, real estate investment.

1. INTRODUCTION

The built environment is one of the main contributors to global emissions, consuming 34% of energy and responsible for around 37% of global CO2 emissions in 2021. It is also a significant consumer of non-renewable resources, among the most essential elements of the Paris Agreement. CO_2 emissions from buildings and construction reached new highs in 2021, leaving the sector well short of the aim of decarbonizing for 2050 (UNEP, 2022). Given the massive growth in the global built environment, it is vital to implement decarbonization strategies for both new and existing buildings. Between 2015 and 2021, new construction represented the equivalent of the built surface of Germany, France, Italy, and the Netherlands together (UNEP, 2022); therefore, improving buildings' decarbonization is a crucial lever to affect sustainable development.

Sustainability certifications are indispensable for assessing the environmental performance of buildings and, by extension, urban sustainability (Chin et al., 2021). Given the built environment's profound impact on cities, society, governance, and nature, cities must adopt sustainability strategies aligned with the UN's 2030 Agenda (European Climate Foundation, 2022), spurring a proliferation of certifications for buildings and infrastructure. Yet, research has primarily focused on energy efficiency—a critical but narrow aspect. Energy efficiency certifications, such as ENERGY STAR, focus solely on quantifying and reducing energy consumption, costs, and environmental impacts. In contrast, sustainable certifications like LEED and BREEAM employ a holistic approach by evaluating resource management, water use, waste reduction, and sustainable material practices while incorporating social and economic dimensions. This disparity underscores a critical research gap that calls for examining sustainable certifications beyond the limited scope of energy efficiency.

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Sustainable urban development hinges on the integration of eco-friendly buildings and infrastructure. Still, many cities contend with aging building stocks, outdated efficiency and health standards, and lack of amenities, making sustainability certifications vital for effective urban planning. Despite their significance, research on the cost-benefit analysis of these certifications is scarce. This study addresses this gap by proposing a method for evaluating sustainability certifications' economic impacts and driving factors and assessing stakeholders' sentiment towards sustainable certifications.

This article applies the case study approach, sentiment analysis of semi-structured interviews, and valuations of professional appraisers to analyze the need for investment, the green premium (increase in buildings' prices derived from sustainable certifications), the profitability, and the real estate professionals' perceptions of eco-labels for residential buildings in Spain. Using six case studies in the two major cities of Spain (Barcelona and Madrid), we propose a method to measure the capital expenditure (CapEx) required to obtain these certifications, the impact on buildings' value, and their profitability. Our natural language processing (NLP) analysis of the eighteen semi-structured interviews with Spanish Real Estate Professionals obtained using openAI's ChatGPT-4o large language (LLM) model offers insights into stakeholders' perceptions of the returns of sustainable certifications in the different building segments. Moreover, nine official appraisers were interviewed to collect and identify their value impact estimate on residential buildings and apartments with green certifications.

We find that the adoption of Sustainable Residential Certification (SRC) is primarily driven by supply-side factors—specifically, the low capital expenditure (CapEx) required relative to market value in prime locations, new constructions, and larger buildings. Data indicates that buildings in prime real estate areas, which generate higher annual income and command greater market values, are more likely to secure the necessary investment for SRC, a finding corroborated by spatial analyses, expert interviews, and Google Trends data. Moreover, new constructions and larger buildings exhibit significant cost advantages, with CapEx per square meter markedly lower than in older or smaller properties. Financially, while average value gains are modest (1.22% for buildings and 0.42% for apartments), substantial heterogeneity exists: international appraisers project increases of 3.17% for buildings and 1.25% for flats, translating into a return on certification of approximately 397% relative to CapEx. Finally, the overall cost of obtaining an SRC is relatively low—representing 21.5% of a building's gross annual income and 0.81% of its value—underscoring that both the economic returns and cost structures of SRCs favor their adoption in high-value, low-cost contexts. We hope this information will allow market players, citizens, and urban planners to make more informed decisions, increase certification adoption, increase market transparency, improve their decision-making, and design better-informed policies.

Due to various factors such as the differences in ownership models, residential-use buildings not only suffer the lowest levels of implementation of sustainability strategies but also the ones that have received the least attention from researchers. For instance, in Europe, less than 3% of the current built environment has an energy performance rating of "A". More than 75% of the stock is energy-inefficient, with ratings of "D" or "E," and around 74% of the buildings for residential use were built before 1970 (Dell'Anna et al., 2019) and thus require renovation to meet the UN's objectives (BPIE, 2023). There is a lack of studies focusing on sustainable certifications. And, the current renovation rate in Europe is below 1% – an insufficient figure – and in Spain it is below 0.1%, the lowest anywhere in Europe. For owners, asset managers, developers, or occupiers of existing or new residential buildings, the decision of whether to obtain a sustainability certification is complex due to its impact on the management of the property and the CapEx required. Reports in the literature suggest that ecolabels positively affect the environment by reducing operating costs, improving occupants' well-being, improving liquidity, complying with the taxonomy, and reducing the property's depreciation – but also by improving cash flow and reducing the financing costs (Leskinen et al., 2020). Given their significant correlation with a property's value, we will now look at these two effects in more detail.

All the buildings we selected for analysis possess or will obtain the Building Research Establishment Environmental Assessment Method (BREEAM) certification developed in the United Kingdom. It is one of the two most prevalent ecolabels worldwide, jointly with its main United States competitor, the Leadership in Energy and Environmental Design (LEED). These certifications evaluate the sustainability of the built environment. More specifically, they assess compliance and performance with environmental goals, resulting in buildings that improve environmental, health, and productivity performance during their life cycle. They are designed to encourage sustainable practices and ensure that buildings meet high environmental performance standards. BREEAM is divided into sections that cover different aspects such as management (MNG), health and well-being (HWB, i.e., indoor air quality, thermal control, and acoustic efficiency), energy efficiency (ENE), the use of sustainable materials (MAT), waste management (WM) or pollution reduction (POL) and the promotion of innovation. Each section has specific requirements that must be met to obtain a given score.

In contrast, other eco-labels such as Green Star (Australia), CASBEE (Japan), DGNB (Germany), and HQE (France) are region-specific systems that emphasize local environmental conditions, regulatory frameworks, and cultural priorities. DGNB stands out for its lifecycle assessment approach, while CASBEE uses a unique Building Environmental Efficiency (BEE) score. Each system reflects its geographical origin's sustainability priorities, with varying methodologies and scopes tailored to their respective regions. The choice of certification system often depends on the project's location, goals, and specific sustainability priorities.

The current article has considered the BREEAM certification to structure and classify the capital expenses of the different case studies. We chose this certification in Spain, as it is one of the two more universally adopted ecolabels in most countries. BREEAM and LEED certifications are not new in Spain; they have existed for almost two decades. However, using these certifications in residential buildings is a recent phenomenon, which is why they are the focus of this paper.

2. LITERATURE REVIEW

Research on the impact of SRC on the value of residential buildings is scarce, especially in southern Europe (Dell'Anna et al., 2019, Huang, 2023). The few existing studies highlight the willingness of building occupiers to assume the green premium (Bernades, 2021; Shibani et al., 2021) (the increase in price due to enhanced ecological characteristics of properties). These studies also indicate that this disposition is more significant in the commercial than in the residential sector (Wiencke, 2022).

Mestrige Jayantha and Sze Man (2013) concluded that green issues have a significant and positive relationship with residential property prices, with a premium ranging from 3.4% to 6.4%. In Barcelona, the energy efficiency certificate impacts the housing price by 1.9% for each rating level from G to A (Marmolejo and Chen, 2022). In Turin, a hedonic price model estimated a price increase of 6.3% for buildings that obtained an energy efficiency certificate (Dell'Anna et al., 2019); Jiang et al. (2021) report an impact on value corresponds to 6%; according to Molina et al. (2020), improvements in energy efficiency raise the value of a property by 2.4% to 7.4%, while indirect benefits and lower exposure to stricter standards account for a further increase of 3%. Kahn and Kok (2014) suggest an impact of 2.4% on the value of a certified building; in the compact Italian city of Bolzano, Bisello et al. (2020) concluded that there was a price premium of more than 6% between the lowest level of energy efficiency and the highest. Copiello and Donati (2023) found that the greener the property, the more significant the relative impact on the value, and the increase was asymmetrical. Dubé and AbdelHalim (2023) identify that residential reconversions lead to a mean price premium of about 2.5%. Yeganeh et al. (2024) identify a positive correlation between sustainable certifications and city gentrification. Generally, the value increase resulting from sustainability certification in residential properties is 3 to 7%, as shown in Table 3, with Hedonic regression analysis used as a preference method. It should be noted that the environmental impact of voluntary environmental certifications could be less than expected (Van der Heijden, 2015).

Table 3. Impact of Sustainability Labels on Residential Property Value for End-users.

This table compiles the findings of various studies that assess the impact of sustainability labels on the value of residential properties for end-users across different locations. The methodologies predominantly involve the hedonic price model, a commonly used approach in real estate economics to estimate the effect of various attributes on property prices. The results indicate a positive impact on property value, with variations depending on the geographical location and study methodology. The percentage range reflects the added value attributed to properties with sustainability certifications.

Study	Year	Methodology	Location	Propertys' Value Impact
Mestrige Jayantha and Sze Man	2013	Hedonic price model	Hong kong	[3.4% – 6.4%]
Marmolejo and Chen	2022	Hedonic price model	Barcelona (Spain)	[6.9% – 8.9 %]
Dell'Anna et al.	2019	Hedonic price model	Barcelona (Spain) and Turin (Italy)	6.3%
Jiang et al.	2021	Hedonic price model	China	6%
Molina et al.	2020	Literature research	Global	[2.4% – 7%]
Kahn and Kok	2014	Hedonic price model	California (EEUU)	2.4%
Dubé and AbdelHalim	2023	Hedonic price model	Québec (Canada)	2.5%

Yeganeh et al.	2024	Hedonic price model	Richmond (EEUU)	[3% – 7%]

Source: Compiled by authors.

The investment necessary to obtain sustainability certifications in residential buildings has been largely overlooked, even though certain studies have underlined its profound importance in meeting decarbonization objectives (He et al., 2019, Bertoldi et al., 2021). This is why we consider it worthwhile to produce this analysis, while at a practical level, it can provide helpful guidance for decision-making regarding sustainable investment.

3. THE ECONOMIC IMPACT OF RESIDENTIAL SUSTAINABILITY CERTIFICATIONS

We distinguish two sources for the potential impact on a building's value related to acquiring sustainability certification. The first relates to changes in *operating expenses* (OpEx) or the ability to generate *income* for the building. We name this the *fundamental value source* of ecolabels. The second one is related to valuation changes due to investors' reduced risk perception about the building's profile or increased appetite for the building due to green-label interest by specialized funds with environmental, social, and corporate governance (ESG) goals and green investment goals. We name this as the *capital market's value source*.

Our value sources distinction is in line with current research on the topic. The impact of certifications on future *income* (that is, *cash flows*) can be the result of higher rental or sale price but also due to other factors as well such as higher occupancy, lower OpEx, lower rates of defaulting on payments, lower depreciation (and thus less need for maintenance), easier conditions for borrowing, a lower risk of opposition from residents' associations, easier compliance with the taxonomy, lower future CapEx needs and wider investor interest (Brounen and Kok, 2011; Mudgal et al., 2013; Hyland et al., 2013; World Economic Forum, 2016; Marmolejo-Duarte et al. 2019; Leskinen et al., 2020; Bernades, 2021; Shibani et al., 2021, Espinoza-Zambrano et al., 2024). All of this confirms the idea that "location" is not the only important factor when defining the potential cash flow of an asset; broader factors, such as services, sustainability, investor goals or sentiment, and technology, all play their part (Enright, 2009; Braesemann et al., 2022).

3.1. The fundamental value

To learn the fundamental value of a building, we must use a valuation method. In this study, we will apply the *equivalent yield model* (Brown and Matysiak, 2000), one of the most common property valuation methods with the minimal necessary complexity, to illustrate the channels through which eco-labels can affect buildings' value. It is a framework based on standard asset pricing theory, in which a building's fundamental value corresponds to the sum of its future income, assuming perpetuity discounted by the capital opportunity cost. According to the constant growth version of this model, a building value is calculated as:

Equation 1

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

Where *Net Income in perpetuity* (NI) is calculated by subtracting all operating expenses *(OpEx)* incurred on a property from all revenue-generated or *gross income* (all incomes generated by the property minus necessary operating expenses), *r* is the *required rate of return* for the building, and *g* is the expected constant NI growth received in perpetuity. The building's *required rate of return* (*r*) can be calculated as follows:

Equation 2

$$r = r_f + i + r_p$$

Where r_f is the real risk-free rate, i is the compensation for expected inflation, and r_p is the risk premium (compensation for additional risk). Based on the *fundamental value view*, the impact on a building's price generated by an ecol-label certification must result from a *post-certification net income variation*. We identify two variation channels: (i) an increase in *net income* due to a higher *annual gross income* derived, for example, from a better market fit, or (ii) an increase in NI due to a reduction in *OpEx* thanks to the building's post-certification cost savings, for instance, because of the building's better engineering, technology, and sustainable-focused construction. Equation 3 shows how variations in *post-certification net income* led to variations in the building's value.

Equation 3

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

Table 1 illustrates how a *net income* increases proportionately to the building's value. Any percentage increase in revenue, maintaining all other variables fixed, such as *yield* (the income return on investment defined as in Equation 1), increases the value in the same proportion illustrated in Equation 3.

Table 1. 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. The proportional relationship between the percentage increase in income and the corresponding increase in property value is illustrated. For instance, a 1.25% increase in income due to sustainability efforts translates into an equivalent 1.25% increase in the property's value, showcasing the potential financial benefits of such certifications.

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

Source: Compiled by authors

3.2. The capital markets value

Capital markets broadly define the level of capital risk-free rates and risk-premiums and thus influence the real estate market through value, liquidity, and financing (Sierack and Hiang Liow, 2008; International Monetary Fund, 2022). Sustainability certifications have been documented to negatively impact rates relative to non–certified buildings by 40 to 80 basis points due to asset risk reduction given their lower delinquency rates, higher occupancy, reduced *CapEx* requirements, taxonomy alignment, higher tenant profile, higher energy efficiency, lower debt costs, and other aspects (Bernades, 2021). Partly for this reason, 60% of real estate investors have already adopted ESG criteria in their investment strategies (Barkham et al., 2021). Equation 4 illustrates how a change in the required rate of return can result from either a change in the risk-free rate, inflation, or the risk premium.

Equation 4

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

In this study, we calculate the property value increase by multiplying the *rate of return variation* (*end capital rate* minus *initial capital rate*) by the total *property value,* as in Equation 5:

Equation 5

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

As a result, eco-label certification can affect a building's value due to capital markets through two channels: (i) changing investors' risk perception. For instance, if eco-label certifications allow for better tenants or lower delinquency rates, these buildings will become less risky in investors' models. Or (ii) with increased *post-certification liquidity* due to the more extensive pool of applicants focusing on ecol-label certified buildings, such as investment funds required to invest in assets that comply with strict ESG policies. Lower legislation and obsolescence risks are also supporting downward pressure on capital rates. As more investors use ESG criteria as a screening tool, demand and, therefore, liquidity of buildings with green ratings will likely increase (Hsieh et al., 2020; Ormond, 2021). Acquiring buildings with eco-labels is an increasingly important requirement for investors due to reducing the environmental impact, enhancing health and well-being, improving market differentiation, and aligning with regulatory compliance (Chin et al., 2021). These changes in market appetite for eco-labeled buildings can significantly affect liquidity and thus reduce buildings' risk premium.

Table 2 illustrates the impact of a capital rate reduction due to a risk-premium ($\Delta\, r_p$) variation on a property's value for different levels of initial yield. It shows how even a tiny change in capital rate can significantly change a building's value. For instance, a slight 45 basis point reduction in the capital rate can increase the value by 9.9%, a strong impact that could justify eco-label-related *CapEx*.

Table 2. Impact of Discount Rate Variation on Property Value.

This table demonstrates the sensitivity of property values to changes in the discount rate, specifically the impact of a variation in the capital rate due ($\Delta\, r$) 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, reducing just 45 basis points (from 5% to 4.55%) results in a 9.9% increase in property value, underscoring the potential financial justification for investments in eco-label-related capital expenditures (CapEx).

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 AND DATA

We apply a dual methodological approach. First, we use the multiple case study method. This research strategy involves analyzing several cases to understand a phenomenon or problem, identifying common patterns, and examining their variations. The approach provides a broad and enriching perspective for the analysis and generation of conclusions based on inductive reasoning in the management of multiple sources of data (Ministry of Education and Science, 1987, Yin, 1994). It has been used in many investigations of complex phenomena to identify their most representative and holistic characteristics (Llewellyn, 1948).

The six case studies are particularly relevant for this topic as there was no previous study with exhaustive officially audited data, and this data is generally confidential. Mainly, all data came from asset managers who had all the information available to manage the properties. The primary data sources were asset managers, building data, audited financial information, quantity surveyors, sustainable certifiers, and market data (Table 4). Some of the available data corresponds to historical retrofit capital expenditure based on accounting audited information (from 2019 to 2023) and forecasted (from 2024 to 2030); building audited cash flows (the last audited year available was 2022); gross incomes, OpEx information or property taxes was also available from 2019 to 2022; official building valuations done in 2022 by a legally authorized appraiser; monthly rental data per customer was all provided by asset managers who answered all questions and doubts regarding the given data and helped to understand all the insights; site visits to the buildings that helped to understand the works done; historical building vacancy rates were also provided by asset managers; or all data and insights regarding green label certificates were available through asset and sustainable certifiers; among other. All buildings analyzed were BREEAM certified. A complete matrix of data was available that could also be divided by years to determine the evolution of the works.

Table 4. Data Sources.

This table provides a detailed summary of the data used in the analysis, specifying the data type, purpose, sources, and descriptions. It includes information on property incomes, expenses, CAPEX, property information, sustainable certifications, property valuations, Spanish property data by municipality, and global cities property data. The table outlines the origin of the data, whether it was received from asset managers, public sources, or other entities, and provides the year or range of years covered by the data. This comprehensive data collection underpins the analysis of case studies, allowing for a thorough comparison with market standards and a detailed understanding of the sustainability investments made.

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 incomes, enable to obtain net income; and the CAPEX allocated on case studies in order to enhance their sustainability and enabling to obtain a sustainable certification	Property audited accounting data	Asset Managers	2019 - 2022	All property incomes organized by concepts and years. The net rent or rechargeable expenses are detailed. All property expenses that have been incurred during the studied period are available. CAPEX classified by Hard costs, which refer to tangible and direct costs, and soft costs, which refer to indirect, non-tangible costs.

Property information	Information to understand the analyzed case studies and to compare with the capex required.	Cadastral and registral information, direct site visit by authors, architectural projects.	Asset Managers, Public Informatio n and Site Visits	2024	Basic information of the property such as surface, number of residential units by building, bedrooms, the energy peformance certificate among others.
Sustainable Certifications	Identify the level of case studies sustainability based on a global benchmark	Breeam Acredited Certifier and Breeam Organization Data	Asset Managers	Certification Date	Breeam certification report, all documentation required by the certified to analyse the accomplishment of sustinable standards required.
Case Study Property Valuations	Comparative data to assess the capex required to invest on sustainability compared to the property valuation.	Official Property Appraisals Acredited by the Bank of Spain	Asset Managers	2022	Official appraisal comprehensive report per each case study including property data, market analysis, valuation methodology, valuation appraisal.
Spanish Property Data by Municipality	Understand market prices.	Institut 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 comparision to the market
Global Cities Property Data	Knowledge of property buildings characteristics in other cities to identify the representativeness of the case studies analized	Global property guide, Statista and other country 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 comparision to the market

Source: Compiled by authors

We conducted nine teleconference interviews in late July 2024 with seasoned real estate appraisers based in Barcelona and Madrid to analyze the potential value increase of residential sustainable certifications on buildings' value. These professionals were tasked with estimating the anticipated price increase of buildings in percentage points attributable to acquiring a sustainable certification such as BREEAM. The appraisers, who averaged over 20 years of experience in the sector, were affiliated with companies with global and local influence. Predominantly holding managerial positions, these appraisers were highly educated, holding both business administration and architecture university degrees, with a gender distribution of 44% female. More characteristics of appraisers' profiles will be presented in Section 5.2.

To understand the role of location factor as a driver of the effect of ecolabels on buildings' value, we gathered geographical search interest in different sustainability certifications using Google Trends. Google Trends is a platform developed by Google that allows users to analyze the popularity of top search queries in Google Search across various regions and languages. This article uses Google Trends to visualize the spatial distribution of interest in different building certifications across Spain's regions and main cities. This involved inputting specific search terms related to each certification, such as "BREEAM", "LEED", or "Green Star" and selecting the geographic region of Spain with a timeframe of June 7, 2016, to June 8, 2024. Google Trends provides this data as downloadable CSV files, which we then processed using Python's data manipulation libraries, namely Pandas and GeoPandas. We combined these libraries with Matplotlib to generate choropleth maps. These maps visually represented the relative popularity of each certification across the different regions of Spain, with a color gradient corresponding to the Google Trends score (0-100), indicating the search interest level.

We used a qualitative research method to assess the perceived impact vectors of green certifications on buildings. We analyzed eighteen semi-structured interviews with real estate professionals using NLP analysis. The interviews were carried out between November 2023 and January 2024. Participants received an email with a short description of the research objectives to allow them to prepare for the interview. Nine interviews were face-to-face, and seven were via teleconference, with an average duration of forty-five minutes. In fifteen cases, the session audio was recorded, except in one interview, upon the interviewee's request, in which notes were taken of their opinions. The base questionnaire comprised ten questions. We analyzed answers to the first item of the interview, as the rest of the questions were not closely related to the topic of interest. Interviewees were informed that no explicit references to the information provided would be included in the analysis. Experts were aggregated according to their professional profile and classified as Certifiers, Real Estate and Financial Consultants, Landlords, and Technical Consultants. More information on interviewed real estate professionals is displayed in Table 5.

Table 5. The Panel of Experts Interviewed.

This table provides a breakdown of industry experience, leadership demographics, gender representation, and affiliation institutional characteristics across the different positions within our sample of interviewed experts: Technical Consultants, Real Estate & Financial Consultants, Landlords, and Certifiers.

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.

A research assistant transcribed audio recordings and notes into structured text. Then, using openAI's API, we requested the LLM ChatGPT-4o to obtain topic detection and sentiment measures to probe the perceived value of sustainability certifications by relevant stakeholders. To safeguard the anonymity of expert opinions, the content analysis is structured based on the Background Code assigned to each segment. This methodology ensures the confidentiality of participants. Concurrently, a document draft was distributed to all experts for validation and informed consent.

5. CASE STUDIES BUILDING CHARACTERISTICS AND REPRESENTATIVENESS

The case studies correspond to apartment buildings managed by professional asset managers leased to end-users. The buildings represent the residential stock of other European and global cities (Table 6 and Table 7). In Europe, 47.5% of people lived in apartments, which is even higher in countries with a significant proportion of compact cities, such as Spain (66%) or Germany (63%), according to Eurostat (2023). Specifically, in cities, 72 % of the EU population lived in a flat and 28 % in a house. Regarding the housing size, the average number of rooms per person is 1.6 in the EU and 1.9 in Spain. Among the Member States, the most significant number was recorded in Malta (2.2 rooms per person), followed by Belgium and Ireland (2.1 rooms). At the other end of the scale were Croatia, Poland, and Romania, all with 1.1 rooms on average per person (Eurostat, 2020).

In Europe, 71.7% of the population living in cities live in flats, rising to 83.5% in Spain; considering that the case studies analyzed are flats, it shows the representativeness of the properties selected for the research. Moreover, the case studies represent the global trend on which the urban structural growth shifts from spreading out to building up (Frolking et al., 2024). Spain is one of the countries with the highest percentage of flats globally. The Barcelona metropolitan area is one of the densest and tallest so far. In Spain 5, floor buildings are the most representative in cities, as the case studies are similar to that height. Most properties in Barcelona were built between 1960 and 1980 – around 46% of the total, similar to the construction year of the selected case studies (Sánchez and Plaza, 2023). And 72% of the properties are below 90 s.q.m., coherent with the selected case studies (Lasose, 2022).

Table 6. Characteristics of Residential Properties in Spanish Cities and Selected Case Studies.

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. The percentage of residential buildings with five or more floors and the average price per square meter (€ / m²) are also reported. Panel A details the case studies, highlighting their unique features compared to broader urban trends. Panel B aggregates data from major cities, offering a benchmark for understanding differences in urban residential structures and pricing. The table shows that cities like Madrid and Barcelona have a higher percentage of buildings with five or more floors, reflecting their denser urban environments and corresponding higher average prices per square meter. The total/average values provide a comprehensive overview, allowing for a comparative analysis of urban residential properties across Spain.

Municipality	Residential Units	Average Year of Construction	Average Residential Surface	Average Surface per Person	Average Number of Floors	% with 5 Floors or more	Price (€ / m²)
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.

Table 7 comprehensively compares residential property characteristics across major global and European cities, with a detailed breakdown provided in two panels. **Panel A** includes global cities such as London, Paris, Tokyo, and New York, highlighting key metrics like average residential surface area, year of construction, number of floors, and residential prices per square meter. The data reveals that global cities generally have higher residential prices and more varied construction periods than the case study buildings, which average a construction year of 1973, a residential surface area of 64.8 m², and an average of 6.2 floors. While case studies reflect a dense and vertical structure typical of compact urban settings, global cities show a mix of heights and older average construction dates, particularly in historic cities like Paris and London.

Panel B shifts focus to European cities. If we compare them against the case study data. The average residential surface in European cities (86 m²) is larger than the case studies (64.8 m²), and the average year of construction (1940) is slightly older than the case studies' average. European cities also tend to have buildings with fewer floors (average of 3.7), contrasting with the case studies' taller structures averaging 6.2 floors. This difference underscores the representativeness of the case studies in reflecting dense, vertically oriented properties seen in highly urbanized European cities like Madrid and Barcelona, which favor apartment living in multi-story buildings. Moreover, the average price per square meter in the case studies (€6,692) is significantly higher than the broader European average (€4,627), aligning more closely with higher-cost urban environments.

The case studies mainly reflect the compact and dense urban structures in cities like Berlin, Rome, and Vienna, which share comparable average construction periods and building characteristics. Additionally, the case studies' average building height and number of floors are consistent with European norms. However, the case studies represent slightly taller and denser configurations, typical of Spanish urban environments like Madrid and Barcelona. This consistency suggests that the case study buildings provide a meaningful representation of the typical residential stock found in these European cities, thus enhancing the generalizability and applicability of the findings to a broader urban context across Europe.

5.1. Case Study 1

The building is in the Sarria - St. Gervasi district of Barcelona, with 32 two-, three- and four-bedroom apartments distributed over eight floors. It has a single stairwell with an elevator and stairs and a roof terrace available for residents, where the heating and cooling installations are also located. The building has a leasable area of 2,073 sq.m., with an average area of 65 sq.m. per apartment. It was renovated in 2019 and has a type B energy rating and a BREEAM sustainability rating of "very good".

5.2. Case Study 2

The building on Ronda General Mitre in Barcelona is trapezoidal-shaped, with 70 apartments distributed on the ground floor, a mezzanine, eight floors, and a rooftop floor. The apartments are one-, two-, or three-bedroom, except on the ground floor with office premises. There is a stairwell with two elevators and stairs. The building has a leasable area of 3,359 sq.m., with an average surface area of 48 sq.m. per apartment. Built in 1966, several renovations have been carried out. It has a type G energy rating, and its BREEAM sustainability rating is pending.

Table 7. Characteristics of Residential Properties in 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. The data reveals that European cities generally feature lower building heights than the case studies. However, global cities exhibit a broader variability in average construction years and significantly higher residential prices, reflecting diverse urban planning and market conditions. The values provide a comprehensive overview, facilitating a comparative analysis of urban residential properties on both global and European scales.

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 Bundesant (2021), Robyn (2023), Bavarian State Office for Statistics, Brussels-Capital Region's Building Stock Reports, Czech Statistical Office, European Statistical Office (Eurostat), Hamburg's Urban Development and Housing Department Reports, Hungarian Central Statistical Office (KSH), Italian National Institute of Statistics (ISTAT), North Rhine-Westphalia State Office for Information and Technology, Poland Statistics (GUS), and Statistik Austria.

5.3. Case Study 3

The building has 51 two-, three-, and four-bedroom apartments in Plaza Villa de Madrid in Barcelona. It has six floors, an attic floor, and two stairwells with elevators. The building has a leasable area of 3,413 sq.m., with an average surface area of 67 sq.m. per apartment. It has undergone renovations in private areas and has a type F energy rating. Heat pumps and splits provide air conditioning and heating.

5.4. Case Study 4

A four-floor building with seven one-, two-, or three-bedroom apartments in the Sarriá —St. Gervasi district of Barcelona has a stairwell with an elevator and stairs and a patio on the private ground floor. The building has a leasable area of 403 sq.m., with an average surface area of 58 sq.m. per apartment. Renovated in 2013, it has a type E energy rating and a cooling and heating system using heat pumps.

5.5. *Case Study 5*

Eight-floor building with 59 one-, two-, or three-bedroom apartments in the Sant Martí district of Barcelona. The building has four stairwells, elevators and stairs, a terrace, green areas, and gardens. It has a leasable area of 4,825 sq.m., with an average surface area of 82 sq.m. per apartment. Built in 2020, on the roof, there are heating and cooling installations, a terrace, and communal areas, including a swimming pool. Its energy rating is type A; an aerothermal system provides heating and air conditioning, and the BREEAM sustainability rating is "very good".

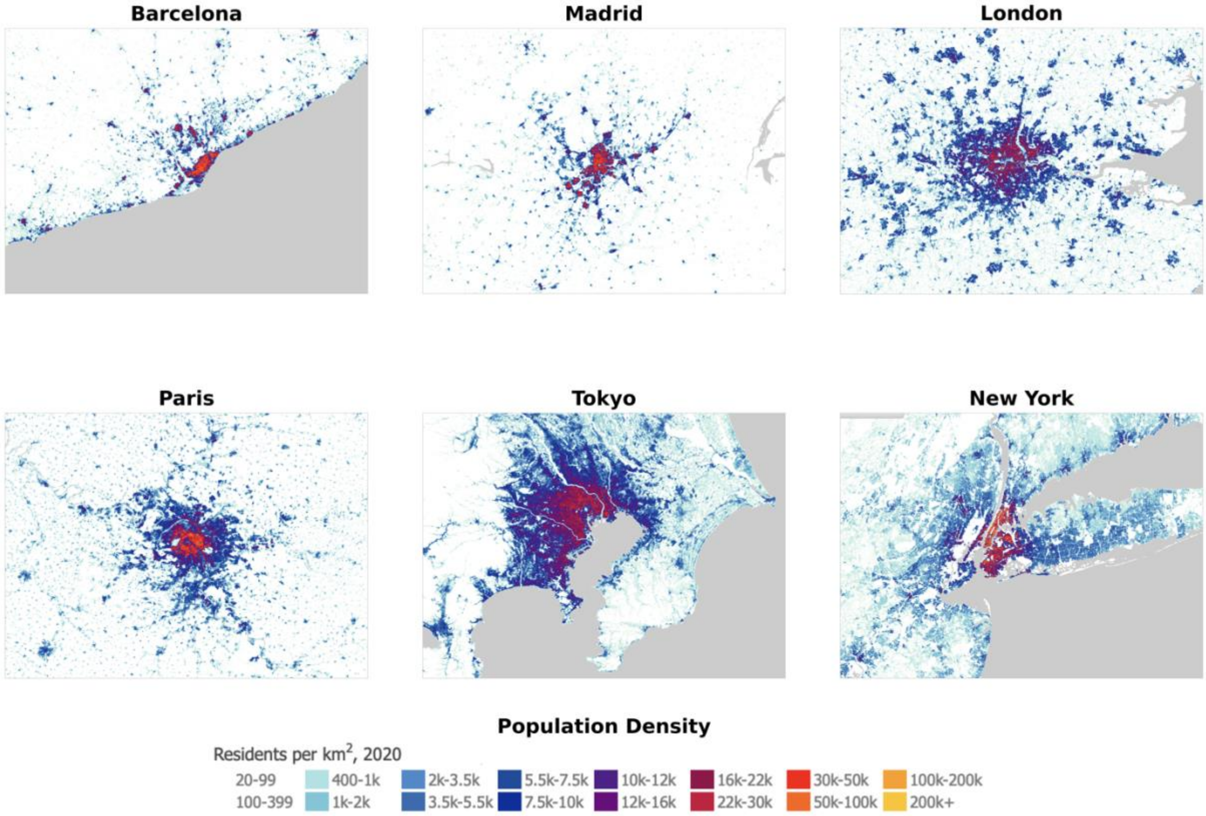


Figure 1: Population density distribution across Barcelona and Madrid and four major global cities. This figure presents the population density (residents per km²) across six major cities: Barcelona, Madrid, London, Paris, Tokyo, and New York. The colour gradient, ranging from light blue to yellow, indicates varying population densities, with cooler colours representing lower densities and warmer colours denoting higher densities. The maps highlight the central concentration of populations in these metropolitan areas, showing distinct patterns of urban sprawl and density. Source: luminocity3d and own elaboration.

5.6. *Case Study 6*

Six-floor building with 14 one-, two-, or three-bedroom apartments in the Prosperidad neighborhood of Madrid. It has a single stairwell with an elevator and stairs, with a leasable surface area of 844 sq.m. and an average surface area of 60 sq.m. per apartment. The building was renovated in 2019, and the rooftop is reserved for energy installations. Its energy rating is type D. The cooling and heating systems use aerothermal energy, energy with solar panels. Its BREEAM sustainability construction rating is "very good" and its BREEAM operational certification is pending.

5.7. *Case studies summary*

Table 8 presents critical data from the different cases analyzed.

Table 8. Description of Cases Studied.

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. The cases range from mid-20th century buildings that have undergone renovations to more recently constructed properties. The data presented offers insights into the diversity of apartment sizes, types, and overall floor space available for rent in each building, which is crucial for analysing the impact of sustainability measures on different property types.

Property	Location	Year of construction / Renovation	Floors	Flats	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.

6. RESULTS

6.1. What is the investment required to obtain sustainability certifications?

The investment required to achieve certifications is divided into *hard* and *soft costs*.

Hard costs refer to the tangible and direct costs associated with construction, such as materials or labor; in this case, they correspond to the direct costs of implementing sustainable measures. These costs include the initial investment in technologies, equipment, and materials necessary to improve energy efficiency, reduce carbon emissions, and implement sustainable practices such as installing solar panels and purchasing energy-efficient equipment.

Soft costs refer to indirect and non-tangible costs, such as legal expenses, market studies, or architectural design. This article relates to the indirect costs of obtaining green labeling.

Table 9 presents the investment required for the different case studies and provides information about surface area, income, and value to allow comparisons. A 0.79 m€ investment is required to obtain a sustainable certification, which is less than a year's income and less than 1% of the property's valuation.

Table 9. CapEx, Gross Income, and Valuation of Residential Properties (in Millions of Euros).

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, highlighting the financial outcomes of these investments. The total figures at the bottom offer a comprehensive overview of the combined financial metrics across all cases studied.

Property	Location	Apartments	Average surface area per apartment	CapEx (M€)			Gross income (M€)	Valuation (M€)
				Hard costs	Soft costs	Total		
Case 1	Barcelona	32	65 m²	0.10	0.04	0.14	0.49	12.7
Case 2	Barcelona	70	48 m²	0.25	0.03	0.28	1.09	27.1
Case 3	Barcelona	51	67 m²	0.13	0.03	0.15	0.69	17.9
Case 4	Barcelona	7	58 m²	0.03	0.02	0.05	0.10	2.9
Case 5	Barcelona	59	82 m²	0.03	0.04	0.08	1.10	32.5
Case 6	Madrid	14	60 m²	0.05	0.05	0.09	0.22	5.1
Total				**0.59 M€**	**0.21 M€**	**0.79 M€**	**3.68 M€**	**98.08 M€**

Source: Compiled by authors.

Table 10 shows that soft costs represent 26% of the investment to obtain green certifications, while hard costs amount to 74%. Health and wellbeing, photovoltaic panels, and management account for the higher investment amount, while certification fees are also significantly relevant.

Table 10. Investment Categorized According to BREEAM Certification (in Millions of Euros).

This table presents a detailed breakdown of investment costs across six residential case studies, categorized according to BREEAM certification standards. The investments are divided into hard and soft costs, with further categorization within the BREEAM framework, such as management, health and well-being, energy, and materials. Notably, the table highlights the allocation towards photovoltaic panels and the specific costs associated with obtaining BREEAM certification. The total investments for each case study are also summarized, providing a comprehensive view of the financial commitment required to achieve sustainability certification across various categories.

Sections	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Total (M€)
Hard costs	**0.099**	**0.252**	**0.124**	**0.030**	**0.033**	**0.046**	**0.59 M€**
BREEAM certification	**0.079**	**0.240**	**0.094**	**0.015**	**0.033**	**0.014**	**0.47**
Management (MNG)	0.006	0.003	0.045	0.012	0.028	0.006	0.10
Health and well-being (HWB)	0.023	0.218	0.022	0.001	0.002	0.001	0.27
Energy (ENE)	0.046	0.009	0.002	0.001	0.002	0.004	0.06
Materials (MAT)	0.005	0.011	0.025	0.001	0.001	0.002	0.04
Photovoltaic panels	**0.020**	**0.012**	**0.032**	**0.015**	**-**	**0.032**	**0.11**
Soft costs	**0.038**	**0.032**	**0.027**	**0.019**	**0.043**	**0.047**	**0.21 M€**
Rates or licenses	0.011	0.006	0.008	0.003	0.006	0.004	0.04
Fees and certification	0.026	0.025	0.016	0.015	0.036	0.040	0.16
Document management	0.002	0.002	0.003	0.002	0.002	0.003	0.01
Total	**0.137**	**0.284**	**0.152**	**0.049**	**0.076**	**0.093**	**0.79 M€**

Source: Compiled by authors.

Table 11 displays the actual and planned investment (CapEx) for each case from 2019 to 2030 to obtain the green label. It incorporates the gross income and the value from 2022 expressed in millions of euros (M€) and their respective percentages. Cases 1, 2, and 3, with similar results, correspond to sizeable buildings with investment rates relative to income fluctuating between 22.1% and 28.0%, with an average of 25.29%. The average CapEx relative to the value is 1.00%. Cases 4 and 6 are categorized as smaller buildings which show higher relative investments in terms of CapEx about income (45,15%) and relation to the property's value (1.78%). Case 5, a new building project, shows notably lower percentages for CapEx relative to annual gross income (6.94%) and property value (0.24%).

Table 11. Analysis of CapEx Impact on Gross Income and Property Value.

This table provides a detailed analysis of the capital expenditure (CapEx) in relation to gross income and property valuation across six case studies. The percentage of CapEx relative to annual gross income and property value is calculated to illustrate the financial efficiency of these investments. The data demonstrate varying degrees of CapEx impact, emphasizing how capital investments correlate with income generation and overall property valuation. Notably, newer properties show a lower CapEx percentage relative to both gross income and property value, reflecting higher efficiency in recent developments.

Property	CapEx (M€)	Gross income (M€)	Valuation (M€)	% CapEx / Annual gross income	% CapEx / Property value
Case 1	0.14	0.49	12.66	28.04%	1.09%
Case 2	0.28	1.09	27.14	26.06%	1.05%
Case 3	0.15	0.69	17.86	22.10%	0.85%
Case 4	0.05	0.10	2.90	49.49%	1.69%
Case 5	0.08	1.10	32.46	6.94%	0.24%
Case 6	0.09	0.22	5.07	43.15%	1.83%
Total	**0.79 M€**	**3.68 M€**	**98.08 M€**	**21.50%**	**0.81%**
Sizeable	**0.57**	**2.27**	**57.65**	**25.3%**	**1.0%**
Smaller	**0.14**	**0.31**	**7.97**	**45.2%**	**1.8%**
New	**0.08**	**1.10**	**32.46**	**6.94%**	**0.24%**

That Source: Compiled by authors.

Table 12 shows the aggregate CapEx of all cases classified according to the BREEAM certification categories with their respective annual incomes and market values in millions of euros (M€). It shows that the relative investment to value is low

We stress that the selected cases are located in large cities, such as Barcelona and Madrid, and that the results for CapEx relative to value and income may be significantly different in other locations (in which case the conclusions will also be different). In section 5.2, the impact of location on decision-making will be assessed. For example, the average price of housing in Spain in 2023Q3, according to the property valuation firm Tinsa, was €1,703/sq.m., but the figures for Barcelona and Madrid were 3,596/sq.m. and €3,537/sq.m. – that is, 211% and 208% higher.

Table 12 shows that hard costs represent 15.88% of the annual gross income and 0.60% of the value of the properties, while the corresponding figures for soft costs are 5.62% and 0.21%, respectively. The investment relative to the property's value is less than 1%. Although this total investment of 0.79 million euros constitutes 21.50% (i.e., approximately 2.4 months) of annual income, it does not seem to be a significant amount due to the potential impacts of sustainability certifications in terms of liquidity, decarbonization, value, cash flow or improvement of the condition of buildings.

Table 12. Analysis of CapEx Relative to Gross Income and Property Value by BREEAM Sections.

This table breaks down the capital expenditure (CapEx) into specific BREEAM sections, analysing its impact relative to annual gross income and property value. The analysis provides insight into how different sustainability investments, such as health and wellbeing, energy, and materials, contribute to overall costs. Notably, hard costs and BREEAM certification constitute the largest portions of CapEx, demonstrating their significant role in property valuation. This breakdown highlights the financial implications of sustainability measures within the BREEAM framework, supporting decision-making for future green investments.

BREEAM section	CapEx (M€)	% CapEx / Annual gross income	% CapEx / Property value
Hard costs	**0.59 M€**	**15.88%**	**0.60%**
BREEAM certification	**0.47**	**12.88%**	**0.48%**
Management (MNG)	0.10	2.71%	0.10%
Health and wellbeing (HWB)	0.27	7.25%	0.27%
Energy (ENE)	0.06	1.71%	0.06%
Materials (MAT)	0.04	1.21%	0.05%
Photovoltaic panels	**0.11**	**3.01%**	**0.11%**
Soft costs	**0.21 M€**	**5.62%**	**0.21%**
Rates or licenses	0.04	1.00%	0.04%
Fees and certification	0.16	4.28%	0.16%
Document management	0.01	0.34%	0.01%
Total	**0.79 M€**	**21.50%**	**0.81%**

Source: Compiled by authors.

For each of the cases in the analysis, Table 13 presents the CapEx in relation to the gross leasable area and the number of homes, in euros per square meter (€/sq.m.) and in euros per apartment (€/apartment) respectively. The data obtained are relevant for analyzing and comparing cases and estimating future investments for other projects. Sizable existing have significantly less required investment compared to smaller size on both, per sqm and per apartment. On the other hand, case 5 presents noticeably lower rates of CapEx relative to income, value, surface area and apartment because it corresponds to a new building project that must comply with the current technical requirements.

Table 13. CapEx Relative to Gross Surface Area and Number of Apartments.

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

Property	Nº of apartments	Gross surface area for rent	CapEx (M€)	CapEx / Gross surface area for rent	CapEx / Apartment
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**
Sizeable	**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.

6.2. Do sustainable certifications have a positive impact on a building's value?

Table 14 displays the appraisers' estimates for the value increase due to a sustainable certification and detailed information about the appraisers' profiles. The results show that sustainable certifications increase a building's value. Specifically, the expected average value increase for a building due to the certification is about 1.22 percentage points and 0.42 percentage points per apartment.

Table 14. Appraisers' Profile and Expected Value Increase for Buildings and Apartments with BREEAM Certification.

This table presents the sample appraisers' profiles detailing their industry experience, positions, educational backgrounds, gender, and whether they work for global or national companies. 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 evaluated by national appraisers, highlighting the perceived value of sustainability certifications in the global 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

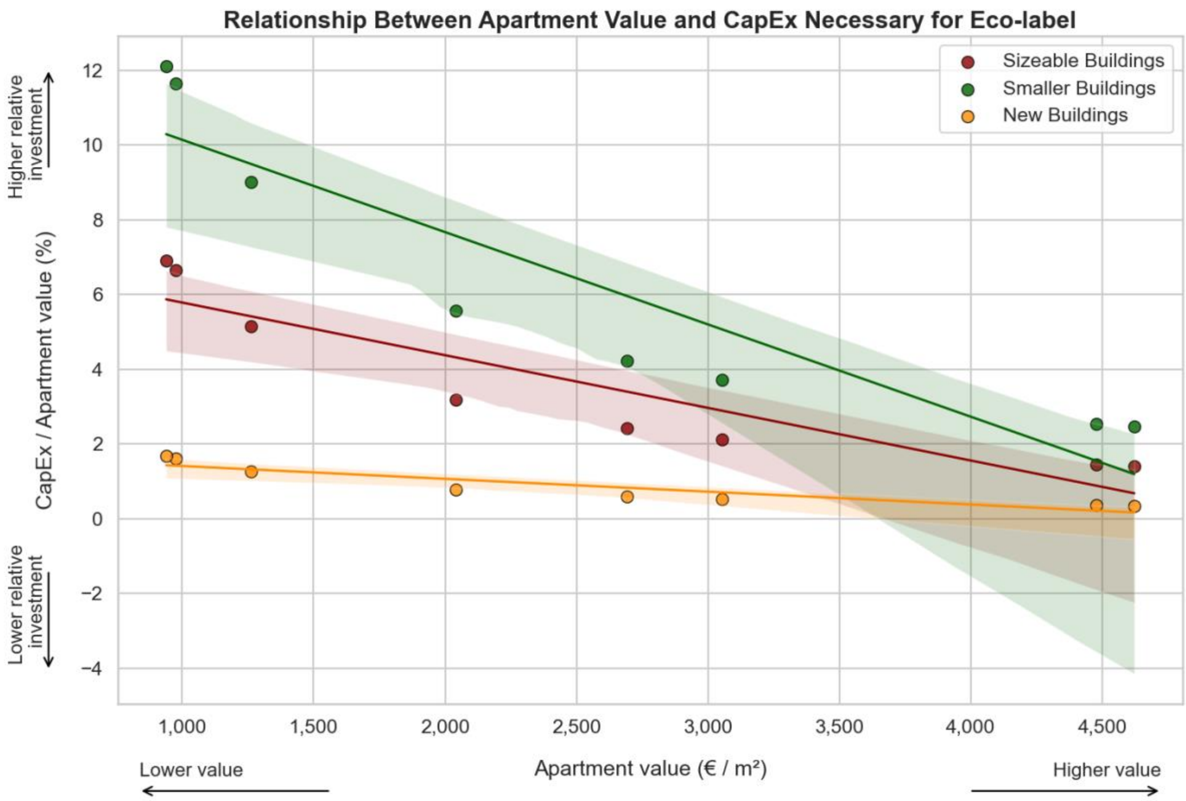
National Average	*0*	*0.25*
Global & National Average	**0.42**	**1.22**

Source: Compiled by authors.

With this data, we are ready to answer whether sustainability certifications increase the value of buildings. The data proves that investing in obtaining sustainability certificates will indeed increase the value of buildings and apartments, although by a small magnitude. Our findings have the same positive sign as those of previous studies, which suggest that a green label increases the value of a building by between 3% and 7%. However, we document a still positive but substantially lower effect on the value of +1.22%.

In the case of new constructions, where the investment required to achieve green labels is lower, the impact on value will be even higher due to the already demanding requirements of current building regulations and the minimal cost to obtain the certification. In smaller buildings already built and below 1,000 sq.m., the investment in international sustainable certifications will lead to increases in the value of buildings, albeit to a lesser extent: it entails an average outlay of 45.2% of the annual gross income and 1.8% of the property's value as seen on Table 11. Therefore, private incentives for applying sustainability strategies in small buildings or single-family homes will be lower. This situation opens up the possibility for public-private collaborations to help reduce the green premium for this segment, especially considering the high proportion of small buildings in a country where 32% of properties are single-family homes (Spanish Ministry of Public Works, 2013, de la Riva, 2021).

The results presented here refer to market environments in cities such as Barcelona and Madrid. In areas with lower property values, the profitability of obtaining eco-labels could be even less apparent in smaller buildings and non-prime areas. The CapEx will be similar regardless of the property's location, but this is different from the expected value increase of the investment. Suppose the CapEx required to obtain the ecolabel exceeds 7% of the value of a building in an area with low property values. In that case, certification may not be economically viable for private concerns, so public-private collaboration will have a role to play. Figure 2 shows the relationship between apartment value and the required CapEx as a share of the apartment value.



Source: Compiled by authors

Figure 2: Relationship between buildings' apartment values and CapEx necessary for eco-label certification. This figure illustrates the relationship between apartment value (€/m²) and the required CapEx (€/m²) as a share of the apartment value (€/m²) across the three building categories. The regression lines and scatter plots depict the relative investment for the sizeable buildings (dark red), smaller buildings (dark green), and newly constructed buildings (dark orange) obtained from the corresponding values of these buildings' categories in this paper's cases. The apartment values were obtained through www.idealista.com (Spain's most prominent real estate portal) and corresponded to the average real state price (€/m²) of eight areas in Spain. From lower apartment values to higher, those areas are Castilla la Mancha Region, Extremadura Region, Murcia Region, Spain, Barcelona Province, Madrid Province, Barcelona City, and Madrid City. This figure depicts three main messages: (i) that smaller buildings, compared to larger ones, require a higher relative investment effort to obtain an eco-label, (ii) that non-prime areas, compared to non-prime, display a much higher relative investment effort to obtain the certification, (iii) that new construction buildings display a significant cost advantage to obtain certifications compared to already built ones. Source: Own elaboration.

Another factor to consider is the predominance of smaller buildings in environments with lower market value. For example, in Cuenca, Zamora, and Toledo, single-family homes account for more than 60% of residential buildings, compared with a figure of 13% in Madrid (Spanish Ministry of Public Works, 2013, de la Riva, 2021). This means that government bodies must apply specific measures to encourage the implementation of sustainability strategies based on opportunity cost to comply with the UN's 2030 Agenda for Sustainable Development.

6.3. Are sustainable certifications profitable?

To answer this question, we calculate the yield of the investment in sustainability certifications in residential buildings. Table 16 presents the profitability for the five cases considering an investment (CapEx) of 0.79 €/sq.m. and a starting value of 98.08 €/sq.m. The table shows that certifications increase the value between 2.5% and 7.0%. This leads to a significant yield between 331% and 928%, which shows that the investment decision leads to a positive outcome and that investing in sustainable certifications is profitable.

Table 15. Yield on Value Increase for All Six Cases.

This table illustrates the yield calculated based on the percentage increase in property value following the addition of an ecolabel across six cases. It highlights the significant impact that even a modest percentage increase in property value can have on the overall yield. For instance, a 3.0% increase in value leads to a yield of 397.6%, underscoring the substantial financial return associated with obtaining sustainability certifications.

	Cases 1, 2, 3, 4, 5 and 6									
Increase in value (%)	2.5%	3.0%	3.5%	4.0%	4.5%	5.0%	5.5%	6.0%	6.5%	7.0%
Total value post ecolabel	100.53	101.02	101.51	102.00	102.49	102.98	103.47	103.96	104.46	104.95
Increase in value	2.45	2.94	3.43	3.92	4.41	4.90	5.39	5.88	6.38	6.87
Yield (%)	331.4%	397.6%	463.9%	530.2%	596.4%	662.7%	729.0%	795.2%	861.5%	927.8%

Source: Compiled by authors.

6.4. Is there heterogeneity in sustainable certification profitability?

6.4.1. Does building size increase sustainable certification adoption?

For existing buildings of considerable size (cases 1, 2, and 3), with a total CapEX required to obtain a green certification of 0.57 M€ (Table 13) and a starting asset appraisal of 57.65 M€ (Table 8), the yield, considering a 4.5% value increase, is 418%, huge.

When the resulting sustainability certification returns are compared with the opportunity costs, that is, the return of a comparable investment, they are expected to be higher than an average alternative equivalent asset return.

As stated in the semi-structured interviews, not only are sustainable certifications much more likely in Tier 1 cities and prime areas where property values are higher, and property markets are liquid and global, but also, as interviews stated, platinum or excellent LEED or BREEAM certifications, the higher rank, are significantly much more frequent in those locations. As Porumb et al. (2020) and Zhang et al. (2024) state, sustainable certifications impact consolidated and liquid areas more, making their impact insignificant in municipalities under 200,000 inhabitants.

In the case of smaller existing buildings (cases 4 and 6), the benefit is significantly lower, though not insignificant. With a total CapEX required to obtain a green certification of 0.14 M€ (Table 14) and a starting asset appraisal of 7.97 M€ (Table 9), the yield, considering a 4.5% value increase, is 276%, very significant

Finally, profitability is even higher in the case of new construction; given the stipulations of current building regulations, the levels of investment required and the requirements of the isolating regulations to obtain certification are lower. With a total CapEX needed to get a green certification of 0.08 M€ (Table 12) and a starting asset appraisal of 32.46 M€ (Table 7), the yield, considering a 4.5% value increase, is 2,478.

Table 16. Yield Related to Value Increase by Building Size with Appraisers' Average Valuation.

This table demonstrates the yield associated with the percentage increase in property value due to sustainability certifications, segmented by building size. The analysis includes significant-sized buildings (Cases 1, 2, and 3), small-sized buildings (Cases 4 and 6), and a new construction building (Case 5). The yield percentages illustrate the substantial financial returns linked to even modest value increases, emphasizing the economic impact of achieving eco-label certifications.

					Significant Size Buildings (Cases 1, 2, 3)					
Increase in value (%)	2.5%	3.0%	3.5%	4.0%	4.5%	5.0%	5.5%	6.0%	6.5%	7.0%
Total value post ecolabel	59.09	59.38	59.67	59.96	60.24	60.53	60.82	61.11	61.40	61.69
Increase in value	1.44	1.73	2.02	2.31	2.59	2.88	3.17	3.46	3.75	4.04
Yield	262.0%	314.5%	366.9%	419.3%	471.7%	524.1%	576.5%	628.9%	681.3%	733.7%
					Small Size Buildings (Cases 4 and 6)					
Increase in value (%)	2.5%	3.0%	3.5%	4.0%	4.5%	5.0%	5.5%	6.0%	6.5%	7.0%
Total value post ecolabel	8.17	8.21	8.25	8.29	8.33	8.37	8.41	8.45	8.49	8.53
Increase in value	0.20	0.24	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56
Yield	153.3%	183.9%	214.6%	245.2%	275.9%	306.5%	337.2%	367.8%	398.5%	429.2%
					New Construction Building (Case 5)					
Increase in value (%)	2.5%	3.0%	3.5%	4.0%	4.5%	5.0%	5.5%	6.0%	6.5%	7.0%
Total value post ecolabel	33.31	33.48	33.64	33.80	33.96	34.13	34.29	34.45	34.61	34.78
Increase in value	0.81	0.98	1.14	1.30	1.46	1.63	1.79	1.95	2.11	2.28
Yield	1,354%	1,625%	1,896%	2,167%	2,438%	2,708%	2,979%	3,250%	3,521%	3,792%

Source: Compiled by authors.

6.4.2. Does building location influence sustainable certification adoption?

To answer this question, we located all buildings in Spain with a residential BREEAM or LEED certification at the municipality level. Figure 3 displays the spatial distribution of BREEAM and LEED-certified residential buildings across Spain. Those buildings are in Spain's two most prominent global cities, Madrid and Barcelona, and the main tourist areas along the Mediterranean coast and Balearic Islands. All these areas are considered Spanish premium locations with average prices much higher than the Spanish average. The map showcases the regional disparities in sustainable building adoption. The data underscores the critical role of urban, tourist, and premium areas in driving green certification efforts, with implications suggesting that policy interventions are needed if we want to promote sustainable urban development.

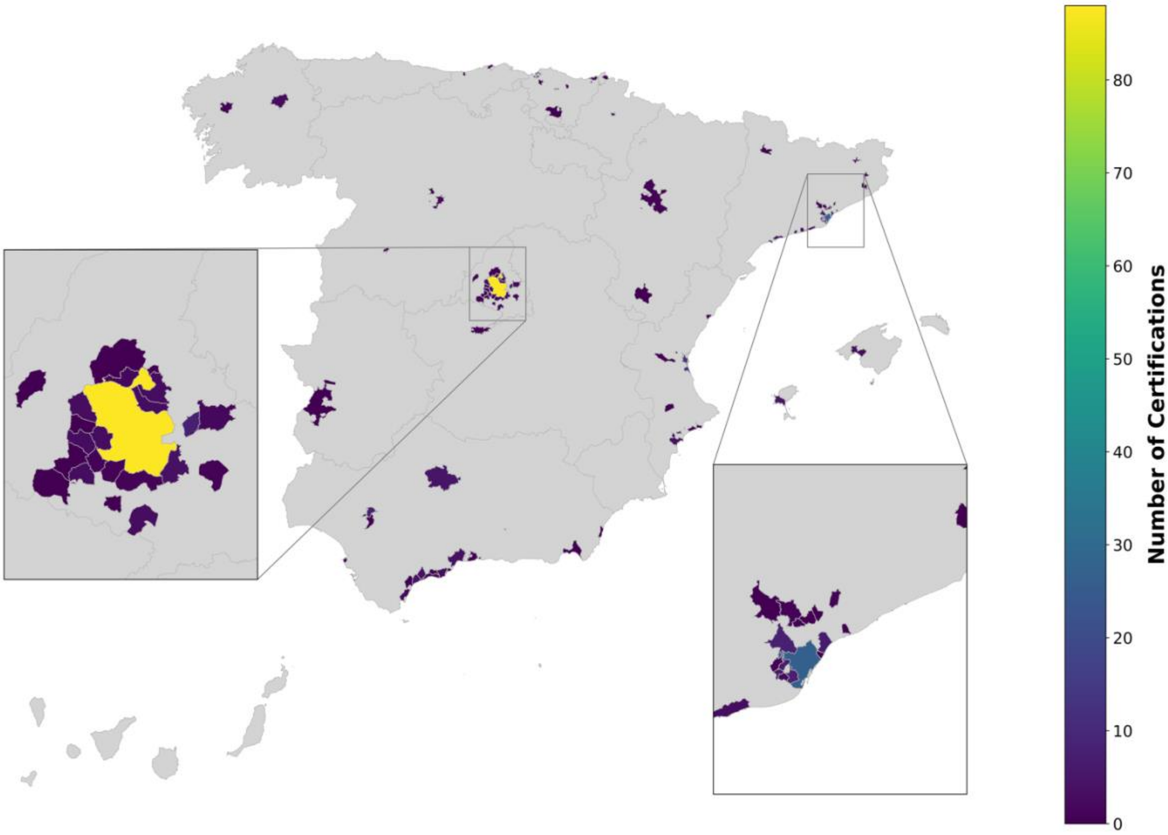


Figure 3: Distribution of LEED and BREEAM Certified Residential Buildings Across Spain. This map illustrates the spatial distribution of LEED and BREEAM-certified residential buildings by municipality within Spain. The color gradient represents the number of certifications, with a higher concentration of certifications indicated by brighter colors. Inset maps provide a detailed view of two regions with the highest concentration of certifications: Madrid and Barcelona. These regions are highlighted to emphasize their significant contribution to Spain's total certified residential stock, showcasing the regional disparities in sustainable building adoption. The data underscores the critical role of urban areas in driving green certification efforts, with implications for policy interventions to enhance sustainable urban development. Source: Own elaboration based on data from www.usgbc.org and https://breeam.es.

Additionally, we used Google Trends to collect data on the geographical search interest in different sustainability certifications. This latter approach allowed us to discern geographical patterns and potential correlations between search interest and adopting sustainable building practices across Spain and provides a clear and concise representation of each certification's spatial distribution of interest.

The generated choropleth maps, presented in Figure 3, visually depict the relative search interest for each certification across different Spanish regions. The color intensity corresponds to the relative search score, with darker shades indicating higher interest. Our analysis reveals distinct geographical trends in Spain's adoption of green building standards. BREEAM and LEED exhibit high search interest, and Madrid and Catalonia emerge as frontrunners, suggesting a potential stronghold for this certification area with Spain's largest cities and metropolitan areas. In contrast, Green Star shows a more distributed interest across the country, containing the most prominent urban areas and featuring the country's most touristic-intensive regions, with a pronounced focus on the Balearic Islands and the Canary Islands. These findings highlight the varying adoption rates and geographical preferences for different green building certifications across Spain, offering valuable insights for policymakers, industry professionals, and researchers promoting sustainable construction practices.

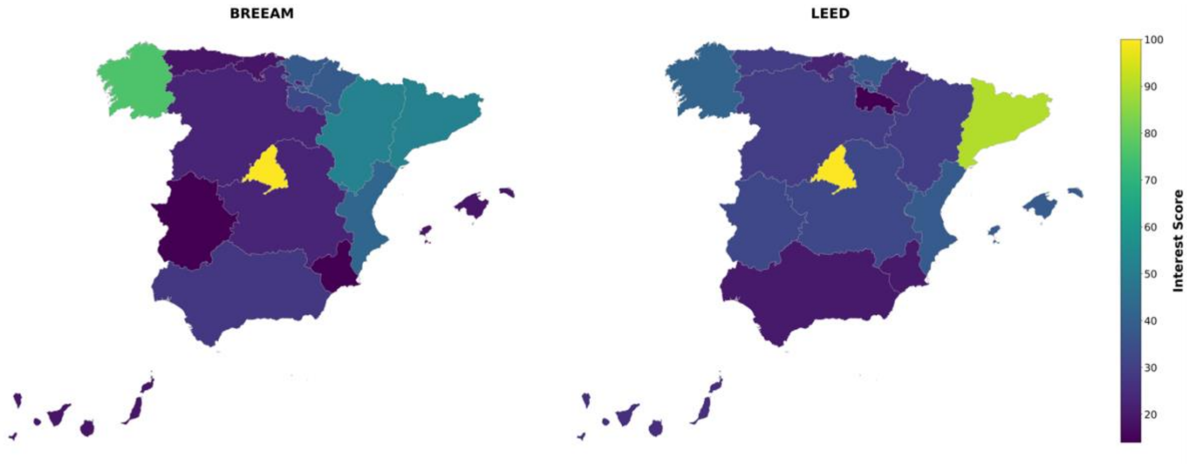


Figure 3: Geographic Distribution of Relative Interest in Green Building Certification in Spain. The maps illustrate the relative popularity of BREEAM, LEED, and Green Star green building certifications across different regions in Spain, based on Google Trends data from June 7, 2016, to June 8, 2024. 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.

Figure 4 illustrates the spatial distribution of residential property prices in Spain, comparing province-level and municipality-level data. The left panel shows average apartment prices per square meter across provinces, with higher prices concentrated in major urban and coastal regions like Madrid, Barcelona, and the Balearic Islands. The right panel, focusing on municipalities with populations over 25,000, reveals significant price variability within provinces, particularly in densely populated and economically active cities. The colour scale from dark purple to bright yellow highlights the diverse economic landscape of Spain's real estate market. For a detailed comparison of regional and local price disparities, refer to Figure 4. The data is sourced from the Spanish Ministry of Transport and Sustainable Mobility for the first quarter 2024.

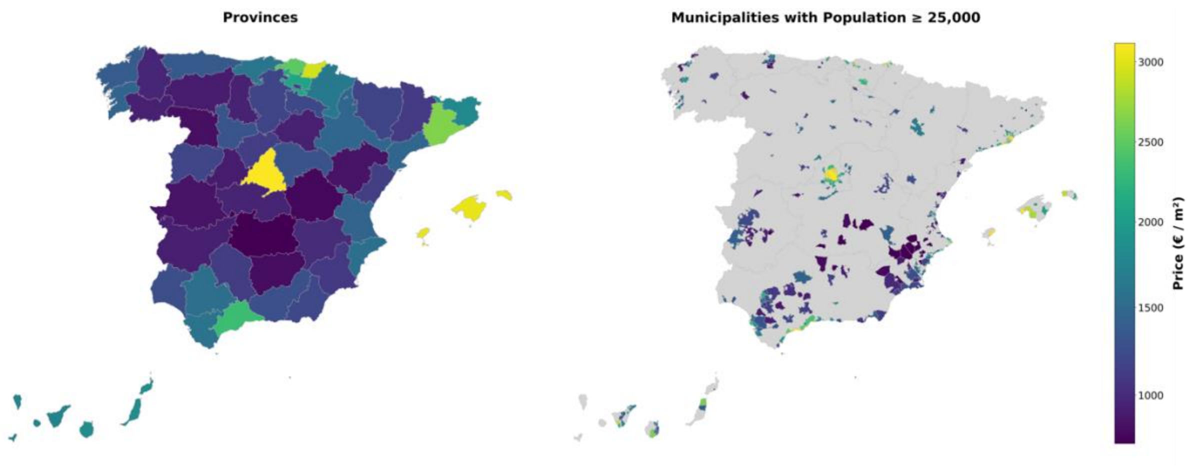


Figure 4: Spatial Distribution of Residential Property Prices in Spain: A Comparison of Province-Level and Municipality-Level Data. The left panel illustrates average apartment prices per square meter across Spanish provinces, highlighting regional disparities with higher prices concentrated in major 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 colour 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 2024.

To further probe the effects of location on ecolabel adoption, we apply topic detection analysis using openAI's ChatGPT-4o model. Table 18 shows the regression output of the topic detection analysis produced with openAI's API using as input the answers of the seventeen real estate professionals to the following three 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?*"

We then proceeded with the topic detection analysis. We asked the LLM to produce a dichotomic measure. This measure takes value one if an interviewee has stated that location quality and the associated characteristics of buildings in these areas' moderate sustainable certification demand. Specifically, the prompt we used was the following:

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 5 summarizes LLM's detection output. Of the seventeen interviewees who answered at least one of the questions, nine mentioned that prime locations and their assets are more likely to obtain sustainability certifications. Therefore, 52.9% of the interviewees consider that location and related building characteristics are a factor that drives the adoption of sustainable certification. We take this as evidence of the importance of location and its associated characteristics, as participants were not explicitly asked to state this link. However, a significant share of them spontaneously mentioned it.

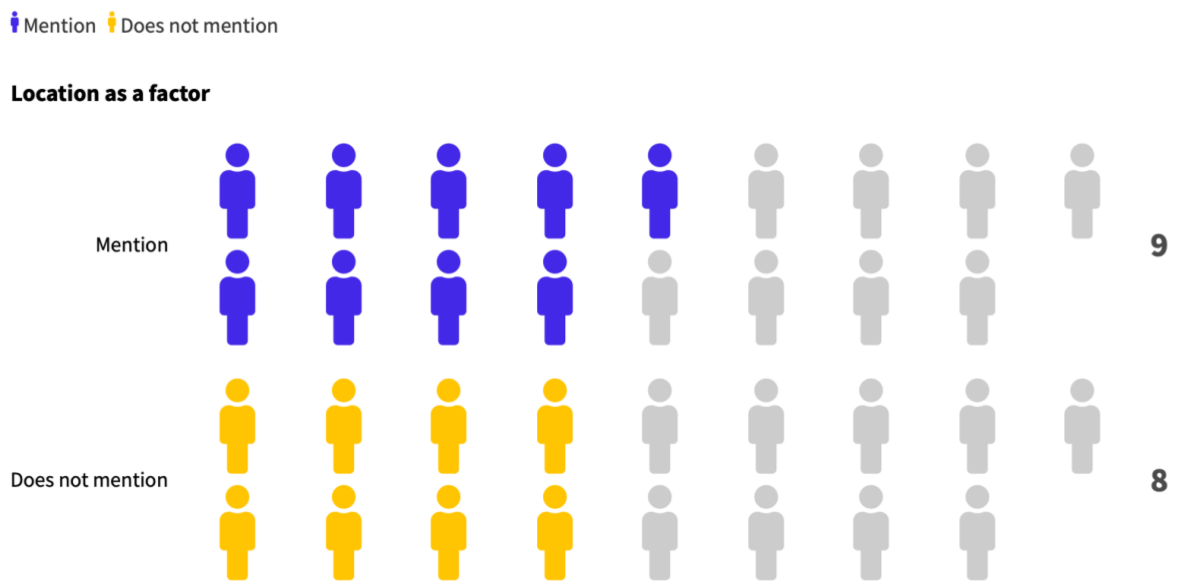


Figure 5: Location as a factor. The number of interviewees that a large language artificial intelligence model classifies as having mentioned (blue) or not having mentioned (yellow) that a prime or liquid location increases the likelihood of buildings receiving sustainable certifications. Source: Own 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.

6.5. Do real estate professionals think the benefits of sustainable certifications outweigh their costs?

We apply sentiment analysis to the answers to **Question 1** using openAI's ChatGPT-4o model. Table 19 shows the regression output of the sentiment analysis produced with openAI's API using the seventeen answers (one interviewee did not answer it) of the real estate professionals as input.

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

The dependent variable in the regression, *Sentiment$_i$*, is the sentiment analysis score determined by model ChatGPT-4o. Zero reflects a strong negative sentiment in the answer, and one hundred reflects a strong positive sentiment. Specifically, the prompt we used was the following:

API prompt call

```
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}"}]
```

The independent variables included in the model are indicator variables referring to the professional group: *Certifier*, *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 she is not. *Manager$_i$* is an indicator variable that takes value one if interviewee *i* is a manager and zero if she is not. *ESG linked bonus$_i$* is an indicator variable that takes value one if interviewee *i* has a bonus related to ESG metrics and zero if she does not. *Sector Experience$_i$* is the number of years of interviewee *i* in the sector. *Multinational$_i$* is an indicator variable that takes value: one if interviewee *i* works for a multinational company and zero if she does not.

Table 17. Sentiment analysis.

*This table presents the results of a sentiment analysis conducted on various roles within the real estate and financial sectors. The coefficients (Coef.) indicate the impact of each role on sentiment relative to the baseline category, Certifier$_i$. Financial Consultants and Landlord$_i$ show significant negative 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, with significant roles highlighted by ***, **, and * for significance at the 1%, 5%, and 10% levels, respectively. The model explains approximately 62.9% of the variation in sentiment.*

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.

The analysis reveals that although the average sentiment towards the financial returns of sustainability certifications of 63.1 in the sample is positive, Financial Consultants and Landlords exhibit significantly lower sentiment scores among the professional groups than Certifiers. Specifically, Financial Consultants display, on average, 29.3 lower sentiment scores and Landlords 26.5 lower scores than certifiers. Other factors such as being a Manager, having ESG-linked bonuses, years of sector experience, and working for a multinational company do not show statistically significant effects on sentiment scores. The regression output explains sentiment variations for different professional groups, with significant coefficients indicating apparent differences in sentiment among certain professional groups. More specifically, real estate professionals whose interests lean more towards the financial performance of real estate assets, such as Landlords or Financial Consultants, are less enthusiastic about the economic benefits of sustainability certifications than professionals with vested interests in producing those certifications, such as Certifiers or Technical Consultants.

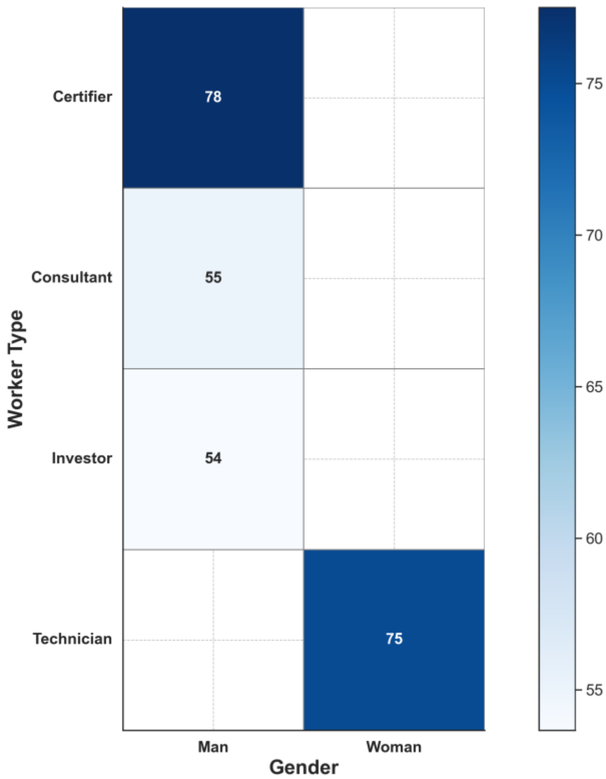


Figure 6: Heatmap of sentiment score by worker type and gender. This heatmap illustrates the average sentiment scores of different worker types across gender categories. The data, derived from a sentiment analysis performed using the GPT-4o model, shows how various worker types perceive sustainability initiatives. The colour intensity represents the average sentiment score, with darker shades indicating higher sentiment scores. The gender categories include 'Man' and 'Woman', while the worker types are categorized as 'Certifier', 'Consultant', 'Investor', and 'Technician'. Source: Own elaboration.

A similar pattern is revealed if we create a heatmap of the sentiment score by worker type and gender. As shown in Figure 6, certifiers and technicians display a similar sentiment score regardless of their gender, of 78 and 75 points correspondingly. As expected, consultants and investors receive a much lower sentiment score around the mid-fifties.

To continue the analysis, we aggregate the answers of investors and financial consultants into the new business category*, as these types of interviewees have a more business-orientated* profile and produce similar results in the sentiment analysis. We also created a new technical category for certifiers and technicians, which also produces similar sentiment analysis results and has a technical background. Then, using the package *wordcloud* of the

Python programming language, we create word clouds based on the answers of the two distinct categories to question 1. With the resulting output, we prepare Figure 7.

Analyzing Figure 7, we observe differences in the use of language in the two profiles. Interviewees with a business profile use more words related to real estate assets (e.g., building, asset, or market) and their profitability (e.g., investment, value, or impact). Technical profiles refer to sustainability with a much higher frequency and, in other words, related to the benefits of sustainable certifications that are not only financial (e.g., health, environment, or benefit). They also refer to people with much higher frequency than business interviewees and less to real estate assets such as buildings or offices than business interviewees.

Figure 7: Word clouds. The size of each word corresponds to the frequency in 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.

7. CONCLUSIONS AND POLICY IMPLICATIONS

This study examines the drivers and financial implications of Sustainable Residential Certification (SRC) through six case studies, semi-structured interviews, and appraiser valuations. The analysis reveals that SRC adoption is primarily driven by supply-side factors, particularly in high-value, prime locations where the relatively low capital expenditure (CapEx) required makes certification an attractive investment.

The average SRC investment in these markets amounts to 21.5% of a building's annual gross income and 0.79% of its property value—approximately €53 per square meter or €3,400 per apartment. This investment is justified by an anticipated post-certification increase of 3–7% in property value, demonstrating a clear financial incentive for adopting sustainable practices. Furthermore, the study finds that economies of scale play a critical role; large properties with more than 30 apartments and over 2,000 square meters benefit from significantly lower relative costs compared to smaller buildings, while single-family homes, which constitute 32% of Spain's housing stock, often face prohibitive expenses.

New constructions are particularly well-suited for SRC, as they incur much lower CapEx—around €16 per square meter and €1,294 per apartment—due to compliance with modern sustainability standards during construction. This inherent cost advantage supports the case for universal certification of new buildings, regardless of location. Moreover, the fixed nature of the required investment means that SRC is financially viable only in markets where property values exceed €1,200 per square meter. In contrast, lower-value areas may require public–private collaboration to improve sustainability.

Appraisal data further substantiates these findings, with international experts forecasting average value gains of 3.17% for buildings and 1.25% for apartments, translating into returns of approximately 397% relative to CapEx. However, sentiment analysis indicates a divergence in perspectives: technical professionals exhibit greater optimism about the financial returns of SRC, while financial consultants and investors express more caution.

Overall, the results suggest that SRC adoption is most economically advantageous in large, dynamic markets where high property values and economies of scale lower relative costs. Coordinated public–private strategies will be essential in less favorable contexts to overcome financial barriers and advance urban sustainability objectives.

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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